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Formulation and Physicochemical Characterization of Herbal Facial Wash Containing *Moringa oleifera* and *Solanum lycopersicum* Extracts

Formulasi dan Karakterisasi Fisikokimia Pembersih Wajah Herbal Mengandung Ekstrak *Moringa oleifera* dan *Solanum lycopersicum*

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ABSTRACT

Cleansing products based on plant extracts require acceptable physicochemical properties and retained antioxidant activity. This study formulated a herbal facial wash containing *Moringa oleifera* leaf extract and *Solanum lycopersicum* fruit extract and evaluated its physicochemical characteristics and antioxidant activity. Three formulas were prepared with different excipient compositions and assessed for organoleptic properties, pH, viscosity, foaming ability, free alkali content, phytochemical profile, TLC pattern, and DPPH radical-scavenging activity. Phytochemical screening detected flavonoids, tannins, saponins, alkaloids, quinones, and triterpenoids. The selected formulation showed chromatographic bands comparable to the extracts, indicating retention of major constituents after formulation. The IC_{50} values were 30.891 ± 0.40 µg/mL for *M. oleifera* extract, 50.532 ± 0.92 µg/mL for *S. lycopersicum* extract, and 46.350 ± 0.08 µg/mL for the selected facial wash. These results indicate that the extracts can be incorporated into a facial wash with measurable antioxidant activity.

Kata kunci:
Aktivitas antioksidan
Formulasi
Pembersih wajah
Moringa oleifera
Solanum lycopersicum

ABSTRAK

Produk pembersih berbasis ekstrak tanaman perlu memiliki sifat fisikokimia yang sesuai dan tetap mempertahankan aktivitas antioksidan. Penelitian ini memformulasikan pembersih wajah herbal yang mengandung ekstrak daun *Moringa oleifera* dan ekstrak buah *Solanum lycopersicum* serta mengevaluasi karakteristik fisikokimia dan aktivitas antioksidannya. Tiga formula dibuat dengan komposisi eksipien berbeda dan diuji terhadap sifat organoleptik, pH, viskositas, kemampuan berbusa, kadar alkali bebas, profil fitokimia, pola KLT, dan aktivitas penangkapan radikal DPPH. Skrining fitokimia menunjukkan adanya flavonoid, tanin, saponin, alkaloid, kuinon, dan triterpenoid. Formula terpilih menunjukkan pita kromatografi yang sebanding dengan ekstrak, mengindikasikan bahwa konstituen utama tetap terdeteksi setelah formulasi. Nilai IC_{50} masing-masing sebesar 30,891 ± 0,40 µg/mL untuk ekstrak *M. oleifera*, 50,532 ± 0,92 µg/mL untuk ekstrak *S. lycopersicum*, dan 46,350 ± 0,08 µg/mL untuk formula terpilih. Hasil ini menunjukkan bahwa kedua ekstrak dapat diformulasikan dalam pembersih wajah dengan aktivitas antioksidan terukur.

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1. INTRODUCTION

The skin is an important protective organ, and the facial area requires particular care because it is frequently exposed to environmental stressors, cosmetics, and cleansing products. Inappropriate cleansing may disturb skin balance, whereas suitable facial cleansers can help remove impurities, excess sebum, and dead skin cells while maintaining acceptable skin comfort. Increasing attention to cosmetic safety has also encouraged the development of skincare products containing plant-derived ingredients, particularly for daily-use products such as facial wash (Mustafa, 2026; Valenzuela et al., 2025).

Recent developments in cosmetic formulation have focused not only on cleansing performance but also on the incorporation of bioactive ingredients that may support skin protection. Antioxidants are commonly considered in facial skincare formulations because oxidative stress induced by ultraviolet exposure, pollution, and other environmental factors contributes to skin damage and premature aging. Therefore, plant materials containing antioxidant constituents are relevant candidates for the development of herbal-based facial wash formulations (Brar et al., 2025).

Moringa oleifera leaves and *Solanum lycopersicum* fruits are natural sources of bioactive compounds with potential relevance for topical formulations. *M. oleifera* leaves contain flavonoids, phenolic compounds, and vitamin C, which are associated with antioxidant and anti-inflammatory properties. *S. lycopersicum* fruits contain carotenoids, including beta-carotene and lycopene, which are known for antioxidant and photoprotective potential. The different phytochemical profiles of these two materials provide a rationale for their combined use in a facial wash formulation (Lacatusu et al., 2020; Čutović et al., 2023).

Although herbal facial cleansers have been widely explored, limited studies have evaluated the combined incorporation of *M. oleifera* leaf extract and *S. lycopersicum* fruit extract in a facial wash system while also assessing physicochemical properties and antioxidant retention after formulation. Therefore, this study aimed to formulate a herbal facial wash containing both extracts and to evaluate its organoleptic properties, pH, viscosity, foaming ability, free alkali content, phytochemical profile, thin-layer chromatographic pattern, and antioxidant activity using the DPPH method.

2. METHODS

2.1. Materials and instruments

M. oleifera leaf extract (thick ethanolic extract of leaves, extracted using 96% ethanol) and *S. lycopersicum* fruit extract (thick ethanolic extract of fruits, extracted using 96% ethanol) were obtained from PT Javaplant, Indonesia, and used as active ingredients. The excipients used in the facial wash formulation included glycerin (PT. Brataco, Indonesia), propylene glycol (PT. Brataco, Indonesia), Viscolam AT 100 (Lamberti S.p.A., Italy), Plantacare® 1200 UP (BASF, Ludwigshafen, Germany), potassium hydroxide (analytical grade, PT. Brataco, Indonesia), triethanolamine (TEA; PT. Brataco, Indonesia), sodium EDTA (Na-EDTA; PT. Brataco, Indonesia), and DMDM hydantoin (Sigma-Aldrich, St. Louis, MO, USA).

The main instruments used in this study included a homogenizer (IKA RW 20 Digital, IKA Works GmbH & Co. KG, Staufen, Germany), pH meter (Mettler Toledo Benchtop pH Meter F20, Mettler-Toledo AG, Greifensee, Switzerland), Brookfield viscometer (DV1 Digital Viscometer, AMETEK Brookfield, Middleboro, MA, USA), analytical balance (Radwag AS 220.R1 PLUS, RADWAG Balances and Scales, Radom, Poland), glassware, test tubes, TLC chamber, silica gel 60 F254 TLC plates (Merck KGaA, Darmstadt, Germany), UV lamp at 254 and 366 nm (CAMAG UV Cabinet dual wavelength 254/366 nm, CAMAG, Muttenz, Switzerland), and UV–Vis spectrophotometer (Shimadzu UV-1800, Shimadzu Corporation, Kyoto, Japan) for antioxidant activity analysis.

2.2. Phytochemical screening

Phytochemical screening was performed to identify major secondary metabolite groups in the extracts, including flavonoids, alkaloids, saponins, quinones, tannins, and steroids/triterpenoids. The screening was conducted using colorimetric reactions with specific reagents.

For flavonoid detection, 1 mL of sample extract was mixed with 1 mL of 2% sodium hydroxide solution. The formation of an intense yellow color that faded after the addition of 2 M hydrochloric acid indicated the presence of flavonoids (Ain et al., 2024). Alkaloids were detected by adding several drops of Mayer's or Dragendorff's reagent to 1 mL of sample extract. The formation of a yellowish-white or orange precipitate indicated the presence of alkaloids (Quirós-Cubillo et al., 2025).

Saponins were identified by adding 5 mL of distilled water to 1 mL of sample extract in a test tube, followed by vigorous shaking for 15–20 s. The formation of stable foam persisting for more than 10 min indicated the presence of saponins (Mujahidah et al., 2026). Quinones were detected by mixing 1 mL of extract with 1 mL of 10% sodium hydroxide solution. The appearance of yellow or orange coloration that disappeared after the addition of hydrochloric acid indicated the presence of quinones (Mutombo et al., 2026).

Tannins were detected by adding several drops of 1% ferric chloride solution to 1 mL of extract. A dark blue, green, or black coloration indicated the presence of tannins (Palacios et al., 2021). Steroids and triterpenoids were evaluated by mixing 1 mL of extract with 1 mL of glacial acetic acid, followed by the careful addition of one drop of concentrated sulfuric acid along the inner wall of the test tube. The formation of a red, purple, or green ring at the interface indicated the presence of steroids or triterpenoids (Hasballah et al., 2021).

2.3. Facial wash formulation and preparation

Three facial wash formulations were prepared using identical concentrations of active ingredients, namely *M. oleifera* leaf extract and *S. lycopersicum* fruit extract at 3% each. The differences among Formula 1, Formula 2, and Formula 3 were based on variations in excipient composition, particularly Plantacare, glycerin, DMDM hydantoin, and Na-EDTA, as shown in **Table 1**.

Formula 1 contained the lowest Plantacare concentration, 1%, and glycerin as the main humectant, without DMDM hydantoin or Na-EDTA. Formula 2 contained an intermediate Plantacare concentration, 3%, and DMDM hydantoin as a preservative, without glycerin or Na-EDTA. Formula 3 contained the highest Plantacare concentration, 5%, and Na-EDTA as a chelating agent, without glycerin or DMDM hydantoin. These formulation variations were designed to evaluate the influence of excipient composition on the physicochemical properties of the facial wash.

Facial wash preparation was initiated by dispersing Viscolam AT 100 in a small amount of distilled water. Propylene glycol and glycerin were then added gradually while mixing with a homogenizer at a controlled speed until a uniform base was obtained. *M. oleifera* leaf extract and *S. lycopersicum* fruit extract were incorporated into the base and homogenized to ensure uniform dispersion of the active ingredients. Potassium hydroxide (KOH) was added as an alkalizing agent according to the formulation composition, followed by the addition of Na-EDTA and DMDM hydantoin until homogeneous. TEA was added at the final stage to adjust the formulation and support the formation of a thick facial wash preparation. Each formulation was prepared as a 150 g batch, and all ingredient compositions are expressed as % w/w. (Hyachinta et al., 2025).

2.4. Physicochemical evaluation

The facial wash formulations were evaluated for organoleptic properties, pH, foaming ability, viscosity, and free alkali content to determine their physicochemical suitability as cosmetic cleansing preparations. All quantitative physicochemical measurements were performed in triplicate, and the results are presented as mean ± standard deviation where applicable.

Organoleptic properties were evaluated by observing the color, texture, and aroma of each formulation. This evaluation was performed to assess the general physical appearance and cosmetic acceptability of the facial wash (Wulandini et al., 2019).

The pH of each formulation was measured using a calibrated pH meter. The instrument was calibrated using standard buffer solutions at pH 4, 7, and 10 before measurement. A 1 mL sample of facial wash was diluted with 10 mL of distilled water, and the pH value was recorded. The acceptable pH range for cosmetic cleansing products according to the Indonesian National Standard is generally 4–10, depending on formulation type (Khesina et al., 2021).

Foaming ability was evaluated by weighing 1 g of formulation into a test tube and adding 10 mL of distilled water. The mixture was shaken until homogeneous and allowed to stand for 5 min, after which the foam height was measured. Based on the Indonesian National Standard, the acceptable foam height range is 0.13–2.2 cm (Belal et al., 2022).

Viscosity was measured using a Brookfield viscometer equipped with an L4 spindle. A total of 100 mL of sample was placed in the viscometer chamber, ensuring that the spindle was fully immersed. The measurement speed was adjusted according to predetermined settings, and the viscosity value was recorded after a stable reading was obtained. According to the Indonesian National Standard, the acceptable viscosity range for cosmetic formulations is 3,000–50,000 cPs (Yuniarsih et al., 2021).

Free alkali content was determined by dissolving the sample in distilled water and adding several drops of phenolphthalein indicator. The solution was titrated with 0.1 N hydrochloric acid until the pink color disappeared, indicating the titration endpoint. The volume of acid used was recorded, and the free alkali content was calculated using the following equation:

$$\text{Free alkali (\%)} = (V \times N \times 0.04 / W) \times 100$$

Where V is the volume of HCl used (mL), N is the normality of HCl, and W is the sample weight (g). The calculation was performed to determine the amount of unneutralized alkaline substances in the formulation. (Traynor et al., 2020).

Table 1. Composition of herbal facial wash formulations containing *Moringa oleifera* and *Solanum lycopersicum* extracts

Ingredient	Function	F1 (%)	F2 (%)	F3 (%)
Moringa oleifera leaf extract	Active ingredient	3	3	3
Solanum lycopersicum fruit extract	Active ingredient	3	3	3
KOH	Alkalizing agent	4	4	4
Plantacare® 1200 UP	Surfactant	1	3	5
Viscolam AT 100	Gelling agent	8	8	8
Propylene glycol	Humectant	3	3	3
Glycerin	Humectant	17.5	—	—
DMDM hydantoin	Preservative	—	0.1	—
Na-EDTA	Chelating agent	—	—	0.14
TEA	Alkalizing agent	q.s.	q.s.	q.s.
Distilled water	Solvent	ad 100	ad 100	ad 100
Total		100	100	100

Note: q.s. = quantum satis; ad 100 = added to 100%. All formulation percentages are expressed as % w/w according to the original formulation table.

2.5. Thin-layer chromatography analysis

Thin-layer chromatography was performed to compare the chromatographic profiles of the extracts and the formulated product. Silica gel 60 F254 TLC plates (Merck KGaA, Darmstadt, Germany) were used as the stationary phase, and chloroform (9:1, v/v) was used as the mobile phase. Prior to development, the TLC chamber was saturated with the mobile phase vapor for 30 min. Sample solutions were prepared by dissolving 500 mg of sample in 2.5 mL solvent to obtain a concentration of 200 mg/mL. The samples were applied onto the TLC plates using a capillary tube with approximately four spotting applications per sample. The plates were developed to a distance of 7 cm, with the spotting line positioned 1 cm from the lower edge of the plate and the solvent front terminated 0.5 cm below the upper edge. After development, the plates were removed, air-dried, and observed visually and under UV light at 254 and 366 nm. The plates were then sprayed with citroboric reagent, and the resulting color changes were observed (Jović et al., 2023).

2.6. Antioxidant activity assay

Antioxidant activity was evaluated qualitatively using thin-layer chromatography–DPPH detection and quantitatively using the DPPH radical-scavenging assay, with vitamin C as the reference standard. For the qualitative assay, the sample was applied to a thin-layer chromatography plate, developed, and sprayed with DPPH solution. The appearance of bleached or yellowish spots indicated the presence of antioxidant compounds.

For the quantitative assay, *M. oleifera* leaf extract was tested at concentrations of 10, 12.5, 15, 17.5, 20, and 22.5 µg/mL, while *S. lycopersicum* fruit extract was tested at concentrations of 10, 20, 30, 40, 50, and 60 µg/mL. Formula 3 was tested at concentrations of 20, 30, 40, 50, 60, and 70 µg/mL. Sample solutions were reacted with 0.1 mM DPPH solution and incubated for 30 min at room temperature. Absorbance was measured at 517 nm using a UV–Vis spectrophotometer. The percentage of inhibition was calculated using the following equation:

$$\% \text{ inhibition} = [(\text{Abs control} - \text{Abs sample}) / \text{Abs control}] \times 100$$

Where Abs control represents the absorbance of the DPPH control solution and Abs sample represents the absorbance of the test sample. IC_{50} values were determined using linear regression analysis between sample concentration and percentage inhibition. A lower IC_{50} value indicates stronger radical-scavenging activity. (Jović et al., 2023; Pratama et al., 2025; Sriwidodo et al., 2022).

2.7. Statistical analysis

Data are presented as mean ± standard deviation (SD), where applicable. Physicochemical parameters, including pH, foam height, viscosity, and free alkali content, were descriptively evaluated against relevant quality requirements for cosmetic cleansing products. Antioxidant activity was determined using the DPPH assay, and IC_{50} values were calculated from the inhibition curve. Prior to inferential analysis, data normality and homogeneity of variance were assessed using the Shapiro–Wilk and Levene's tests, respectively. Differences in IC_{50} values among *M. oleifera* leaf extract, *S. lycopersicum* fruit extract, and Formula 3 were analyzed using one-way ANOVA followed by Tukey's post-hoc test. A value of $p < 0.05$ was considered statistically significant. Significant differences among groups are indicated using different lowercase letters.

3. RESULTS AND DISCUSSION

3.1. Phytochemical profile and relevance to formulation

Phytochemical screening showed that both *M. oleifera* leaf extract and *S. lycopersicum* fruit extract contained flavonoids, alkaloids, saponins, quinones, tannins, and steroids/triterpenoids (**Table 2**). The presence of these metabolite groups is relevant to the development of herbal facial wash formulations because several of them, particularly flavonoids, phenolic-related compounds, and carotenoid-associated constituents, are commonly associated with antioxidant activity and skin-protective potential (Ain et al., 2024). These results provided an initial chemical basis for incorporating both extracts into the facial wash system and for evaluating their antioxidant activity after formulation.

The comparable phytochemical profiles of both extracts suggest that the formula combined materials with overlapping but potentially complementary bioactive characteristics. In the context of facial wash development, this finding is important because the formulation process should ideally retain the detectable constituents of the extracts while producing acceptable physical properties. Therefore, the subsequent formulation evaluation focused not only on physicochemical parameters but also on chromatographic profile and antioxidant activity.

3.2. Physicochemical characteristics of facial wash formulations

The physicochemical characteristics of the three facial wash formulations are presented in **Table 3**. All formulas showed a slightly brownish color, characteristic extract odor, and thick but slightly fluid consistency. These similar organoleptic characteristics indicate that the variation in excipient composition did not substantially alter the visible appearance or aroma of the preparations. The brownish color and extract-like odor were likely influenced by the incorporated plant extracts, while the thick fluid consistency reflected the contribution of the gelling and surfactant system (Yuniarsih et al., 2021; Marlina et al., 2022).

The pH values ranged from 8.69 to 8.83 and remained within the SNI reference range for liquid soap products. Although the formulations were slightly alkaline, the values were still within the stated acceptance range for cleansing products. Among the three formulas, Formula 3 showed the lowest pH value, which may be preferable for further development because facial cleansing products should minimize excessive alkalinity to reduce the potential for skin discomfort.

Table 2. Phytochemical screening results of *Moringa oleifera* leaf extract and *Solanum lycopersicum* fruit extract

Compound group	*M. oleifera* leaf extract	*S. lycopersicum* fruit extract
Flavonoids	(+)	(+)
Alkaloids	(+)	(+)
Saponins	(+)	(+)
Quinones	(+)	(+)
Tannins	(+)	(+)
Steroids/triterpenoids	(+)	(+)

Note: (+) = detected.

Table 3. Physicochemical evaluation of facial wash formulations containing *Moringa oleifera* and *Solanum lycopersicum* extracts

Parameter	Formula 1	Formula 2	Formula 3	Reference
Color	Slightly brownish	Slightly brownish	Slightly brownish	-
Odor	Extract-like	Extract-like	Extract-like	-
Physical form	Thick, slightly fluid	Thick, slightly fluid	Thick, slightly fluid	-
pH	8.83 ± 0.020	8.77 ± 0.026	8.69 ± 0.026	4–10 (SNI)
Viscosity (cPs)	3856.67 ± 49.33	2526.67 ± 236.92	1933.33 ± 5.77	3000–50,000 cPs (SNI)
Foam height (cm)	16.56 ± 4.42	13.36 ± 5.79	8.59 ± 1.72	0.13–2.2 cm (SNI)
Free alkali (%)	0.95	0.91	0.88	<0.1%

The viscosity results showed clear differences among formulas. Formula 1 met the SNI viscosity range, whereas Formula 2 and Formula 3 were below the recommended lower limit of 3000 cPs. The decrease in viscosity from Formula 1 to Formula 3 indicates that changes in excipient composition influenced the internal structure and flow behavior of the preparation. Formula 3 had the lowest viscosity, which may improve ease of spreading and dispensing, but also indicates that additional rheological adjustment may be required if the formulation is intended to meet the specified viscosity standard (Wijaya et al., 2024).

Foam height also decreased from Formula 1 to Formula 3. Formula 1 produced the highest foam height, followed by Formula 2 and Formula 3. This trend may be related to the increasing Plantacare concentration and differences in supporting excipients, although the measured foam values remained above the SNI reference range shown in Table 3. High foam formation may support consumer perception of cleansing performance, but excessive foam is not always necessary for mild facial cleansing. Therefore, the foam profile should be interpreted together with other quality parameters rather than as an isolated indicator of formulation performance (Belal et al., 2022).

Free alkali content exceeded the recommended SNI threshold of <0.1% in all formulations. This is a critical formulation issue because residual alkalinity may affect skin compatibility and increase the risk of irritation. Among the three formulas, Formula 3 showed the lowest free alkali value, although it still remained above the recommended limit. These findings indicate that further optimization of neutralization conditions is required, particularly to reduce residual alkaline components and improve suitability for facial application.

Formula 3 was selected for subsequent chromatographic and antioxidant evaluation because it showed the lowest pH, foam height, and free alkali value among the three formulations. However, this selection should be interpreted as a preliminary formulation choice rather than evidence that the formula fully met all cosmetic quality requirements. The viscosity, foam height, and free alkali results indicate that further refinement is still needed before the formulation can be considered fully compliant with the referenced standards.

3.3. TLC profile of extracts and selected formulation

Thin-layer chromatography was performed to evaluate whether the main detectable constituents of the extracts remained observable after formulation. The TLC profiles of *M. oleifera* leaf extract, *S. lycopersicum* fruit extract, and Formula 3 are shown in Figure 1. Spots were observed under visible light, UV 254 nm, and UV 366 nm, and yellow fluorescent spots appeared after spraying with citroboric reagent. This response supports the presence of flavonoid-type compounds in the extracts and selected formulation (Saepudin et al., 2024).

The similarity between the extract profiles and the selected formulation indicates that the formulation process did not eliminate the major TLC-detectable constituents. The major fluorescent band observed after citroboric reagent derivatization appeared at an approximate Rf value of 0.5, which is consistent with flavonoid-type compounds commonly reported in *M. oleifera* leaf extracts (Saepudin et al., 2024). This finding supports the interpretation that bioactive constituents remained detectable in the formulated product.

The retention of comparable TLC bands is relevant because formulation processes may affect the stability or detectability of plant-derived compounds. In this study, the TLC results suggest that the selected facial wash matrix was able to retain detectable phytochemical constituents after incorporation of the extracts. This observation provides a chemical basis for the antioxidant activity measured in the subsequent DPPH assay, although TLC

remains a qualitative method and cannot confirm compound concentration or structural identity (Musakhanian et al., 2022).

3.4. Antioxidant activity

The antioxidant activity of *M. oleifera* leaf extract, *S. lycopersicum* fruit extract, and Formula 3 was evaluated using the DPPH method, and the IC_{50} values are presented in **Figure 2**. *M. oleifera* leaf extract showed the lowest IC_{50} value, 30.891 ± 0.40 µg/mL, indicating the strongest antioxidant activity among the tested samples. This result is consistent with the phytochemical screening, which detected flavonoids and other secondary metabolites that may contribute to radical-scavenging activity.

S. lycopersicum fruit extract showed an IC_{50} value of 50.532 ± 0.92 µg/mL, which was higher than that of *M. oleifera* leaf extract. This difference may reflect differences in dominant antioxidant constituents between the two extracts. Tomato-derived materials are commonly associated with carotenoid-based antioxidant activity, whereas *M. oleifera* leaves contain flavonoids and phenolic-related constituents that may show stronger radical-scavenging performance under the DPPH assay conditions (Salsabilla et al., 2024).

Formula 3 had an IC_{50} value of 46.350 ± 0.08 µg/mL. This value was higher than that of *M. oleifera* leaf extract but lower than that of *S. lycopersicum* fruit extract. The result indicates that antioxidant activity was retained after formulation, although the activity was not equivalent to the strongest individual extract. This reduction is reasonable because the active extracts were incorporated into a formulation matrix and may have been diluted or partially affected by interactions with excipients.

The relatively small standard deviation in Formula 3 indicates consistent measurement in the antioxidant assay. Previous studies have reported lower IC_{50} values for vitamin C using the DPPH method, indicating that the extracts and formulated product were less active than the reference antioxidant but still showed measurable radical-scavenging activity (Fatmawati et al., 2020; Pratama et al., 2025). The antioxidant activity observed in the selected formulation may be influenced by the combined contribution of phytochemicals from both extracts and their retention within the formulation matrix.

Overall, the results show that *M. oleifera* and *S. lycopersicum* extracts can be incorporated into a facial wash while retaining detectable phytochemical constituents and measurable antioxidant activity. However, the physicochemical evaluation also indicates important formulation limitations, particularly free alkali content, foam height, and viscosity. Therefore, further optimization is required before the product can be considered suitable for broader cosmetic application. Future work should include refinement of neutralization conditions, viscosity adjustment, microbial stability testing, skin irritation evaluation, and longer-term stability studies to better establish product safety and performance (Abidin et al., 2024; Marlina et al., 2022; Zeng et al., 2020).

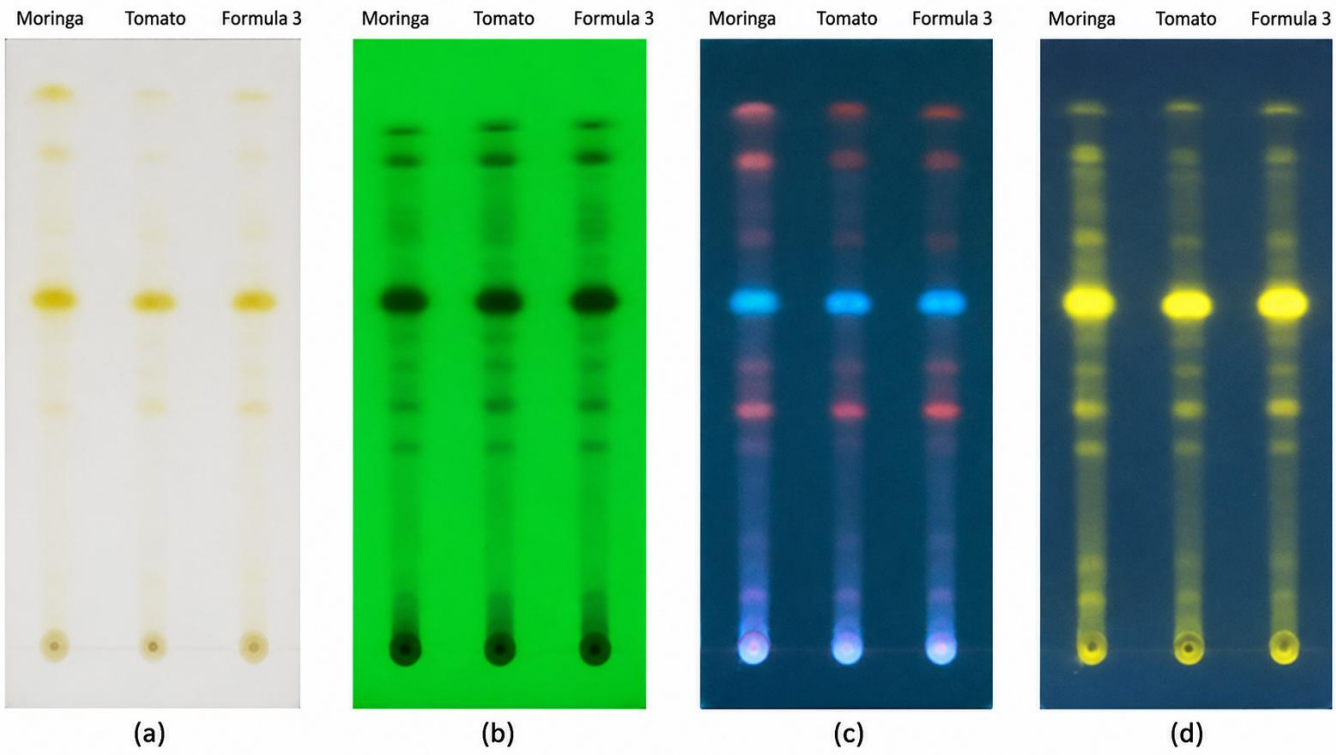

Figure 1. TLC profiles of *Moringa oleifera* leaf extract, *Solanum lycopersicum* fruit extract, and Formula 3: (a) visual appearance, (b) spots under UV 254 nm, (c) spots under UV 366 nm, and (d) after spraying with citroboric reagent

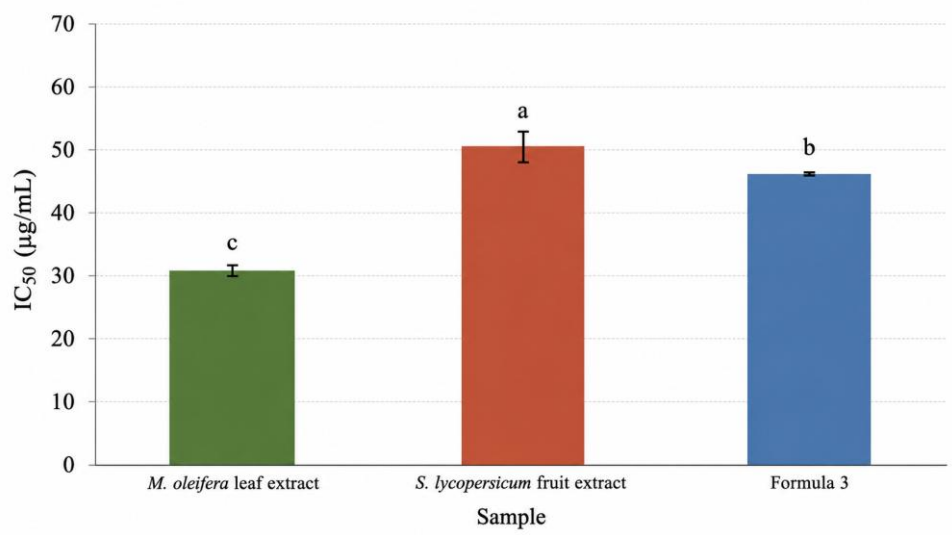

Figure 2. Antioxidant activity of extracts and Formula 3. IC_{50} values were determined using the DPPH assay and are presented as mean ± SD. Lower IC_{50} values indicate stronger antioxidant activity. Different letters indicate significant differences among groups based on Tukey's post-hoc test ($p < 0.05$).

4. CONCLUSION

This study showed that *M. oleifera* leaf extract and *S. lycopersicum* fruit extract contained several groups of secondary metabolites, including flavonoids, alkaloids, saponins, quinones, tannins, and steroids/triterpenoids. The incorporation of both extracts into a facial wash formulation retained measurable antioxidant activity, with the selected formula showing an IC_{50} value of 46.350 ± 0.08 µg/mL. Thin-layer chromatography indicated that detectable flavonoid-related bands remained present in the selected formulation. Differences in excipient composition influenced the physicochemical properties of the facial wash, particularly viscosity, foam height, and free alkali content. Among the tested formulations, Formula 3 showed relatively better overall characteristics; however, the free alkali content remained above the recommended limit and requires further optimization. These findings indicate that *M. oleifera* and *S. lycopersicum* extracts can be incorporated into a facial wash system, but formulation refinement is still needed to improve compliance with cosmetic quality and safety requirements.

AUTHOR CONTRIBUTIONS

Conceptualization, R.P. and N.D.S.; methodology, N.D.S. and R.P.; software, S.S.; validation, R.P., N.D.S., M.S., and S.S.; formal analysis, R.P.; investigation, R.P. and S.S.; resources, N.D.S.; data curation, R.P.; writing—original draft preparation, R.P.; writing—review and editing, N.D.S.; visualization, R.P.; supervision, N.D.S.; project administration, R.P.; funding acquisition, N.D.S. All authors have read and agreed to the published version of the manuscript.

INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable. This study did not involve human participants.

DATA AVAILABILITY STATEMENT

Data supporting the findings of this study are available upon reasonable request from the corresponding author.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

DECLARATION OF GENERATIVE ARTIFICIAL INTELLIGENCE (AI) USE

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with grammar checking and language refinement. After using this tool, the authors carefully reviewed, edited, and verified the content to ensure that it accurately represents their own data, analysis, and interpretation. The authors take full responsibility for the integrity, accuracy, and originality of the manuscript.

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