Indonesian Journal of Cosmetic
E-ISSN: 3026-3352

Formulation, Physicochemical Characterization, and Stability Assessment of a *Moringa oleifera* Leaf Extract Serum Gel

Agitha Casanova Capah[1]*, Aida Febina Soleha[1], Chika Ari Dinar Rorensya[1], Herayati[1]

1. Department of Cosmetic Engineering, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Kec. Jati Agung, Kabupaten Lampung Selatan, Lampung 35365

***Corresponding Email: aida.122500039@student.itera.ac.id**

ABSTRAK

Moringa oleifera leaves have attracted considerable interest as a natural source of bioactive compounds for cosmetic applications because of their antioxidant and antimicrobial properties. This study aimed to develop and evaluate a gel serum containing *M. oleifera* leaf extract as a natural skincare formulation with desirable physicochemical properties and storage stability. The leaves were extracted by maceration using 96% ethanol, and the resulting extract was subjected to qualitative phytochemical screening before incorporation into a gel serum formulation containing glycerin, butylene glycol, hyaluronic acid, and niacinamide. The formulated gel serum was evaluated for its organoleptic characteristics, homogeneity, pH, viscosity, and physical stability under storage at 25°C and 40°C for one month. Phytochemical screening confirmed the presence of flavonoids, steroids, tannins, and saponins, whereas alkaloids were not detected. The developed gel serum exhibited a homogeneous appearance, a skin-compatible pH of 5.35, and viscosities of 420 and 303 mPa·s at 30 and 60 rpm, respectively, while maintaining good physical stability under both storage conditions. These findings suggest that *M. oleifera* leaf extract is a promising natural bioactive ingredient for stable and multifunctional serum formulations and warrants further investigation regarding long-term stability, skin compatibility, and clinical efficacy.

Keywords: *Moringa oleifera* extract; gel serum; cosmetic; stability; antibacterial.

1. PENDAHULUAN

The cosmetic and skincare industry has experienced substantial growth in recent years, driven by increasing public awareness of the importance of skin health and personal care. One of the most prominent trends is the growing demand for natural ingredients in skincare formulations, as they are generally perceived to be safer, more sustainable, and environmentally friendly. Among the promising botanical resources, *Moringa oleifera* leaf extract has attracted considerable attention due to its wide range of biological activities and potential applications in cosmetic products (Hossain et al., 2020). *M. oleifera* leaves are rich in bioactive compounds, including flavonoids, phenolic acids, vitamin C, and essential oils, which exhibit potent antioxidant, anti-inflammatory, antibacterial, and antimicrobial properties (Bhat et al., 2019; Rani et al., 2021). Consequently, *M. oleifera* leaf extract has emerged as a promising natural ingredient for the development of skincare products, particularly facial serums.

Serum is a cosmetic formulation characterized by a higher concentration of active ingredients than conventional creams or lotions, enabling enhanced delivery of bioactive compounds into the deeper layers of the skin. Due to this property, serums are widely used to address various skin concerns, including premature aging, hyperpigmentation, and dull skin (Zhang et al., 2022). The selection of appropriate active ingredients is therefore essential to ensure both the efficacy and safety of serum formulations. *M. oleifera* leaf extract represents a valuable candidate because its phytochemical constituents have been reported to protect the skin against oxidative stress, reduce inflammation, and stimulate collagen synthesis (Singh et al., 2020).

Despite its considerable potential, developing an optimal serum formulation containing *M. oleifera* extract remains challenging. One of the major issues associated with natural ingredient-based cosmetics is maintaining product stability throughout storage. Serum stability is influenced by multiple factors, including pH, viscosity, temperature, and interactions between the active compounds and excipients (Huang et al., 2020). Therefore, this study aims to determine the optimal formulation of *M. oleifera* leaf extract serum by evaluating its physicochemical characteristics and storage stability.

The physicochemical properties of serum, including pH, viscosity, color, and odor, are critical quality parameters that determine product performance and consumer acceptance. An appropriate pH ensures compatibility with the skin and minimizes irritation, while suitable viscosity influences product spreadability, ease of application, and overall user experience (Li et al., 2021). Furthermore, changes in color or odor may indicate degradation of bioactive compounds or incompatibility among formulation components, making these characteristics important indicators of formulation stability (Bera et al., 2020).

In addition to physicochemical properties, long-term stability is an essential aspect of serum quality. Instability may result in undesirable physical or chemical changes that compromise both the effectiveness and safety of the product. Factors such as light exposure, storage temperature, and pH fluctuations can accelerate degradation processes during storage (Savić et al., 2020). Accordingly, this study will evaluate the stability of *M. oleifera* leaf extract serum under different storage conditions to ensure that the formulation maintains its quality and therapeutic potential throughout its shelf life.

Previous studies have extensively investigated the biological activities of *M. oleifera* in skincare applications; however, relatively few have focused specifically on optimizing serum formulations containing *M. oleifera* leaf extract. Pustokhina et al. (2021) demonstrated that *M. oleifera* extract promotes skin regeneration and alleviates inflammation, while Arumugam et al. (2021) emphasized the importance of stability testing in cosmetic formulations containing natural ingredients, as these materials are generally more susceptible to degradation than synthetic compounds.

The development of a stable and effective serum formulation also requires careful selection of carrier materials and preservatives. Carrier agents facilitate the dissolution and delivery of active compounds, whereas preservatives are essential for preventing microbial contamination that may compromise product quality and safety (Ibrahim et al., 2020). Therefore, this study will investigate suitable carrier materials, including glycerin, propylene glycol, and vegetable oils, to improve the stability and efficacy of *M. oleifera* leaf extract in serum formulations.

Another important aspect of formulation development is determining the optimal concentration of *M. oleifera* leaf extract. The concentration of the extract directly influences both the biological efficacy and the physical stability of the final product (Rani et al., 2021). Sahu et al. (2019) reported that *M. oleifera* extract at appropriate concentrations significantly enhances skin hydration and reduces signs of aging. Therefore, identifying an optimal concentration is essential to maximize therapeutic benefits while minimizing the risk of skin irritation.

Furthermore, stability evaluation under different storage conditions constitutes an integral part of this research. Serum samples will be stored under various temperature and humidity conditions to assess the effects of environmental factors on product quality over time. Kumar et al. (2021) reported that exposure to fluctuating temperatures or direct sunlight can substantially reduce serum quality, ultimately affecting its efficacy and consumer acceptability.

The findings of this study are expected to provide an optimized *M. oleifera* leaf extract serum formulation that is both effective for skincare applications and stable during long-term storage. Such a formulation has the potential to serve as a natural and sustainable alternative in cosmetic products while meeting consumer demand for safe and environmentally friendly skincare solutions. Moreover, this research is anticipated to contribute to the advancement of green cosmetic formulations in line with the global trend toward the utilization of plant-based ingredients in the cosmetic industry (Manzoor et al., 2021).

Overall, this study aims to identify the optimal formulation of *M. oleifera* leaf extract serum by focusing on its physicochemical characteristics, formulation stability, and product performance. The results are expected to provide a scientific basis for the development of safe, stable, and effective natural skincare products. Several physicochemical parameters, including pH, viscosity, color, and stability under different storage conditions, will be systematically evaluated to ensure the quality and efficacy of the developed serum formulation.

.

2. METODE PENELITIAN

This study employed an experimental approach to determine the optimal formulation of *Moringa oleifera* leaf extract serum based on its physicochemical characteristics and product stability. *M. oleifera* leaves were extracted using the maceration method with 70% ethanol as the extraction solvent for 48 h, with intermittent stirring to maximize the extraction of bioactive compounds. The resulting extract was filtered and concentrated using a rotary evaporator to obtain a viscous crude extract for serum formulation (Bhat et al., 2019). The serum formulations were prepared by incorporating *M. oleifera* leaf extract into a carrier system consisting of glycerin, propylene glycol, and distilled water, together with appropriate preservatives and stabilizing agents to ensure product quality and shelf life (Hossain et al., 2020). Three formulations with different extract concentrations were developed, namely Formula A (5% *M. oleifera* extract), Formula B (7%), and Formula C (10%), to identify the most suitable formulation in terms of both product perfomance and stability.

The formulated serums were subsequently evaluated for several physicochemical characteristics, including pH, viscosity, color, and odor. The pH of each formulation was measured using a calibrated pH meter to ensure compatibility with the physiological pH of human skin (4.5–6.5) (Zhang et al., 2022). Viscosity was determined using a viscometer, as this parameter influences the spreadability and ease of application of the serum (Li et al., 2021). Color measurements were performed using a spectrophotometer, while odor was assessed through sensory evaluation to detect any changes that might indicate degradation or instability of the active ingredients (Bera et al., 2020).

The stability of the serum formulations was evaluated to determine their ability to maintain physicochemical integrity during storage. The formulations were stored under three different temperature conditions: room temperature (25°C), refrigerated conditions (4°C), and accelerated conditions (40°C) for a period of 12 weeks. Stability assessments were conducted at monthly intervals by monitoring changes in pH, viscosity, color, and potential microbiological contamination that could affect product quality and safety (Savić et al., 2020). This stability study aimed to verify whether the formulated serums remained effective and safe throughout storage and to identify the formulation exhibiting the greatest stability under various storage conditions (Kumar et al., 2021).

The results of the physicochemical characterization and stability evaluation were analyzed descriptively to determine the optimal serum formulation. The selected formulation was defined as the one exhibiting the most favorable physicochemical properties, acceptable stability throughout the storage period, and the highest potential for cosmetic application.

3. RESULTS AND DISCUSSION

3.1. Phytochemical screening of Moringa oleifera leaf extract

Qualitative phytochemical screening revealed that the ethanol extract of Moringa oleifera leaves contained flavonoids, steroids, tannins, and saponins, whereas alkaloids were not detected (Table 2). The presence of these secondary metabolites confirms that ethanol is an effective extraction solvent for recovering bioactive compounds with potential cosmetic applications.

Table 1 Phytochemical screening results

Parameters	**Results**

Alkaloid	-
Flavonoid	+
Steroid	+
Tanin	+
Saponin	+

Flavonoids are among the major phytochemicals responsible for the antioxidant activity of M. oleifera. These compounds are capable of scavenging reactive oxygen species (ROS) and inhibiting oxidative stress, thereby protecting skin cells from premature aging induced by ultraviolet radiation and environmental pollutants. Their antioxidant capacity also contributes to maintaining skin elasticity and preventing collagen degradation.

Steroids detected in the extract may contribute to anti-inflammatory activity by modulating inflammatory responses in the skin. This property is particularly beneficial for cosmetic formulations intended for sensitive or acne-prone skin, where inflammation plays an important role in skin disorders. Meanwhile, tannins possess astringent properties that may improve skin firmness, reduce excessive sebum production, and enhance pore-tightening effects. These characteristics make tannins attractive ingredients for facial skincare products.

The presence of saponins further increases the cosmetic value of the extract because these compounds exhibit natural cleansing, antimicrobial, and surface-active properties. Saponins may assist in reducing microbial colonization on the skin while improving the spreadability of topical formulations. Conversely, the absence of alkaloids may be advantageous for topical cosmetic applications because several alkaloids are known to cause skin irritation or toxicity at relatively high concentrations.

Overall, the phytochemical profile suggests that M. oleifera leaf extract contains multiple classes of bioactive compounds that may act synergistically to provide antioxidant, anti-inflammatory, antimicrobial, and skin-conditioning effects. These multifunctional properties support the suitability of the extract as a natural active ingredient for gel serum formulations.

3.2. Physicochemical characteristics of the gel serum

The formulated gel serum exhibited desirable physicochemical characteristics, including a clear appearance, vanilla odor, homogeneous texture, pH of 5.35, and viscosities of 420 and 303 mPa·s at rotational speeds of 30 and 60 rpm, respectively (Table 3). These characteristics indicate that the formulation met the basic quality requirements for topical cosmetic products.

Table 2 physicochemical characteristics of gel serum

Parameter	Results
Color	Colourless
Aroma	Vanilla
pH	5.35
Viscocity (30 rpm)	420 mPa.s
Viscocity (60 rpm)	303 mPa.s
Homogenity	Homogen
Stability	Remained Stable

The formulation exhibited a clear appearance without visible precipitation or phase separation, indicating good compatibility among the formulation components. Such physical clarity reflects the successful incorporation of the M. oleifera extract into the gel matrix and suggests adequate dispersion of both active and inactive ingredients. The vanilla odor effectively masked the characteristic herbal odor of the extract, which may improve consumer acceptance and overall sensory quality.

The measured pH of 5.35 falls within the physiological pH range of healthy human skin (approximately 4.5–5.5). Maintaining a skin-compatible pH is essential because it preserves the integrity of the skin barrier, supports the natural microbiome, and minimizes the risk of irritation during repeated application. Therefore, the formulated gel serum is considered suitable for topical use.

Viscosity values decreased from 420 mPa·s at 30 rpm to 303 mPa·s at 60 rpm, indicating shear-thinning (pseudoplastic) flow behavior. This rheological property is highly desirable in cosmetic serum formulations because the viscosity decreases during application, allowing the product to spread easily over the skin, while recovering its consistency after application to prevent excessive runoff. Such behavior improves user comfort and enhances product performance.

The gel serum also demonstrated excellent homogeneity without visible aggregates or coarse particles, suggesting that the active ingredients were uniformly distributed throughout the formulation. Uniform dispersion is important for ensuring dose consistency and maintaining product efficacy during use.

Furthermore, the formulation remained physically stable throughout the evaluation period without observable changes in appearance, homogeneity, or phase separation. The stability of the formulation indicates that the selected combination of carbomer, humectants, preservatives, and active ingredients successfully maintained the structural integrity of the gel system. Stable formulations are essential for extending product shelf life and preserving both efficacy and consumer acceptability.

Collectively, these findings demonstrate that the developed M. oleifera gel serum possesses favorable physicochemical properties suitable for cosmetic applications. The combination of appropriate pH, desirable rheological behavior, homogeneity, and physical stability indicates that the formulation has strong potential for further product development and commercialization.

4. Conclusion

This study demonstrated that *Moringa oleifera* leaf extract can be successfully formulated into a gel serum with desirable physicochemical properties and satisfactory storage stability. The developed formulation exhibited an appropriate skin-compatible pH, acceptable viscosity, good homogeneity, and maintained its physical integrity under both ambient (25°C) and accelerated (40°C) storage conditions, indicating its suitability for topical cosmetic applications.

The phytochemical profile of the extract, characterized by the presence of flavonoids, tannins, steroids, and saponins, further supports its potential as a multifunctional cosmetic ingredient. These bioactive constituents, together with the favorable physicochemical characteristics of the formulation, suggest that *M. oleifera* gel serum is a promising natural skincare product with potential to protect the skin against oxidative stress while maintaining formulation quality and stability.

REFERENCES

Arumugam, A., et al. (2021). "Formulation and Stability of Natural Cosmetics: An Overview." Journal of Cosmetic Dermatology, 20(1), 34-45.

Banerjee, S., Patel, D., & Kaur, R. (2021). "Potential of Natural Products in Skin Care: Antibacterial Properties of Moringa oleifera." Cosmetic Dermatology, 45(2), 65-73.

Bera, T., et al. (2020). "The Stability and Effectiveness of Plant-Based Cosmetic Formulations." International Journal of

Cosmetic Science, 42(2), 156-162.

Bhat, T. A., et al. (2019). "Bioactive Compounds of Moringa oleifera: Pharmacological Perspectives." Phytochemistry Reviews, 18(1), 97-113.

Chandra, S., Mehta, S., & Soni, R. (2022). "Eco-friendly Alternatives in Cosmetics: The Role of Moringa oleifera in Sustainable Beauty Care." Journal of Sustainable Cosmetics, 14(1), 12-19.

Dua, R., Rathi, A., & Lamba, D. (2022). "Saponins and Their Role in Skin Protection." International Journal of Herbal Medicine, 8(3), 45-52.

Fadilah, N., & Hasan, H. (2020). "Optimization of Extraction Methods for Moringa oleifera Leaves: A Review." Asian Journal of Herbal Medicine, 16(4), 51-57.

Ghojogh, B., Yeganeh, M., & Habibi, S. (2020). "Moringa oleifera: An Emerging Source of Antioxidants and Anti-inflammatory Compounds." Journal of Phytochemistry, 22(6), 122-134.

Hassan, A., Ahmad, M., & Rafiq, M. (2020). "Bioactive Compounds of Moringa oleifera Leaves and Their Cosmetic Applications." Journal of Medicinal Plants Research, 12(4), 157-165.

Hossain, M. A., et al. (2020). "Moringa oleifera as a Cosmetic Ingredient: Benefits and Challenges." Phytotherapy Research, 34(5), 1111-1120.

Huang, C., et al. (2020). "Stability of Cosmetic Formulations with Natural Ingredients." Journal of the Society of Cosmetic Chemists, 71(6), 456-467.

Ibrahim, M. A., et al. (2020). "Preservation Systems in Natural Cosmetic Formulations." International Journal of Cosmetic Science, 42(3), 273-284.

Karimi, N., Rahman, M., & Ahmad, S. (2019). "pH Balance in Skin Care Formulations and Its Importance in Dermatological Treatments." Journal of Dermatological Science, 17(3), 125-133.

Kumar, A., et al. (2021). "Impact of Storage Conditions on the Stability of Cosmetics." Journal of Applied Pharmaceutical Science, 11(7), 45-50.

Kumar, P., Saini, D., & Sharma, G. (2021). "Formulation Stability and Shelf-life of Gel-Based Cosmetic Products: An Overview." Cosmetic Dermatology Journal, 5(1), 18-26.

Li, X., et al. (2021). "Viscosity and pH in Cosmetic Formulations: Their Role in Skin Permeability." Journal of Dermatological Science, 101(1), 67-76.

Manzoor, M., et al. (2021). "Sustainability and Natural Ingredients in the Cosmetics Industry." Sustainability, 13(15), 813-822.

Mishra, M., Jha, R., & Singh, P. (2020). "Antioxidant Activity of Moringa oleifera Leaf Extract: A Review." Antioxidants & Free Radical Research, 22(1), 45-53.

Nandita, A., Prasada, A., & Rani, S. (2021). "Extraction of Bioactive Compounds from Moringa oleifera: Methods, Benefits, and Applications." International Journal of Medicinal Plants, 8(1), 65-71.

Pal, N., Kumar, S., & Gupta, A. (2020). "Effect of Temperature on the Stability of Herbal Cosmetics: A Study on Moringa oleifera Formulations." Journal of Pharmaceutical and Cosmetic Science, 72(2), 123-130.

Pereira, M., Baptista, C., & Silva, S. (2021). "Packaging Techniques for Cosmetic Products: Impact on Stability and Shelf Life." Journal of Cosmetic Science, 72(4), 295-302.

Rani, P., et al. (2021). "Evaluation of Moringa Oleifera Extract in Dermatological Applications: A Comprehensive Review." Journal of Ethnopharmacology, 269, 113715.

Sahu, N., et al. (2019). "Cosmetic Applications of Moringa Oleifera: A Review of its Benefits and Formulation Strategies." Cosmetics, 6(3), 35-45.

Sahu, N., & Soni, R. (2022). "Impact of Humidity on the Stability of Gel Formulations: Implications for Cosmetic Industry." Cosmetic Science Review, 30(3), 79-84.

Sharma, P., Kumar, A., & Singh, S. (2021). "Anti-inflammatory Properties of Moringa oleifera: A Therapeutic Approach for Skin Care." Skin Pharmacology and Physiology, 34(1), 12-18.

Shetty, P., Mishra, S., & Deshmukh, R. (2020). "Formulation and Stability Testing of Skin Care Products." Pharmaceutical Technology, 28(1), 34-42.

Singh, P., Gupta, S., & Singh, N. (2021). "Antimicrobial Properties of Moringa oleifera: A Comprehensive Review." Journal of Applied Microbiology, 129(3), 698-710.

Sudha, R., Kumar, A., & Tiwari, S. (2020). "Antibacterial Activity of Moringa oleifera Leaf Extract Against Pathogenic Microorganisms." International Journal of Microbial Research, 4(2), 155-163.

Zhang, J., et al. (2022). "Evaluation of Serum Formulations in Skin Care: Effectiveness and Stability." Journal of Cosmetic Science, 73(2), 201-210.

Zhang, L., Li, H., & Zhang, Q. (2021). "Effect of pH on the Stability of Topical Cosmetic Products." Journal of Cosmetic Dermatology, 24(6), 1123-1131.

Zhao, L., Zhang, F., & Li, H. (2021). "Flavonoid Compounds from Moringa oleifera and Their Potential for Skin Health." Antioxidants in Dermatology, 34(2), 99-108.