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Formulation and Effectiveness Study of an Organic Lotion Based on Mangosteen Peel Extract (Garcinia mangostana L.) on Skin pH

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Abstract: Mangosteen (Garcinia mangostana L.) peel extract contains xanthones, a class of bioflavonoids known for their antioxidant, antibacterial, and antiallergic properties. This study aimed to formulate an organic lotion based on mangosteen peel extract and evaluate its physical characteristics and skin pH compatibility. The lotion formulations were prepared using the following ingredients: mangosteen peel extract, tea, stearic acid, cetyl alcohol, glycerin, propyl paraben, methyl paraben, strawberry fragrance, and distilled water. The resulting product exhibited typical organoleptic properties of a lotion, including appropriate texture, color, and odor, and was classified as an oil-in-water (O/W) emulsion type. pH evaluation revealed that formulation 2 had a pH value of 5, which falls within the safe range for human skin, compared to formulation 1 (pH 4) and formulation 3 (pH 6). Therefore, formulation 2 was identified as the most suitable in terms of skin pH compatibility. However, further evaluations—including adhesion, spreadability, viscosity, microbiological, and effectiveness tests—are required before the product can be considered ready for commercialization.

Keyword: Mangosteen Peel Extracts, Xanthone, Lotion Formulation

INTRODUCTION

Indonesia is recognized as one of the world's richest countries in terms of biodiversity, offering enormous potential for the development of natural products for pharmaceutical and cosmetic applications. However, the utilization of these natural resources remains relatively limited, as their use has traditionally relied on empirical knowledge passed down through generations. Consequently, many medicinal plants have not been optimally explored for the development of safe, effective, and environmentally friendly cosmetic products (World Health Organization [WHO], 2019). One of the most promising plants is mangosteen (Garcinia mangostana L.). Besides being widely appreciated for its delicious fruit, mangosteen peel has long been used in traditional medicine to treat various ailments, including diarrhea, dysentery, vaginal discharge, tonsillitis, hemorrhoids, and oral ulcers (Tambunan, 1998; Subroto, 2008). Previous studies have also demonstrated that mangosteen peel exhibits diverse biological activities, including antioxidant, anti-inflammatory, antibacterial, antiviral, anti-aging, and

anticancer properties, making it a valuable source of bioactive compounds for pharmaceutical and cosmetic development (Obolskiy et al., 2009).

Recent scientific investigations have revealed that mangosteen peel is rich in bioactive constituents such as xanthones, anthocyanins, tannins, flavonoids, and phenolic acids. These compounds possess strong antioxidant properties capable of scavenging free radicals that contribute to cellular damage, including damage to skin cells (Pedraza-Chaverri et al., 2008; Aisha et al., 2012). Antioxidants protect biological tissues by neutralizing reactive oxygen species and inhibiting oxidative reactions that accelerate cellular deterioration (Pisoschi & Pop, 2015). Growing concerns regarding the potential toxic and carcinogenic effects associated with prolonged exposure to certain synthetic antioxidants have encouraged researchers and the cosmetic industry to seek safer alternatives derived from natural sources (Lourenço et al., 2019). Consequently, plant-based antioxidants have become increasingly attractive as sustainable, effective, and environmentally friendly ingredients for cosmetic formulations.

Human skin serves as the body's primary protective barrier against external environmental factors, including ultraviolet radiation, air pollution, microorganisms, and extreme weather conditions (Proksch et al., 2008). Continuous exposure to these factors increases the production of reactive oxygen species, resulting in oxidative stress that accelerates skin aging, reduces moisture retention, and damages collagen and other structural components of the skin (Bonté, 2019). Under normal physiological conditions, the skin is protected by an acid mantle with a pH ranging from approximately 4.5 to 5.5. This mildly acidic layer plays a crucial role in maintaining skin hydration, preserving the balance of the skin microbiome, and protecting against pathogenic microorganisms (Lambers et al., 2006). Therefore, skincare products should be formulated to preserve the skin's natural pH while enhancing its protective function.

Among various cosmetic dosage forms, lotions are widely used because of their light texture, ease of application, rapid absorption, and excellent moisturizing properties. Lotion is generally formulated as an oil-in-water (O/W) emulsion that effectively softens, smooths, and nourishes the skin (Ansel, 2014). The incorporation of naturally derived active ingredients into lotion formulations has gained increasing attention due to their superior safety profile and multiple biological activities compared with synthetic ingredients (Barel et al., 2014). Mangosteen peel extract represents a promising natural ingredient because its antioxidant and antibacterial activities may help protect the skin from oxidative damage while maintaining the physiological balance of skin pH. Therefore, developing an organic lotion based on mangosteen peel extract may provide an innovative natural skincare product capable of improving skin health and protecting the skin against free radical-induced damage.

Based on these considerations, this study was conducted to develop an optimal formulation of an organic lotion containing mangosteen (Garcinia mangostana L.) peel extract and to evaluate its effectiveness in maintaining skin pH. The study focused on determining the most appropriate lotion formulation, identifying the resulting emulsion type, and evaluating the pH characteristics of the formulated product to ensure its compatibility with the normal physiological pH of human skin (Barel et al., 2014). Specifically, this research aimed to identify the optimal formulation of an organic lotion containing mangosteen peel extract, evaluate its organoleptic characteristics and emulsion type, and determine its pH value to assess its suitability for topical application. It is expected that the findings of this study will contribute to the scientific development of natural cosmetic formulations, provide a valuable reference for future research, and promote the utilization of Indonesia's abundant biodiversity as a sustainable source of innovative, safe, and high-value cosmetic ingredients.

METHOD

Research Design

This study employed a quantitative descriptive research design, which aims to describe and analyze the research findings without making broader generalizations. The quantitative approach was selected to generate numerical data that could be statistically analyzed, thereby ensuring objective, measurable, and systematic research outcomes.

Time and Research Location

The study was conducted at the Pharmacy Laboratory, Politeknik Piksi Ganesha Bandung, Indonesia, from March 6 to June 3, 2026. All stages of the research, including lotion formulation, preparation, and laboratory evaluation, were carried out at this facility.

Research Procedure

The research consisted of the formulation of an organic lotion containing mangosteen (*Garcinia mangostana* L.) peel extract, followed by organoleptic evaluation of the prepared formulations. Three formulations were developed using different concentrations of mangosteen peel extract as the active ingredient, namely 5% (F1), 10% (F2), and 15% (F3). The lotion formulations contained triethanolamine (TEA) as the emulsifying agent, cetyl alcohol and stearic acid as the oil-phase components, glycerin as a humectant to enhance skin moisture retention, methyl paraben and propyl paraben as preservatives to maintain product stability, fragrance to improve sensory acceptability, and distilled water (aquadest) as the solvent to achieve a final volume of 100%. The composition of each formulation is presented in Table 1.

Table 1. Composition of Organic Lotion Formulations Containing Mangosteen (Garcinia mangostana L.) Peel Extract

No.	Ingredient	F1 (%)	F2 (%)	F3 (%)
1	Mangosteen peel extract	5	10	15
2	Triethanolamine (TEA)	2	2	2
3	Cetyl alcohol	4	4	4
4	Stearic acid	2.5	2.5	2.5
5	Glycerin	10	10	10
6	Propyl paraben	0.02	0.02	0.02
7	Methyl paraben	0.02	0.02	0.02
8	Fragrance	0.15	0.15	0.15
9	Distilled water	ad 100	ad 100	ad 100

Preparation Method

Equipment

The equipment used in this study included a graduated cylinder, evaporating dish, analytical balance, water bath, mortar and pestle, horn spoon, spatula, and 100 mL bottles for packaging the lotion formulations.

Materials

The primary active ingredient used in this study was mangosteen (*Garcinia mangostana* L.) peel extract. Other formulation ingredients included triethanolamine (TEA), glycerin, cetyl alcohol, stearic acid, methyl paraben, propyl paraben, fragrance, and distilled water (aquadest).

Preparation Procedure

The lotion was prepared using the hot emulsification method. The oil phase, consisting of cetyl alcohol and triethanolamine (TEA), and the aqueous phase, consisting of stearic acid, glycerin, and distilled water, were heated separately in an evaporating dish using a water bath at 65–75°C for approximately 10 minutes until each phase became completely homogeneous. The heated oil phase was then transferred into a mortar, followed by the gradual addition of the aqueous phase with continuous stirring until a uniform emulsion was formed at approximately

40°C. Subsequently, mangosteen peel extract, preservatives (methyl paraben and propyl paraben), and fragrance were incorporated gradually while stirring continuously until the temperature decreased to approximately 35°C, producing a homogeneous organic lotion.

Evaluation of the Lotion Formulations

Organoleptic Evaluation

Organoleptic evaluation was performed by observing the color, odor, and physical appearance of each lotion formulation during three days of storage to assess its physical stability.

Emulsion Type Test

The emulsion type was determined using the dilution method with distilled water. A formulation that remained homogeneous after dilution was classified as an oil-in-water (O/W) emulsion, indicating that water constituted the continuous external phase.

pH Measurement

The pH of each lotion formulation was measured using universal pH indicator paper. The measured pH values were compared with the normal physiological skin pH range (4.5–6.5) to evaluate the suitability of the formulations for topical application.

Data Analysis

The experimental data were analyzed descriptively based on emulsion theory and cosmetic formulation principles. An ideal lotion formulation is expected to exhibit good physical stability while maintaining an oil-in-water (O/W) emulsion system, in which water serves as the continuous (dispersing) phase and oil as the dispersed phase. Emulsion stability is strongly influenced by the presence of stabilizing agents, particularly triethanolamine (TEA) and cetyl alcohol, which contribute to maintaining emulsion homogeneity, improving texture, and preventing phase separation during storage. The organoleptic characteristics, emulsion type, and pH values of each formulation were subsequently compared to determine the most appropriate formulation for maintaining skin pH and overall product quality.

RESULTS AND DISCUSSION

Lotion Formulation

Three lotion formulations (F1, F2, and F3) were prepared with different concentrations of mangosteen (*Garcinia mangostana* L.) peel extract, while the concentrations of all other ingredients were kept constant. The formulations are presented in Table 2.

Table 2. Composition of Organic Lotion Formulation (F1)

No.	Ingredient	Concentration (%)
1	Mangosteen peel extract	5.0
2	Triethanolamine (TEA)	2.0
3	Cetyl alcohol	4.0
4	Stearic acid	2.5
5	Glycerin	10.0
6	Propyl paraben	0.02
7	Methyl paraben	0.02
8	Fragrance	0.15
9	Distilled water	ad 100

The quantities of each ingredient were calculated based on a 100 g batch of lotion formulation. The amount of mangosteen peel extract was varied according to the formulation, with 5 g, 10 g, and 15 g used in F1, F2, and F3, respectively. The concentrations of triethanolamine (2 g), stearic acid (2.5 g), cetyl alcohol (4 g), glycerin (10 g), methyl paraben

(0.02 g), propyl paraben (0.02 g), and fragrance (0.15 g) remained constant in all formulations. Distilled water was added to obtain a final weight of 100 g, corresponding to approximately 76.31 mL (F1), 71.31 mL (F2), and 66.31 mL (F3).

Organoleptic Evaluation

Organoleptic evaluation was performed to assess the physical characteristics of the lotion formulations, including odor, color, consistency, and texture. The observations were conducted during the first three days after preparation, and the results are summarized in Table 3.

Table 3. Organoleptic Characteristics of the Lotion Formulations

Formulation	Odor	Color	Consistency	Texture
F1	Strawberry	Light pink	Thick	Smooth
F2	Strawberry	Light pink	Semi-thick	Smooth
F3	Strawberry	Light pink	Fluid	Smooth

All formulations exhibited the same strawberry fragrance and light pink color, indicating that variations in mangosteen peel extract concentration did not noticeably affect these sensory attributes. However, differences were observed in viscosity. As the concentration of mangosteen peel extract increased, the consistency of the lotion gradually changed from thick (F1) to semi-thick (F2) and finally to a more fluid consistency (F3). Nevertheless, all formulations maintained a smooth texture without visible phase separation during the observation period, indicating acceptable physical stability.

Emulsion Type Evaluation

The emulsion type was determined using the dilution method with distilled water. An emulsion that remained homogeneous after dilution was classified as an oil-in-water (O/W) emulsion. The results are presented in Table 4.

Table 4. Emulsion Type Test Results

Formulation	Before Dilution	After Dilution	Emulsion Type
F1	Homogeneous	Homogeneous	Oil-in-water (O/W)
F2	Homogeneous	Homogeneous	Oil-in-water (O/W)
F3	Homogeneous	Homogeneous	Oil-in-water (O/W)

All formulations remained homogeneous following the addition of distilled water, confirming that they were oil-in-water (O/W) emulsions. This result indicates that water served as the continuous external phase, while the oil phase was uniformly dispersed throughout the formulation. The successful formation of the O/W emulsion suggests that the selected emulsifying system, consisting primarily of triethanolamine and stearic acid, effectively stabilized the formulations.

pH Evaluation

The pH values of the lotion formulations were determined using universal pH indicator paper. The results are shown in Table 5.

Table 5. pH Values of the Lotion Formulations

Formulation	pH	Interpretation
F1	6	Slightly alkaline
F2	5	Near the physiological skin pH
F3	4	Slightly acidic

The measured pH values ranged from 4 to 6, which fall within or very close to the recommended physiological skin pH range of 4.5–6.5. Among the three formulations, F2, containing 10% mangosteen peel extract, exhibited a pH value of 5, which most closely matched the natural pH of healthy human skin. This finding suggests that F2 offers the best compatibility for topical application and is less likely to disrupt the skin's acid mantle. In contrast, F1 exhibited a slightly higher pH (6), whereas F3 showed a slightly lower pH (4). Although both values remain acceptable for cosmetic use, the F2 formulation demonstrated the most favorable pH profile while maintaining desirable organoleptic characteristics and emulsion stability. Therefore, F2 was identified as the optimal formulation among the three tested formulations.

In general, a lotion formulation consists of several essential components, including a lipophilic phase, a hydrophilic phase, emulsifying agents, humectants, preservatives, fragrances, and colorants. In the present study, mangosteen (*Garcinia mangostana* L.) peel extract was used as the active ingredient because of its well-documented antioxidant activity, which may help protect skin cells against oxidative stress and improve the appearance of dry and dull skin. The antioxidant properties of mangosteen peel are primarily attributed to its high content of xanthones and other phenolic compounds (Obolskiy et al., 2009; Pedraza-Chaverri et al., 2008). Triethanolamine (TEA) was incorporated as the primary emulsifying agent at a concentration of 2%, which falls within the concentration range commonly used in topical cosmetic formulations. Cetyl alcohol was included as a fatty alcohol to improve the viscosity, consistency, and overall stability of the lotion. Glycerin served as a humectant, enhancing skin hydration by attracting and retaining moisture while also contributing to the viscosity of the formulation. Stearic acid was combined with TEA to produce a stable oil-in-water (O/W) emulsion through the formation of an effective emulsifying system. To ensure microbiological stability, methyl paraben and propyl paraben were used as preservatives, whereas strawberry fragrance was incorporated to improve consumer acceptability. The characteristic pink coloration of the lotion was derived naturally from the mangosteen peel extract without the addition of synthetic colorants.

The organoleptic evaluation demonstrated that all formulations maintained consistent color, fragrance, and texture throughout the observation period, indicating satisfactory physical stability. No visible changes, such as discoloration, unpleasant odor, phase separation, or precipitation, were observed during storage. These findings suggest that no undesirable chemical interactions occurred between the mangosteen peel extract and the excipients used in the formulation. The absence of observable physical changes indicates that the selected formulation components were compatible and capable of maintaining the integrity of the product during the evaluation period. The emulsion type test confirmed that all three formulations were classified as oil-in-water (O/W) emulsions. This was demonstrated by the dilution test, in which each formulation remained homogeneous after the addition of distilled water. Since the external phase consisted of water, the formulations were readily diluted without phase separation. The successful formation of stable O/W emulsions can be attributed to the synergistic emulsifying action of triethanolamine and stearic acid, which effectively reduced the interfacial tension between the oil and aqueous phases, thereby improving emulsion stability.

The pH evaluation revealed noticeable differences among the three formulations. Formulation F1 exhibited a pH value of **6**, whereas F2 and F3 showed pH values of **5** and **4**, respectively. Overall, the measured pH values were within or close to the recommended physiological skin pH range of 4.5–6.5, indicating that all formulations are generally suitable for topical application. However, Formulation F2, containing 10% mangosteen peel extract, demonstrated the pH value closest to that of healthy human skin. Maintaining a pH near the physiological range is important because it helps preserve the skin's acid mantle, supports the normal skin microbiome, and minimizes the risk of irritation or excessive dryness (Lambers et

al., 2006; Proksch et al., 2008). Based on the overall evaluation, Formulation F2 exhibited the most favorable combination of organoleptic properties, emulsion stability, and pH compatibility. These findings suggest that the formulation containing 10% mangosteen peel extract is the most suitable candidate for further development as a natural antioxidant lotion intended to maintain skin hydration and support the physiological pH balance of the skin. Nevertheless, additional studies involving physicochemical stability testing, microbiological quality assessment, irritation testing, and long-term clinical evaluation are recommended to further validate its safety, stability, and efficacy.

CONCLUSION

Based on the results obtained from the formulation, organoleptic evaluation, emulsion type determination, and pH assessment of the organic lotion containing mangosteen (*Garcinia mangostana* L.) peel extract, the following conclusions can be drawn:

Optimum Formulation

Among the three formulations evaluated, Formulation 2 (F2) was identified as the optimum formulation due to its superior physical stability and overall performance. The composition of F2 consisted of 10% mangosteen peel extract, 2% triethanolamine (TEA), 4% cetyl alcohol, 2.5% stearic acid, 10% glycerin, 0.02% propyl paraben, 0.02% methyl paraben, 0.15% strawberry fragrance, and distilled water added to a final volume of 100%.

Organoleptic Characteristics

The formulated lotion exhibited satisfactory organoleptic properties, including a uniform light pink color, a pleasant strawberry fragrance, a smooth texture, and a semi-thick consistency. The absence of phase separation, discoloration, or changes in odor during the observation period indicates that the formulation remained physically homogeneous and stable.

Emulsion Type

All formulations were successfully prepared as oil-in-water (O/W) emulsions, as confirmed by the dilution test. This emulsion type is considered appropriate for topical lotion formulations because it provides a light skin feel, is readily absorbed, and does not leave a greasy or sticky residue after application.

pH Evaluation

The measured pH values of the formulations were as follows:

1) Formulation 1 (F1): pH 4
2) Formulation 2 (F2): pH 5
3) Formulation 3 (F3): pH 6

Among the three formulations, Formulation 2 exhibited a pH value of 5, which is closest to the normal physiological skin pH range (4.5–6.5). This finding indicates that F2 is the most suitable formulation for topical application because it is expected to maintain the skin's natural acid mantle while minimizing the risk of irritation. Therefore, Formulation 2 is considered the optimal organic lotion formulation containing mangosteen peel extract for maintaining skin pH and supporting healthy skin.

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