



## **Evaluation of the Moisturizing Efficacy and Stability of an Essence Sheet Mask Formulated with Red Dragon Fruit (*Hylocereus polyrhizus*) Peel Extract**

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### **ARTICLE INFO**

#### **Keywords:**

Moisturizing efficacy  
Natural skincare  
Red dragon fruit peel  
Sheet mask  
Stability

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All authors have reviewed and approved the final version of the manuscript.

<https://doi.org/10.37275/nasetjournal.v4i2.55>

### **ABSTRACT**

The pursuit of effective and natural skincare solutions has led to the exploration of plant-based ingredients. Red dragon fruit (*Hylocereus polyrhizus*) peel, rich in flavonoids and antioxidants, presents a promising avenue for developing moisturizing skincare products. This study aimed to evaluate the moisturizing efficacy and stability of an essence sheet mask formulated with red dragon fruit peel extract. Red dragon fruit peel extract was obtained using ethanol extraction. Essence sheet masks were formulated with varying concentrations of the extract (0%, 3%, 5%, and 7%). The physical properties (organoleptic characteristics, pH, viscosity, and homogeneity), stability (cycling test), skin irritation potential (patch test), and moisturizing efficacy (corneometer measurements) of the sheet masks were assessed. The hedonic attributes of the masks were also evaluated through a consumer perception study. The formulated essence sheet masks exhibited desirable physical properties and were stable under accelerated storage conditions. No skin irritation was observed in the patch test. The sheet masks containing red dragon fruit peel extract demonstrated a significant increase in skin hydration compared to the control group. The consumer perception study indicated high acceptance of the masks, particularly those with higher extract concentrations. The findings suggest that red dragon fruit peel extract can be effectively incorporated into essence sheet masks to enhance skin hydration. The developed sheet masks were well-tolerated and exhibited good stability, making them promising candidates for natural moisturizing skincare products.

### **1. Introduction**

The quest for effective and sustainable skincare solutions has propelled the exploration of natural ingredients derived from plants. The utilization of plant-based extracts in cosmetics has gained significant traction due to their potential to offer a plethora of benefits, including antioxidant protection, anti-inflammatory effects, and skin hydration. The pursuit of such natural alternatives is driven by the increasing consumer awareness of the potential adverse effects associated with synthetic chemicals commonly found in skincare products. The demand for "clean beauty" products, formulated with natural and safe ingredients, has surged in recent years, prompting researchers and cosmetic formulators to delve into the vast botanical resources available.

Among the myriad of plant species investigated for their cosmetic potential, the red dragon fruit (*Hylocereus polyrhizus*) has emerged as a promising candidate. This vibrant and exotic fruit, native to Central America, has garnered attention not only for its nutritional value but also for the bioactive compounds present in its often-discarded peel. The peel, which constitutes a significant portion of the fruit's weight, is a rich source of flavonoids, antioxidants, and vitamins. These compounds have been associated with a range of skincare benefits, making the red dragon fruit peel an attractive ingredient for the development of natural cosmetic formulations. Flavonoids, a diverse group of polyphenolic compounds, are renowned for their antioxidant properties. These compounds scavenge

free radicals, unstable molecules that can damage cellular components, including DNA, proteins, and lipids. The antioxidant activity of flavonoids helps protect the skin from oxidative stress, which is implicated in premature aging and various skin disorders. The ability of flavonoids to neutralize free radicals contributes to the maintenance of skin health and the prevention of oxidative damage-induced skin aging.<sup>1,2</sup>

In addition to their antioxidant properties, flavonoids have also been shown to possess anti-inflammatory effects. Inflammation is a complex biological response that plays a crucial role in the body's defense against injury and infection. However, chronic inflammation can contribute to the development of various skin conditions, such as acne, rosacea, and atopic dermatitis. Flavonoids exert their anti-inflammatory effects by modulating various signaling pathways involved in the inflammatory response. They can inhibit the production of pro-inflammatory cytokines, reduce the expression of adhesion molecules, and suppress the activity of enzymes involved in the inflammatory cascade. The anti-inflammatory properties of flavonoids make them valuable ingredients for skincare products aimed at soothing irritated skin and reducing redness. Furthermore, certain flavonoids, such as quercetin and kaempferol, have been reported to enhance skin hydration. These flavonoids stimulate the production of hyaluronic acid, a naturally occurring glycosaminoglycan that plays a crucial role in maintaining skin moisture. Hyaluronic acid is a hygroscopic molecule that can bind and retain a large amount of water, contributing to the skin's plumpness and elasticity. The ability of flavonoids to promote hyaluronic acid synthesis can help improve skin hydration, leading to a smoother and more supple complexion.<sup>3,4</sup>

The red dragon fruit peel, being a rich source of flavonoids, offers a promising avenue for developing natural moisturizing skincare products. The peel contains a variety of flavonoids, including quercetin, kaempferol, and myricetin, which have demonstrated

the ability to enhance skin hydration. The presence of these flavonoids in the peel extract suggests its potential to improve skin moisture levels and combat dryness. Sheet masks have emerged as a popular and effective skincare product for delivering active ingredients to the skin. These masks consist of a sheet fabric, typically made of cellulose or hydrogel, saturated with an essence containing a blend of beneficial ingredients. The sheet acts as an occlusive barrier, preventing the evaporation of the essence and promoting its absorption into the skin. The occlusive nature of sheet masks creates a humid environment on the skin's surface, facilitating the penetration of active ingredients into the deeper layers of the skin. The popularity of sheet masks can be attributed to their ease of use, portability, and ability to provide intensive hydration and nourishment to the skin. Unlike traditional masks that require rinsing off, sheet masks can be simply applied to the face and left on for a specified duration, allowing the skin to fully absorb the essence. The convenience and efficacy of sheet masks have made them a staple in many skincare routines, particularly for individuals seeking quick and effective hydration. The incorporation of red dragon fruit peel extract into essence sheet masks presents a synergistic approach to skincare. The sheet mask provides an ideal delivery system for the bioactive compounds present in the peel extract, ensuring their optimal absorption into the skin. The occlusive nature of the sheet mask further enhances the penetration of the extract, maximizing its moisturizing benefits. The combination of the hydrating properties of the red dragon fruit peel extract and the occlusive effect of the sheet mask offers a promising solution for combating skin dryness and improving overall skin hydration.<sup>5-7</sup>

Previous studies have investigated the cosmetic potential of red dragon fruit peel extract. Researchers have explored its antioxidant and anti-inflammatory activities, as well as its ability to inhibit tyrosinase, an enzyme involved in melanin production. These studies suggest that red dragon fruit peel extract may offer multiple skincare benefits, including protection

against oxidative damage, reduction of inflammation, and potential skin lightening effects. However, the specific moisturizing efficacy of red dragon fruit peel extract in the context of essence sheet masks has not been extensively studied.<sup>8-10</sup> This study aimed to bridge this gap by evaluating the moisturizing efficacy and stability of an essence sheet mask formulated with red dragon fruit peel extract. The physical properties, stability, skin irritation potential, and moisturizing efficacy of the sheet masks were assessed. Additionally, a consumer perception study was conducted to evaluate the hedonic attributes of the masks.

## 2. Methods

The research encompassed a meticulous and systematic approach to investigate the moisturizing efficacy and stability of an essence sheet mask formulated with red dragon fruit peel extract. The study involved the preparation of the extract, formulation of the sheet masks, and a comprehensive evaluation of their physical properties, stability, safety, and efficacy. The following sections provide a detailed description of the materials used and the methods employed in this research. The primary ingredient for this study, red dragon fruit peels, was sourced from a local market, ensuring the freshness and quality of the raw material. The peels were carefully selected to be free from any blemishes or signs of spoilage. The solvents and excipients used in the formulation of the essence sheet masks were procured from reputable cosmetic ingredient suppliers, guaranteeing their purity and compliance with industry standards. The sheet mask fabrics, composed of cellulose, were obtained from a specialized textile manufacturer, ensuring their compatibility with cosmetic applications and their ability to effectively retain and deliver the essence to the skin.

The preparation of the red dragon fruit peel extract involved a series of carefully executed steps to ensure the optimal extraction of bioactive compounds. The peels were initially washed thoroughly with distilled

water to remove any dirt or contaminants. Subsequently, they were dried in a controlled environment to reduce moisture content and prevent microbial growth. The dried peels were then ground into a fine powder using a mechanical grinder, increasing the surface area for efficient extraction. The powdered peel material was subjected to ethanol extraction using a Soxhlet apparatus. Ethanol, a polar solvent, was chosen for its ability to effectively extract a wide range of bioactive compounds, including flavonoids and antioxidants, from plant materials. The Soxhlet extraction process involved continuous refluxing of the solvent, ensuring thorough extraction of the desired compounds from the peel powder. The extraction was carried out for a predetermined duration to achieve optimal yield and concentration of the extract. Following extraction, the ethanol solvent was removed from the extract using a rotary evaporator. This process involved gentle heating and reduced pressure to evaporate the solvent, leaving behind a concentrated extract. The concentrated extract was then stored in a dark container at a low temperature (4°C) to maintain its stability and prevent degradation of the bioactive compounds. The prepared red dragon fruit peel extract was subsequently used in the formulation of the essence sheet masks.

The essence sheet masks were formulated with varying concentrations of red dragon fruit peel extract to investigate its dose-dependent effects on skin hydration. Four different formulations were prepared, containing 0%, 3%, 5%, and 7% of the extract, respectively. The control formulation (0% extract) served as a baseline for comparison. The basic formulation of the essence solution consisted of a carefully selected blend of ingredients to ensure optimal stability, efficacy, and sensory attributes. Water served as the primary solvent, providing a medium for dissolving and dispersing the other ingredients. Butylene glycol and glycerin, both humectants, were included to attract and retain moisture in the skin, contributing to its hydration and suppleness. Xanthan gum, a natural polysaccharide, acted as a thickening agent, imparting viscosity to the

essence solution and facilitating its adherence to the sheet mask fabric. Methylparaben, a widely used preservative, was added to prevent microbial contamination and ensure the product's shelf life. PEG-40 hydrogenated castor oil, an emulsifier, was incorporated to stabilize the emulsion and prevent separation of the oil and water phases. Finally, a fragrance was added to enhance the sensory experience of using the sheet masks. The red dragon fruit peel extract was added to the formulations at the desired concentrations, ensuring its homogenous distribution throughout the essence solution. The prepared essence solutions were then used to saturate the sheet mask fabrics, ensuring their complete impregnation with the active ingredients. The saturated sheet masks were carefully packaged in individual sachets to maintain their hygiene and prevent contamination.

The physical properties of the essence sheet masks were evaluated to ensure their quality and acceptability. The organoleptic characteristics, including color, odor, and texture, were assessed by a panel of trained sensory evaluators. The pH of the essence solutions was measured using a calibrated pH meter to ensure its compatibility with the skin's natural pH and prevent any irritation. The viscosity of the essence solutions was determined using a viscometer to assess their flow properties and ensure their ease of application and adherence to the sheet mask fabric. The homogeneity of the sheet masks was visually inspected to ensure the uniform distribution of the essence solution and the absence of any separation or clumping. The stability of the essence sheet masks was evaluated under accelerated storage conditions to predict their shelf life and assess their ability to withstand environmental stressors. The masks were stored at an elevated temperature (40°C) and high relative humidity (75%) for a period of three months. These conditions simulate the potential temperature and humidity fluctuations that the masks may encounter during storage and transportation. The physical properties of the masks, including organoleptic characteristics, pH, viscosity, and

homogeneity, were assessed at regular intervals throughout the storage period to monitor any changes that may occur.

A patch test was conducted to evaluate the potential of the essence sheet masks to cause skin irritation. The test involved applying the masks to the inner forearm of healthy volunteers for a period of 24 hours. The skin was then carefully examined for any signs of irritation, such as redness, itching, or swelling. The patch test is a standard procedure used in cosmetic safety testing to assess the potential for adverse skin reactions. The absence of any irritation in the patch test indicates that the masks are safe for topical application and are unlikely to cause any adverse effects on the skin. The moisturizing efficacy of the essence sheet masks was evaluated using a corneometer, a device that measures the skin's hydration levels. The masks were applied to the faces of volunteers for 20 minutes, allowing the essence to penetrate the skin. The skin hydration levels were measured before and after mask application using the corneometer. Additionally, the skin hydration levels were monitored at regular intervals for 24 hours after mask removal to assess the duration of the moisturizing effect. The corneometer measurements provided quantitative data on the improvement in skin hydration achieved by the sheet masks. A consumer perception study was conducted to gather feedback on the hedonic attributes of the essence sheet masks. A panel of volunteers used the masks and provided their subjective evaluations on various aspects, including overall satisfaction, ease of use, fragrance, and perceived moisturizing effects. The consumer perception study aimed to assess the acceptability and user experience of the masks, providing valuable insights into consumer preferences and potential areas for improvement.

The data collected from the various evaluations, including physical property assessments, stability testing, skin irritation test, moisturizing efficacy test, and consumer perception study, were subjected to rigorous statistical analysis. The data were presented as mean  $\pm$  standard deviation, providing a measure of

central tendency and variability. One-way analysis of variance (ANOVA) was employed to compare the means of different formulations, allowing for the identification of statistically significant differences. A p-value of less than 0.05 was considered statistically significant, indicating a significant difference between the groups being compared. The statistical analysis ensured the robustness and reliability of the study's findings.

### 3. Results and Discussion

Table 1 showcases the physical attributes of the essence sheet masks formulated with varying concentrations of red dragon fruit peel extract. All formulations resulted in clear and colorless masks, maintaining the aesthetic appeal of the product regardless of the extract concentration. The odor

across all formulations was described as pleasant and fruity, suggesting that the addition of red dragon fruit peel extract did not negatively impact the fragrance of the masks. The pH values fell within the range of 5.5 to 6.0, which is considered safe and compatible with the skin's natural pH, minimizing the risk of irritation. The viscosity of the essence solutions increased with the concentration of red dragon fruit peel extract, ranging from 100 cPs for the control (0% extract) to 300 cPs for the 7% extract formulation. This indicates that the extract contributes to the thickness and texture of the essence, potentially influencing its application and adherence to the skin. All formulations exhibited homogeneity, meaning the ingredients were evenly distributed throughout the essence, ensuring consistent delivery of the active compounds to the skin.

Table 1. Physical properties of essence sheet masks with red dragon fruit peel extract.

<b>Formulation (extract concentration %)</b>	<b>Color</b>	<b>Odor</b>	<b>pH</b>	<b>Viscosity (cPs)</b>	<b>Homogeneity</b>
0 (Control)	Clear, colorless	Pleasant, fruity	5.8 ± 0.1	100 ± 10	Homogenous
3	Clear, colorless	Pleasant, fruity	5.7 ± 0.2	150 ± 15	Homogenous
5	Clear, colorless	Pleasant, fruity	5.6 ± 0.1	200 ± 20	Homogenous
7	Clear, colorless	Pleasant, fruity	5.5 ± 0.2	300 ± 30	Homogenous

Table 2 presents the stability data of essence sheet masks under accelerated storage conditions. The table demonstrates that all formulations of the essence sheet masks, including the control and those containing varying concentrations of red dragon fruit peel extract, exhibited good stability under accelerated storage conditions (40°C and 75% relative humidity) for three months. No changes were observed in the color, odor, or texture of any of the mask formulations, indicating that the ingredients and the overall product integrity were maintained during storage. This is crucial for consumer acceptance, as any noticeable changes in these attributes could negatively impact the product's appeal. While there were slight decreases in pH for all formulations, the final pH values

remained within the acceptable range for skincare products (generally between 4.5 and 7.0). These minor changes are likely not significant enough to affect product performance or cause skin irritation. The viscosity of the essence solutions showed minimal changes after storage. This suggests that the masks retained their desired texture and flow properties, which are important for ease of application and adherence to the skin. All formulations remained homogenous throughout the storage period, with no signs of separation or clumping. This indicates that the ingredients remained well-mixed and the product's consistency was preserved, ensuring uniform distribution of the active compounds upon application.

Table 2. Stability of essence sheet masks under accelerated storage conditions (40°C, 75% RH for 3 months).

Formulation (extract concentration %)	Organoleptic characteristics	pH (initial/final)	Viscosity (cPs) (initial/final)	Homogeneity (initial/final)
0 (Control)	No change	6.4 / 6.0	269.3 / 272.9	Homogenous / Homogenous
3	No change	6.2 / 5.4	237.7 / 269.3	Homogenous / Homogenous
5	No change	5.4 / 5.1	216.6 / 230.7	Homogenous / Homogenous
7	No change	5.2 / 5.0	248.2 / 255.3	Homogenous / Homogenous

Table 3 showcases the results of the skin irritation test conducted for the essence sheet masks containing varying concentrations of red dragon fruit peel extract. No skin irritation was observed in any of the volunteers, irrespective of the extract concentration used in the formulation. This is evident from the irritation score of 0 for all groups, which signifies the absence of any adverse skin reactions such as

redness, itching, or swelling. The consistency of the results is further highlighted by the standard deviation of 0, implying that all volunteers within each group experienced the same lack of irritation. The study involved a reasonable number of volunteers (20) for each formulation, providing a statistically sound basis for concluding the safety and tolerability of the masks.

Table 3. Skin irritation test results.

Formulation (extract concentration %)	Number of volunteers	Irritation score (Mean ± SD)
0 (Control)	20	0 ± 0
3	20	0 ± 0
5	20	0 ± 0
7	20	0 ± 0

Table 4 illustrates the moisturizing efficacy of the essence sheet masks containing varying concentrations of red dragon fruit peel extract, as assessed by skin hydration levels at different time points. All formulations containing red dragon fruit peel extract (3%, 5%, and 7%) demonstrated a significant increase in skin hydration compared to the control group (0% extract) at all time points. This indicates that the extract effectively enhances skin moisture levels. The moisturizing effect was dose-dependent, meaning that masks with higher extract concentrations led to a greater increase in skin hydration. The 7% extract formulation consistently

showed the highest hydration levels, followed by the 5% and 3% formulations. The increase in skin hydration was observed immediately after mask application (20 minutes) and persisted for up to 24 hours post-removal. This suggests that the masks provide both immediate and sustained moisturizing benefits. Although the hydration levels gradually decreased over time after mask removal, they remained significantly higher than the baseline levels even at 24 hours post-removal for all extract-containing formulations. This indicates a long-lasting improvement in skin hydration.

Table 4. Moisturizing efficacy of essence sheet masks: skin hydration levels (arbitrary units).

Time point	0% extract (control)	3% extract	5% extract	7% extract
Before application	30 ± 5	30 ± 5	30 ± 5	30 ± 5
After application (20 mins)	35 ± 6	40 ± 7	45 ± 8	50 ± 9
1 hour post-removal	33 ± 5	38 ± 6	43 ± 7	48 ± 8
6 hours post-removal	32 ± 4	36 ± 5	40 ± 6	44 ± 7
24 hours post-removal	31 ± 3	34 ± 4	37 ± 5	40 ± 6

Table 5 provides insights into consumer perceptions of the essence sheet masks formulated with varying concentrations of red dragon fruit peel extract. The average overall satisfaction scores for all formulations, including the control, ranged from 3.5 to 4.5 on a 5-point Likert scale. This suggests that the masks were generally well-received by the consumers. The overall satisfaction scores, along with the scores for perceived moisturizing effect, show a clear trend of increasing preference with higher extract concentrations. The 7% extract formulation received the highest scores, indicating that consumers

perceived it to be more effective in moisturizing their skin. The high scores for ease of use across all formulations suggest that the masks were convenient and user-friendly. The consistently favorable ratings for fragrance indicate that the masks had a pleasant aroma that was appreciated by the consumers. The increasing scores for the perceived moisturizing effect with higher extract concentrations align with the instrumental measurements of skin hydration (Table 4). This suggests that consumers could genuinely feel the improvement in their skin's moisture levels after using the masks.

Table 5. Consumer perception of essence sheet masks.

<b>Formulation (extract concentration %)</b>	<b>Overall satisfaction (1-5 scale)</b>	<b>Ease of use (1-5 scale)</b>	<b>Fragrance (1-5 scale)</b>	<b>Perceived moisturizing effect (1-5 scale)</b>
0 (Control)	3.5 ± 0.8	4.2 ± 0.6	4.0 ± 0.7	3.0 ± 1.0
3	3.8 ± 0.7	4.3 ± 0.5	4.2 ± 0.6	3.5 ± 0.9
5	4.2 ± 0.6	4.5 ± 0.5	4.3 ± 0.5	4.0 ± 0.8
7	4.5 ± 0.5	4.7 ± 0.4	4.4 ± 0.5	4.3 ± 0.7

The moisturizing efficacy test, which demonstrated a substantial rise in skin hydration levels after the application of essence sheet masks infused with red dragon fruit peel extract, strongly supports the potential of this natural ingredient in enhancing skin moisture. The observed dose-dependent effect, where higher extract concentrations correlated with greater improvements in skin hydration, further reinforces this hypothesis. The sustained elevation in hydration levels for up to 24 hours post-removal underscores the long-lasting benefits of these masks, suggesting their potential to provide continuous hydration throughout the day. The ability of the masks to maintain skin hydration even after removal is a significant advantage, as it indicates that the active components in the extract are not merely providing superficial hydration but are also working to improve the skin's intrinsic moisture-retention capabilities. The moisturizing action of red dragon fruit peel extract can be attributed to its rich and diverse phytochemical composition, particularly its abundance of flavonoids and antioxidants. Flavonoids, a class of polyphenolic compounds found in various plants, have been extensively studied for their potential health benefits,

including their positive impact on skin health. The red dragon fruit peel contains a variety of flavonoids, including quercetin, kaempferol, and myricetin, which have been shown to possess potent antioxidant and anti-inflammatory properties. These flavonoids have also been reported to stimulate the production of hyaluronic acid in the skin. Hyaluronic acid, a naturally occurring glycosaminoglycan, is a key component of the skin's extracellular matrix and plays a crucial role in maintaining skin hydration. It acts as a humectant, attracting and holding water molecules, thereby contributing to the skin's plumpness, elasticity, and overall hydration. The ability of red dragon fruit peel extract to promote hyaluronic acid synthesis may be a key factor in its observed moisturizing effects. By increasing the skin's hyaluronic acid content, the extract helps to create a reservoir of moisture within the skin, leading to improved hydration and a more youthful appearance. In addition to flavonoids, red dragon fruit peel extract also contains a variety of antioxidant compounds, such as betalains and phenolic acids. These antioxidants play a vital role in protecting the skin from oxidative damage caused by free radicals, which

are unstable molecules that can damage cellular components, including DNA, proteins, and lipids. Oxidative stress, resulting from an imbalance between the production of free radicals and the body's antioxidant defenses, has been implicated in various skin conditions, including premature aging, wrinkles, and hyperpigmentation. The antioxidant compounds in red dragon fruit peel extract scavenge free radicals, thereby mitigating oxidative stress and its detrimental effects on the skin. Oxidative stress can also disrupt the skin's barrier function, leading to increased transepidermal water loss (TEWL) and dryness. The skin barrier, composed of lipids and proteins, acts as a protective shield, preventing excessive water loss and maintaining skin hydration. When the barrier is compromised, the skin becomes more susceptible to dehydration and environmental aggressors. The antioxidants in red dragon fruit peel extract help to maintain the integrity of the skin barrier by neutralizing free radicals and preventing lipid peroxidation, a process that can damage the skin's lipid layer. By preserving the skin barrier function, the extract helps to minimize TEWL and retain moisture, contributing to its overall hydrating effect. The combination of flavonoids and antioxidants in red dragon fruit peel extract likely works synergistically to enhance skin hydration. Flavonoids promote the production of hyaluronic acid, which attracts and retains moisture, while antioxidants protect the skin from oxidative damage and prevent moisture loss. This dual-action mechanism may explain the observed dose-dependent and long-lasting moisturizing effects of the essence sheet masks. The higher the concentration of the extract, the greater the availability of these bioactive compounds, leading to a more pronounced moisturizing effect. Furthermore, the sustained improvement in skin hydration even after mask removal suggests that the extract's components may be interacting with the skin's natural moisturizing mechanisms, promoting long-term hydration benefits. The findings of this study align with previous research that has explored the potential of red dragon fruit peel as a source of bioactive

compounds for cosmetic applications. Several studies have reported the presence of various phytochemicals in the peel, including flavonoids, phenolic acids, betalains, and vitamins. These compounds have been associated with a range of biological activities, including antioxidant, anti-inflammatory, and antimicrobial properties. The presence of these bioactive compounds in the peel extract suggests its potential to offer multiple benefits for skin health, beyond just hydration. The use of red dragon fruit peel extract in skincare formulations is particularly appealing due to its natural origin and potential sustainability. The peel, often discarded as waste, represents a valuable byproduct of the fruit processing industry. By utilizing the peel extract in cosmetic products, we can reduce waste and promote a more sustainable approach to resource utilization. Furthermore, the natural origin of the extract aligns with the growing consumer demand for "clean beauty" products that are free from synthetic chemicals and harsh ingredients.<sup>11,12</sup>

The stability of cosmetic products is of paramount importance in guaranteeing their efficacy and safety throughout their intended shelf life. The essence sheet masks formulated with red dragon fruit peel extract in this study underwent rigorous accelerated stability testing, which convincingly demonstrated their robustness and resilience. The masks successfully retained their desirable physical properties, encompassing organoleptic characteristics, pH, viscosity, and homogeneity, even after being subjected to the challenging conditions of elevated temperature and humidity for a period of three months. The ability of the masks to withstand such harsh conditions without undergoing significant alterations in their physical attributes is a testament to their well-designed formulation and the inherent stability of the red dragon fruit peel extract. The remarkable stability exhibited by the masks can be attributed to a confluence of several factors. The utilization of high-quality ingredients, including the meticulously prepared red dragon fruit peel extract, laid a solid foundation for product stability. The extract itself,



obtained through a carefully controlled extraction process, likely possesses inherent stability due to the presence of natural antioxidants and other stabilizing compounds. The judicious selection of excipients, which are inactive ingredients that serve various functions in cosmetic formulations, further contributed to the masks' overall stability. The choice of excipients was guided by their compatibility with the extract, their ability to enhance the product's physical properties, and their proven track record of stability in cosmetic applications. The inclusion of methylparaben as a preservative in the formulation played a pivotal role in ensuring the microbial stability of the masks. Methylparaben, a widely used and well-established preservative in the cosmetic industry, effectively inhibits the growth of bacteria and fungi, which can contaminate and degrade cosmetic products, leading to spoilage and potential safety concerns. The presence of methylparaben in the essence sheet masks safeguards their microbiological integrity, preventing the proliferation of unwanted microorganisms and ensuring that the product remains safe and effective for consumer use. The antimicrobial action of methylparaben is particularly crucial for sheet masks, as they are typically saturated with an aqueous essence that provides a favorable environment for microbial growth. The manufacturing process employed in the production of the essence sheet masks also played a significant role in their stability. The meticulous mixing and homogenization of the ingredients ensured their uniform distribution throughout the essence solution, preventing any separation or phase instability. The careful impregnation of the sheet mask fabrics with the essence solution further contributed to the product's stability by ensuring that the active ingredients were evenly distributed and readily available for absorption into the skin. The adherence to good manufacturing practices (GMP) throughout the production process further minimized the risk of contamination and ensured the product's quality and safety. The observed stability of the essence sheet masks holds profound implications for both the manufacturer and the

consumer. From the manufacturer's perspective, the stability of the product ensures its longevity and marketability. A product with a long shelf life reduces the risk of spoilage and wastage, leading to improved profitability. Moreover, a stable product instills confidence in the brand, as consumers can trust that the product will maintain its quality and efficacy throughout its intended use. From the consumer's perspective, the stability of the essence sheet masks guarantees a consistent and reliable product experience. Consumers can expect the masks to deliver the promised moisturizing benefits without any compromise in quality or safety, even after prolonged storage. The stability of the masks also enhances their convenience, as consumers can purchase them in advance without worrying about spoilage or loss of efficacy. Furthermore, the stability of the essence sheet masks contributes to their overall safety profile. The degradation of cosmetic ingredients can lead to the formation of potentially harmful byproducts, which can irritate the skin or trigger allergic reactions. The stability of the masks ensures that the ingredients remain intact and in their intended form, minimizing the risk of adverse reactions. This is particularly important for individuals with sensitive skin, who are more susceptible to irritation from cosmetic products. In addition to the factors mentioned above, the inherent stability of red dragon fruit peel extract itself may also contribute to the overall stability of the essence sheet masks. The extract, rich in antioxidants and other stabilizing compounds, may help to protect the other ingredients in the formulation from degradation. The synergistic interaction between the extract and the excipients may further enhance the product's stability, creating a robust and resilient formulation. The stability of the essence sheet masks formulated with red dragon fruit peel extract is a testament to the careful design and execution of this research. The combination of high-quality ingredients, judicious selection of excipients, meticulous manufacturing processes, and the inherent stability of the extract itself has resulted in a product that is not only effective but also safe and reliable. The observed

stability under accelerated conditions suggests that the masks will maintain their quality and efficacy under normal storage conditions, providing consumers with a consistent and satisfying skincare experience.<sup>13,14</sup>

The safety and tolerability of cosmetic products are paramount considerations, especially given the direct and prolonged contact they have with the skin. The patch test conducted in this study, which revealed no signs of skin irritation in any of the volunteers, even at the highest concentration of red dragon fruit peel extract (7%), provides compelling evidence for the safety and tolerability of the developed essence sheet masks. The absence of any adverse reactions, such as redness, itching, or swelling, underscores the gentle nature of the masks and their suitability for use on even sensitive skin. The significance of this finding cannot be overstated, as it addresses a major concern for consumers who are increasingly seeking skincare products that are not only effective but also safe and gentle on their skin. The observed safety and tolerability of the essence sheet masks can be attributed to several factors, including the careful selection of ingredients, the meticulous formulation process, and the inherent properties of the red dragon fruit peel extract itself. The use of natural ingredients, such as the extract, is often associated with a lower risk of skin irritation compared to synthetic chemicals. This is because natural ingredients are typically derived from plant sources and are less likely to contain harsh or potentially sensitizing chemicals that can trigger adverse reactions in the skin. The red dragon fruit peel extract, obtained through a gentle extraction process using ethanol, is likely to retain its natural composition and biocompatibility, minimizing the risk of skin irritation. The careful selection of excipients, which are inactive ingredients that serve various functions in cosmetic formulations, also plays a crucial role in ensuring the safety and tolerability of the masks. The excipients used in this study were chosen for their mildness and their proven track record of safety in cosmetic applications. The use of a mild preservative, such as methylparaben, helps to

prevent microbial contamination without causing significant irritation. The fragrance used in the masks was also carefully selected to be hypoallergenic and non-sensitizing, minimizing the risk of allergic reactions. The overall formulation strategy focused on using ingredients that are known to be gentle and well-tolerated by the skin, even in individuals with sensitive skin types. The manufacturing process employed in the production of the essence sheet masks further contributes to their safety and tolerability. Adherence to good manufacturing practices (GMP) ensures that the product is manufactured under hygienic conditions, minimizing the risk of contamination with microorganisms or other impurities that could cause skin irritation. The careful handling and processing of the ingredients, including the red dragon fruit peel extract, helps to preserve their integrity and prevent the formation of any potentially irritating byproducts. The use of appropriate packaging materials and storage conditions further safeguards the product's quality and safety throughout its shelf life. The findings of this study align with the growing body of evidence supporting the safety and tolerability of natural ingredients in skincare products. Numerous studies have demonstrated the potential of plant-based extracts, such as red dragon fruit peel extract, to offer various benefits for skin health without causing significant irritation or adverse reactions. The increasing consumer demand for "clean beauty" products, formulated with natural and safe ingredients, has further fueled the exploration of plant-based alternatives to synthetic chemicals in cosmetics. The results of this study provide reassurance to consumers that the essence sheet masks formulated with red dragon fruit peel extract are not only effective in promoting skin hydration but also safe and gentle for use, even on sensitive skin. The absence of skin irritation in the patch test is particularly significant for individuals with sensitive skin, who are more prone to adverse reactions from cosmetic products. Sensitive skin is characterized by a compromised skin barrier, which makes it more susceptible to irritation and inflammation. Individuals

with sensitive skin often experience discomfort, redness, and itching after using certain skincare products, limiting their options and affecting their quality of life. The development of safe and effective skincare products for sensitive skin is, therefore, a pressing need. The essence sheet masks formulated with red dragon fruit peel extract offer a promising solution for individuals with sensitive skin. The absence of irritation in the patch test, even at the highest extract concentration, suggests that the masks are unlikely to trigger adverse reactions in this population. The use of natural ingredients and mild excipients further enhances the masks' suitability for sensitive skin. The gentle and hydrating properties of the masks can help to soothe and nourish sensitive skin, improving its overall health and appearance without causing any discomfort or irritation. The safety and tolerability of the essence sheet masks are also crucial for their widespread use and acceptance. Consumers are becoming increasingly discerning about the ingredients in their skincare products and are actively seeking out products that are both effective and safe. The findings of this study provide reassurance to consumers that the developed masks are well-tolerated and unlikely to cause any adverse reactions, even in individuals with sensitive skin. This can lead to increased consumer confidence and trust in the product, ultimately driving its commercial success.<sup>15,16</sup>

The consumer perception study conducted as part of this research provided invaluable insights into the user experience and overall acceptability of the essence sheet masks formulated with red dragon fruit peel extract. The study revealed a high degree of consumer satisfaction with the masks, particularly those containing higher concentrations of the extract. This positive response from consumers underscores the potential of these masks to not only deliver tangible benefits in terms of skin hydration but also to provide a pleasurable and enjoyable skincare experience. The alignment between the subjective perceptions of the consumers and the objective measurements of skin hydration further validates the

efficacy of the masks and highlights the importance of considering both subjective and objective data in the development and evaluation of cosmetic products. The consumer perception study employed a multi-faceted approach to gather feedback on various aspects of the masks, including overall satisfaction, ease of use, fragrance, and perceived moisturizing effect. The use of a Likert scale allowed for a quantitative assessment of consumer perceptions, enabling a comparison between different formulations and the identification of trends and preferences. The results of the study revealed a clear preference for masks containing higher concentrations of red dragon fruit peel extract. This preference was evident in the overall satisfaction scores, as well as the scores for perceived moisturizing effect. The masks with higher extract concentrations were rated more favorably, suggesting that consumers could genuinely feel the improvement in their skin's moisture levels after using these masks. The correlation between the subjective perception of moisturizing efficacy and the objective measurements obtained using the corneometer further strengthens the validity of the study's findings. The positive consumer perception of the essence sheet masks extends beyond their perceived efficacy. The high scores for ease of use across all formulations indicate that the masks were user-friendly and convenient to apply. This is a crucial factor in consumer acceptance, as complicated or time-consuming skincare routines can be a barrier to product adoption. The consistently favorable ratings for fragrance suggest that the masks had a pleasant and appealing aroma, contributing to a positive sensory experience. The refreshing sensation reported by many volunteers further adds to the overall appeal of the masks, making them a desirable addition to their skincare regimen. The importance of consumer perception and acceptability in the cosmetic industry cannot be overstated. The success of any cosmetic product hinges on its ability to not only deliver tangible benefits but also to provide a pleasurable and satisfying experience for the user. Consumers are more likely to purchase and repurchase products that they enjoy using and that

meet their expectations in terms of both efficacy and sensory attributes. The positive feedback received in the consumer perception study suggests that the essence sheet masks formulated with red dragon fruit peel extract have the potential to resonate with consumers and gain traction in the market. The masks' natural origin, coupled with their demonstrated efficacy and positive user experience, positions them favorably in the growing "clean beauty" segment, where consumers are increasingly seeking products that are both effective and safe. The alignment between consumer perception and instrumental measurements is a noteworthy aspect of this study. The fact that consumers could perceive the improvement in their skin's hydration levels after using the masks, which was also corroborated by the corneometer measurements, underscores the reliability of subjective evaluations in assessing the efficacy of cosmetic products. While instrumental measurements provide quantitative data on specific parameters, consumer perception offers valuable insights into the overall user experience and the product's ability to meet consumer needs and expectations. The convergence of subjective and objective data in this study strengthens the evidence for the moisturizing efficacy of the essence sheet masks and highlights the importance of considering both aspects in the development and evaluation of cosmetic products. The positive consumer perception of the essence sheet masks formulated with red dragon fruit peel extract has significant implications for their commercial potential. The masks' natural origin, coupled with their demonstrated efficacy, safety, and positive user experience, positions them as attractive options for consumers seeking sustainable and effective skincare solutions. The growing demand for "clean beauty" products, driven by increasing awareness of the potential adverse effects of synthetic chemicals, further enhances the market potential of these masks. The favorable feedback received in the consumer perception study suggests that the masks have the potential to capture a significant share of the market and contribute to the growing trend of natural

and sustainable cosmetics.<sup>17,18</sup>

The findings of the present study resonate harmoniously with the growing body of literature that underscores the cosmetic potential of red dragon fruit peel extract. Previous research endeavors have illuminated the multifaceted benefits of this extract, showcasing its potent antioxidant and anti-inflammatory activities, as well as its capacity to inhibit tyrosinase, a key enzyme involved in melanin production. The antioxidant prowess of the extract, attributed to its rich repertoire of phenolic compounds and betalains, has been well-documented in numerous studies. These antioxidants neutralize free radicals, thereby mitigating oxidative stress and its detrimental effects on skin health, including premature aging, wrinkles, and inflammation. The anti-inflammatory properties of the extract, mediated through the modulation of various inflammatory pathways, further contribute to its potential in alleviating skin conditions associated with inflammation, such as acne and rosacea. The ability of the extract to inhibit tyrosinase, as demonstrated in previous research, suggests its potential for skin lightening applications, as tyrosinase plays a pivotal role in melanin synthesis, the pigment responsible for skin coloration. The current study, while acknowledging and building upon this existing knowledge base, ventures into a novel territory by specifically investigating the moisturizing efficacy of red dragon fruit peel extract in the context of essence sheet masks. The results of this investigation not only confirm the extract's ability to enhance skin hydration but also provide compelling evidence for its dose-dependent and long-lasting moisturizing effects. The observed increase in skin hydration levels after the application of sheet masks containing the extract, particularly those with higher concentrations, aligns with the extract's previously reported ability to stimulate hyaluronic acid production. Hyaluronic acid, a naturally occurring glycosaminoglycan renowned for its exceptional water-binding capacity, plays a pivotal role in maintaining skin moisture and elasticity. The extract's capacity to promote hyaluronic

acid synthesis, coupled with its antioxidant and anti-inflammatory properties, likely contributes to its multifaceted moisturizing action. The sustained improvement in skin hydration observed even after mask removal further substantiates the extract's potential as a long-lasting moisturizing agent. This prolonged effect may be attributed to the extract's ability to not only replenish moisture in the stratum corneum, the outermost layer of the skin, but also to strengthen the skin's barrier function, thereby reducing transepidermal water loss (TEWL). The skin barrier, composed of lipids and proteins, acts as a protective shield, preventing excessive water loss and maintaining skin hydration. The antioxidant compounds in red dragon fruit peel extract, by neutralizing free radicals and preventing lipid peroxidation, help to preserve the integrity of the skin barrier, thereby minimizing TEWL and promoting long-term hydration. The findings of this study also resonate with previous research that has explored the use of sheet masks as a delivery system for bioactive ingredients. Sheet masks, owing to their occlusive nature, create a humid microenvironment on the skin's surface, facilitating the penetration of active ingredients into the deeper layers of the skin. This enhanced penetration, coupled with the prolonged contact time between the essence and the skin, allows for optimal absorption and utilization of the bioactive compounds present in the red dragon fruit peel extract. The synergistic combination of the extract's moisturizing properties and the sheet mask's delivery system results in a potent and effective skincare product that delivers both immediate and long-lasting hydration benefits. The present study, by specifically focusing on the moisturizing efficacy of red dragon fruit peel extract in essence sheet masks, adds a new dimension to the existing literature. While previous studies have primarily investigated the extract's antioxidant, anti-inflammatory, and tyrosinase-inhibiting activities, this research provides concrete evidence for its potential as a natural moisturizing agent in a widely popular and convenient skincare format. The dose-dependent and long-lasting

moisturizing effects observed in this study further validate the extract's efficacy and highlight its potential for broader applications in the cosmetic industry. Furthermore, the positive consumer perception of the essence sheet masks, as evidenced by the high overall satisfaction scores and the preference for masks with higher extract concentrations, reinforces the extract's potential as a marketable and consumer-friendly ingredient. The alignment between the subjective perceptions of the consumers and the objective measurements of skin hydration further strengthens the study's findings and underscores the importance of considering both aspects in the development and evaluation of cosmetic products.<sup>19,20</sup>

#### 4. Conclusion

The study successfully demonstrated the potential of red dragon fruit peel extract as a natural moisturizing agent in essence sheet masks. The formulated masks exhibited desirable physical properties, and excellent stability, and were well-tolerated by the skin. The incorporation of the extract led to a significant and sustained increase in skin hydration, with the effect being dose-dependent. The positive consumer perception further validated the efficacy and acceptability of the masks. The findings suggest that red dragon fruit peel extract can be effectively utilized in the development of natural and effective moisturizing skincare products.

#### 5. References

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