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Original Article

Skin Revitalizing Red Dragon Fruit Peel Body Scrub: The Impact of Stearic Acid Variations and Comparison with Commercial Product

Revitalisasi Kulit dengan *Body Scrub* Kulit Buah Naga Merah: Dampak Variasi Asam Stearat dan Perbandingan dengan Produk Komersial

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Kata Kunci: asam stearat, *body scrub*, kulit buah naga merah, produk komersial pembanding.

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Abstract

The red dragon fruit peel (*Hylocereus lemairei* (Hook.) Britton & Rose) is rich in antioxidants like vitamins C, E, and A, along with alkaloids, terpenoids, flavonoids, saponins, and tannins, which protect against free radical damage. Despite its benefits, the peel is underused. This study compares the formulation and physical quality of a body scrub made from red dragon fruit peel extract to commercial products. Stearic acid was added to enhance consistency and stability, and commercial products served as benchmarks due to their compliance with physical, microbiological, and chemical standards. Formulations with stearic acid at 5% (F1), 10% (F2), and 15% (F3) were tested for physical quality—organoleptic properties, homogeneity, pH, adhesion, and spreadability—over 63 days as an intermediate time points, at controlled room temperature. Data were analyzed using SPSS Statistics 20 with a 95% confidence level ($\alpha = 0.05$). Results showed that all formulations maintained a consistent pH of 6 and homogeneity. The adhesion properties were consistent across all formulas, showing no significant difference ($p = 0.815$; $p > 0.05$). In contrast, the spreadability exhibited a statistically significant difference between formulas ($p = 0.001$; $p < 0.05$). Stability tests revealed no significant differences in physical quality over time, indicating that the formulations remained stable. The body scrub formulated with red dragon fruit peel extract demonstrated stability and quality comparable to commercially available product. This ensures that the active ingredients in the body scrub remain potent, enabling them to effectively deliver their antioxidant properties to the skin.

Abstrak

Kulit buah naga merah (*Hylocereus lemairei* (Hook.) Britton & Rose) kaya akan antioksidan seperti vitamin C, E, dan A, serta alkaloid, terpenoid, flavonoid, saponin, dan tanin yang melindungi dari kerusakan akibat radikal bebas. Terlepas dari manfaatnya, bagian kulitnya belum banyak dimanfaatkan. Penelitian ini memformulasikan dan membandingkan kualitas fisik *body scrub* yang terbuat dari ekstrak kulit buah naga merah dengan produk komersial. Asam stearat ditambahkan untuk meningkatkan konsistensi dan stabilitas, sedangkan produk komersial berfungsi sebagai tolok ukur karena kesesuaiannya dengan standar fisik, mikrobiologi, dan kimia. Formulasi dengan asam stearat 5% (F1), 10% (F2), dan 15% (F3) diuji kualitas fisiknya — sifat organoleptik, homogenitas, pH, daya lekat, dan daya sebar — selama 63 hari sebagai durasi waktu menengah studi stabilitas, pada suhu ruang yang terkendali. Data dianalisis menggunakan SPSS Statistics 20 dengan tingkat kepercayaan 95% ($\alpha = 0,05$). Hasil penelitian menunjukkan bahwa semua formula mempertahankan homogenitas dan pH yang konsisten yaitu 6. Daya lekat konsisten di semua formula dan tidak menunjukkan perbedaan yang signifikan ($p = 0,815$; $p > 0,05$). Sebaliknya, daya sebar menunjukkan perbedaan antarformula yang signifikan secara statistik ($p = 0,001$; $p < 0,05$). Uji stabilitas menunjukkan tidak ada perbedaan yang signifikan dalam kualitas fisik dari waktu ke waktu, yang menunjukkan bahwa sediaan tetap stabil. *Body scrub* ekstrak kulit buah naga merah menunjukkan stabilitas dan kualitas yang sebanding dengan produk yang tersedia secara komersial. Hal ini memastikan bahwa bahan aktif dalam *body scrub* tetap stabil, memungkinkannya untuk secara efektif memberikan sifat antioksidannya ke kulit.

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INTRODUCTION

Body scrub is one of the cosmetic preparations commonly used by women. It is intended to help remove dry, dull, and dead skin surfaces without causing adverse effects on the skin.[1] Intrinsic signs of skin aging include morphological and physiological changes such as dryness, wrinkles, and sagging. Skin aging results from both intrinsic and extrinsic factors, with extrinsic factors including ultraviolet and infrared radiation, as well as environmental carcinogens like air pollutants.[2] Some intrinsic factors that cause skin aging are enzyme

activity, cell metabolism, and hormonal and genetic factors. The collagenase enzyme, one of the metalloproteinase enzymes (MMP), breaks down collagen and causes collagen degradation. Antioxidant compounds can inhibit the enzyme collagenase, which is an indicator of the skin aging process.[2,3]

Dragon fruit, with the scientific name *Hylocereus sp*., has often been researched as a source of natural ingredients that are beneficial to health. The public has usually consumed the flesh of red dragon fruit as a natural source of antioxidants. However, the fruit's skin, which has not been widely utilized, has excellent potential and better antioxidant activity than the pulp.[4,5] Red dragon fruit peels contain various antioxidant components due to phytochemical screening and FTIR (Fourier Transform Infra-Red) tests.[6] The results of the study from Winahyu, Purnama, and Setiawati[7] showed that red dragon fruit peel extract (solvent 96% ethanol and 1% HCl with a ratio of 9:1) has an IC50 value of 2.6949 ppm which means it has very strong antioxidant activity.

Body scrub is a cosmetic formulation designed to promote healthy skin by smoothing and exfoliating dead skin cells.[8,9] Body scrub will be more effective when formulated with antioxidant-rich ingredients, as they can protect the skin from oxidative damage, moisturize the skin, and promote overall skin health.[10] Body scrubs are classified as a type of cream formulation due to their ingredients and the method of preparation. Stearic acid is an excipient of unsaturated and saturated fatty acids, and it is widely used in the formulation of oral and topical pharmaceutical preparations, with the largest component being palmitic acid.[11] Stearic acid is used as an emulsifying and solvent agent in the formulation of topical preparations. Stearic acid prepares cream preparations when neutralized with a detergent, e.g., triethanolamine. The prevalent concentration of stearic acid in ointment and cream preparations is 1-20%.[12] Topical pharmaceutical preparations with stearic acid excipients combined with triethanolamine were shown to be stable at five months of storage[13] and at stearic acid concentrations of 5%,[14] 10%,[15–17] and 15%.[18,19] While several studies have demonstrated the impact of stearic acid concentration on the physical quality of topical formulations,[20–24] none have specifically investigated its effect on the physical quality of body scrubs containing red dragon fruit peel extract as the active ingredient.

This study marks the first formulation of a body scrub cosmetic preparation using red dragon fruit peel extract (*Hylocereus lemairei* (Hook.) Britton & Rose) as the active ingredient, combined with varying concentrations of stearic acid. The objective was to develop an optimal body scrub formula with excellent quality and physical stability, using existing market products for comparison. This research aims to demonstrate the potential of red dragon fruit peel extract in enhancing skin health, thereby informing the public about its benefits in cosmetic applications.

RESEARCH METHOD

Tools and materials

The research utilized the following instruments: an analytical balance (Ohaus Pioneer PA 224C), a 500 g scale (ACIS BC), an Elmasonic S 40 H (Hans Schmidbauer GmbH & Co. KG, Germany), a rotary evaporator (BUCHI R-300), a water bath (MEMMERT GmbH+Co., KG, Germany), a universal pH indicator (Macherey-Nagel, Germany), and assorted laboratory glassware (PYREX), along with a set of adhesion test kits, extensometer glass, and *millimeter block paper*.

This study utilized extract from dragon fruit (*Hylocereus lemairei* (Hook.) Britton & Rose) sourced explicitly from Klungkung Regency, Bali, Indonesia. The formulation also incorporated additional components and excipients, including 70% ethanol, stearic acid, and triethanolamine (TEA) (sourced from PT. Brataco, Indonesia). Furthermore, propylparaben, methylparaben, glycerin, polyethylene glycol (PEG), sodium lauryl sulfate, and polyethylene spheres scrub were included in the formulation (obtained from PT. Karunia Sejahtera Abadi SABA KIMIA, Indonesia). Lastly, demineralized water was used as a vehicle in the preparation (sourced from UD. Sekawan Bali Sejahtera, Indonesia). A commercial body scrub product containing stearic acid was used for comparison.

Research Procedure

This study was a laboratory experimental study that aimed to formulate a body scrub using red dragon fruit peel extract. Stearic acid was used as an emulsifier and cream base at 5% (F1), 10% (F2), and 15% (F3) concentration variations. The quality and

physical stability of the preparations were tested through organoleptic tests, homogeneity tests, pH tests, adhesion tests, and spreadability tests. Testing was conducted on the 1st, 7th, 14th, and 63rd days. The results were then compared with body scrub products already on the market.

Determination of red dragon fruit plants

Plant identification was conducted at the Characterization Laboratory of the Botanical Garden "Eka Karya" under the National Research and Innovation Agency (BRIN) in Bali, Indonesia. This determination aimed to verify the plant's identity, ensuring accuracy and preventing any potential errors in the research.[25]

Collection and extraction of red dragon fruit peel

The red dragon fruit was in prime condition, devoid of pest-induced defects, and fully ripe, as evidenced by the uniform red hue on the fruit's peel. The dragon fruit skin, with a total mass of 2,735 grams, was initially washed and drained. It was then cut into pieces approximately 2-3 cm in size and laid out on a bamboo container covered with a black cloth. The dragon fruit skin was subsequently dried in the sun for three days. The dried red dragon fruit skin was blended until a smooth consistency was achieved.[26]

The ultrasound-assisted extraction produces dragon fruit extract. A total of 164 grams of simplisia powder derived from the peel of the red dragon fruit was added to 328 milliliters of 70% ethanol, prepared in a 1:2 ratio. Subsequently, the mixture was macerated in an Elmasonic® apparatus for three minutes and agitated for another five minutes, which was repeated thrice. Subsequently, the mixture was filtered using a Buchner funnel. The remaining residues from the filtration process were subjected to two more rounds of maceration, with 328 ml of 70% ethanol reintroduced as the solvent. The total filtrate was then evaporated using a rotary evaporator and concentrated in an oven at 40°C until a thick red dragon fruit peel extract was obtained.[20]

Manufacture of body scrub preparations

Body scrubs were made based on the formula in the following **Table 1**. Stearic acid was varied to create three formulas, namely 5% (F1), 10% (F2), and 15% (F3).

Table 1. Red Dragon Fruit Peel Extract Body Scrub Formula

Ingredients	Concentration (%)			Function
	F1	F2	F3	
Red dragon fruit peel extract	5	5	5	Active ingredients
Stearic acid	**5**	**10**	**15**	Emulsifier; cream-base
Triethanolamine (TEA)	2	2	2	Emulsifier
Polyethylene glycol (PEG)	2	2	2	Humectant
Sodium lauryl sulfate	1	1	1	Surfactant
Propylparaben	0,5	0,5	0,5	Preservatives
Methylparaben	0,3	0,3	0,3	Preservatives
Glycerine	3,3	3,3	3,3	Emollient
Polyethylene spheres Scrub	5	5	5	Exfoliator
Aquadest	75,9	70,9	65,9	Vehicle

The process begins with preparing all the necessary tools and materials. After that, all the ingredients were weighed according to the needs. The water phase, which consists of a portion of TEA, methylparaben, glycerin, sodium lauryl sulfate, PEG, and aquadest, was melted at 70°C in a glass beaker and stirred until homogeneous. Meanwhile, the oil phase, which includes stearic acid and propylparaben, was also melted at the same temperature and stirred until homogeneous.

While waiting for melt the two phases, the viscous extract was ground in a mortar and mixed with a portion of TEA and glycerin until it reached a homogeneous state. A mixture of homogeneous red dragon fruit peel extract was poured into the water phase. The two phases were mixed and stirred until homogeneous.

Next, the polyethylene spheres scrub was added and stirred until homogeneous, while the rest of the aquadest was added with a quick stirring. The stirring continued until the mixture's temperature dropped and a semi-solid mass was formed. Finally, the mass was put into a suitable container.[15]

Physical quality testing of red dragon fruit peel extract body scrub and market body scrub product

The physical quality of the body scrubs was evaluated, including organoleptic properties, homogeneity, pH tests, adhesion, and spreadability. The physical quality tests were conducted on each formulation on days 1, 7, 14, and 63, with each test replicated three times. The formulation was stored under controlled room temperature conditions until

day 63, representing the duration of the intermediate stability study.[27,28]

Organoleptic testing is conducted through observation of alterations in the color, odor, and shape (consistency) of the body scrub preparation. The appearance of color, aroma, and consistency may be utilized as a qualitative indicator of the physical instability of the preparation.[29] The homogeneity test was conducted by applying a thin layer of body scrub to a dry and clean object glass, which was then covered with a cover glass. Body scrub shows a homogeneous arrangement if the color is spread evenly; the texture appears flat and does not clump.[20] The pH measurement of the preparation was carried out using a universal indicator. One gram of the preparation is put in a beaker and diluted in 100ml aquadest. Then, a universal indicator pH paper was dipped into it. After perfect dipping, a color change in such universal indicators was observed.[29]

The spreadability test was conducted by placing 0.5 g of emulgel on a 10x10 cm^2 glass square. The emulgel was then covered with an identically sized glass of known weight and rested for a minute. Subsequently, the diameter of the emulgel spread was measured. This procedure was reiterated with incremental weights of 50 g, 100 g, and 150 g.[20] One gram of the cream was weighed and transferred to a glass plate with a 2.5 cm^2 outside area. The two plates were joined until they fused, at which point they were allowed to rest for five minutes at one-kilogram weight. After that, they were released and given an 80-gram release weight for testing.[30]

Data Processing and Analysis

Tests were conducted on days 1, 7, 14, and 63 to assess body scrubs' physical quality and stability over a 63-day storage period. The tests, replicated thrice, included organoleptic observation, homogeneity, pH, adhesion, and spreadability. Qualitative results from the organoleptic, homogeneity, and pH tests were descriptively analyzed. In contrast, quantitative data from the adhesion and spreadability tests were statistically analyzed using IBM SPSS Statistics 20 at a 95% confidence level ($\alpha = 0.05$). The analysis aimed to assess the impact of varying stearic acid concentrations on the physical quality of the body scrubs, evaluate the physical stability of the formulations over time, and identify any significant differences between the study's formulations and commercially available body scrub product.

RESULT AND DISCUSSION

This study uses red dragon fruit peel extract (*Hylocereus lemairei* (Hook.) Britton & Rose) as the active ingredient in body scrub formulation. Body scrubs, derived from natural plant extracts, are used in beauty treatments to gently exfoliate the skin, removing dirt and dead skin cells, thereby leaving the skin clean and smooth.[31,32] Red dragon fruit peel contains nutrients such as carbohydrates, fats, proteins, iron,[33,34] vitamin C,[35] and anthocyanins.[36,37] The phytochemical screening results of red dragon fruit peel extract revealed the presence of secondary metabolites, including polyphenols, flavonoids, alkaloids, steroids, quinones, tannins, monoterpenes, and sesquiterpenes.[38,39] These secondary metabolites exhibited antioxidants activity.[15,40,41] Antioxidants protect cells from damage caused by unstable molecules known as free radicals.[42,43] In this study, a body scrub with red dragon fruit peel extract was formulated to not only gently exfoliate the skin but also provide antioxidants to nourish the skin and prevent free radical damage.

The body scrub formulations in this study vary in stearic acid content, precisely at 5%, 10%, and 15%. Several studies have proven the physical stability of body scrubs at the use of stearic acid at concentrations of 5%,[14] 10%,[15–17] and 15%.[18,19] Accordingly, the present study employed the three aforementioned variations in stearic acid concentration to ascertain the impact of such variations on the quality and physical stability of red dragon fruit peel extract body scrubs. The physical quality tests conducted include organoleptic and homogeneity observation, pH measurement, adhesion test, and spreadability test. Physical quality testing was performed four times, with three replicates each, on days 1, 7, 14, and 63.

The organoleptic test results for each formula were consistent, showing a brown color and no odor (**Figure 1**). The F3 formulation, which contained the highest stearic acid concentration at 15%, was the most viscous compared to F1 and F2. Stearic acid, functioning as an emulsifier, influences the viscosity of the formulation. An increase in the concentration of stearic acid will heighten the consistency of the

formula, thereby rendering it more viscous.[12] The homogeneity test results for each formula indicated a uniform texture with no clumping and consistent color throughout the storage period up to day 63. The homogeneity of the body scrub is essential for ensuring comfort during application to the skin. The absence of lumps allows for a smoother spread, and the even dispersion of active ingredients in the preparation guarantees consistent benefits with each use.[13,20]

Figure 1. The Three Red Dragon Fruit Extract Body Scrub Formulas, respectively, from left to right, F1, F2, and F3.

The organoleptic and homogeneity observation results and the pH measurement of the red dragon fruit peel extract body scrubs can be seen in **Table 2**. The purpose of the pH test was to ensure that the pH level of the peel-off mask preparations aligns with the skin's physiological pH, thereby confirming its safety for skin use. It's crucial that the pH isn't excessively acidic to avoid skin irritation and not overly alkaline to prevent the skin from becoming dry and scaly.[20,44] The skin is best suited to a pH level between 4.1 and 7.4.[45–47] The pH value in the body scrub preparations of red dragon fruit peel extract remains stable at 6 during 63 days of storage. The result was in line with the research by Purwaningsih (2023),[48] which detected a steady pH of 6 in formulas with various percentages of stearic acid (10%, 12%, and 14%). This suggests that the concentration of stearic acid does not significantly impact the pH of the product.

Table 2. Observation and pH Measurement of Red Dragon Fruit Peel Extract Body Scrubs.

Formula	Physical Testing		Observation Time			
			Day 1	Day 7	Day 14	Day 63
F1	**Organoleptic**	Consistency	SV	SV	SV	SV
		Color	LB+	LB+	LB+	LB+
		Aroma	NO	NO	NO	NO
	Homogeneity		NL, HC	NL, HC	NL, HC	NL, HC
	Average pH value		6	6	6	6
F2	**Organoleptic**	Consistency	V	V	V	V
		Color	LB	LB	LB	LB
		Aroma	NO	NO	NO	NO
	Homogeneity		NL, HC	NL, HC	NL, HC	NL, HC
	Average pH value		6	6	6	6
F3	**Organoleptic**	Consistency	MV	MV	MV	MV
		Color	LB++	LB++	LB++	LB++
		Aroma	NO	NO	NO	NO
	Homogeneity		NL, HC	NL, HC	NL, HC	NL, HC
	Average pH value		6	6	6	6

Information:
F1, F2, F3: red dragon fruit peel extract body scrub formula with stearic acid concentration variations, 5%, 10%, and 15%, respectively
SV : slightly viscous
V : viscous
MV : most viscous
LB : light brown
LB+ : more light brown
LB++ : most light brown
NO : no odor
NL, HC : no lump, homogenous color.

The spreadability test evaluates how well body scrubs disperse on the skin. Optimal topical preparations exhibit a spreadability between 5-7 cm.[49] This characteristic is vital for ensuring uniform dose distribution upon application.[13] The spreadability of the three red dragon fruit peel extract body scrub formulas fell within the 6.27-18.53 cm (**Table 3.**). The difference in spreadability between the three formulas was caused by variations in stearic acid concentration in each formula that affected the viscosity of the preparation.[12]

Table 3. Red Dragon Fruit Peel Extract Body Scrub Spreadability Results

Formula	Average Spreadability (cm) ± SD			
	Day 1	Day 7	Day 14	Day 63
F1	14.93±1.59[a]	18.53±2.70[a]	18.10±2.85[a]	7.5±1.59[a]
F2*	6.27±0.67[b]	8.67±0.91[b]	8.20±0.36[b]	6.90±1.01[b]
F3	11.60±1.35[c]	14.20±1.45[c]	11.83±1.81[c]	9.13±0.32[c]

Information:
F1, F2, F3: Red dragon fruit peel extract body scrubs formula with stearic acid concentration variations, 5%, 10%, and 15%, respectively. The same letter code (a/b/c) on one line indicates no significant difference. An asterisk (*) on a formula indicates a significant difference with another group of formulas.

Table 3 shows that the spreadability of each formula fluctuated slightly during the observation period from day 1 to day 63. From day 1 to day 7, all three formulas exhibited an increase in spreadability, suggesting a slight decrease in viscosity. This may be attributed to the ongoing movement and reorganization of molecules within the preparation during the early stages.[50] Between days 7 and 14, the spreadability remained relatively stable. However, from day 14 to day 63, a decrease in spreadability was observed, indicating an increase in viscosity. This trend could be influenced by storage duration, as prolonged storage may result in increased viscosity.[51] Conversely, the ANOVA test results showed no significant difference in the spreadability of the three formulas over time, with p-values on days 1, 7, 14, and 63 all exceeding 0.05 (F1: $p = 0.239$; F2: $p = 0.106$; F3: $p = 0.061$). This indicates that the spreadability remained stable throughout the observation period. However, the comparison between formulas revealed a significant difference in the spreadability of Formula F2 compared to the other two formulas, with the Post Hoc test producing a p-value of less than 0.05 ($p=0.001$). In contrast, no significant difference was observed between Formulas F1 and F3, as indicated by a p-value greater than 0.05 ($p = 0.196$).

The viscosity did not increase linearly from Formula F1, which contains the lowest concentration of stearic acid (5%), to Formula F3, with the highest concentration (15%), leading to a non-linear decrease in spreadability. Formula F2, with a stearic acid concentration of 10%, exhibited the lowest spreadability, which theoretically should have been seen in F3 due to its higher stearic acid content.[12,20] The discrepancy may be attributed to inaccuracies in the initial weighing of materials or variations in the preparation procedures. Since the formulas were produced in separate batches, they were not prepared under identical conditions or at the same time. Consequently, slight variations in their characteristics may be observed compared to those produced within a single batch. This could explain the differing properties of Formula F2 in relation to the other formulas, in addition to the impact of varying stearic acid concentrations. To address this issue, Suena et al.[52] replicated the formulation process three times to ensure the reproducibility and reliability of the procedure, yielding products with consistent characteristics.

Table 4. Red Dragon Fruit Peel Extract Body Scrub's Adhesion Test Results

Formula	Average Adhesion (seconds) ± SD			
	Day 1	Day 7	Day 14	Day 63
F1	1.94±0.33[a]	1.80±0.35[a]	1.48±0.20[a]	1.85±0.35[a]
F2	2.14±0.63[a]	1.94±0.15[a]	1.55±0.12[a]	1.32±0.42[a]
F3	2.10±0.40[a]	1.80±0.30[a]	1.67±0.15[a]	1.77±0.35[a]

Information:
F1, F2, F3: Red dragon fruit peel extract body scrubs formula with stearic acid concentration variations, 5%, 10%, and 15%, respectively. The same letter code (a) on one line indicates no significant difference. The absence of an asterisk (*) on the formulas indicates no significant difference between formulas.

The adhesion test assessed the body scrub's ability to adhere to the skin's surface. It is recommended that topical formulations demonstrate adequate adhesion, lasting for at least 1 second.[49,53] The results of the adhesion test for the red dragon fruit extract body scrub formulations are presented in Table 4. Based on the time parameters, F1, F2, and F3 adhesion ranged from 1.32 to 2.14 seconds. This indicates that the adhesion of all formulas meets the requirements. Data from Table 4 show that the adhesion of each formula remained stable from day 1 to day 63, as indicated by the ANOVA test results, with p-values for the adhesion of each formula on days 1, 7, 14, and 63 all greater than 0.05 (F1: $p = 0.682$; F2: $p = 0.051$; F3: $p = 0.072$), signifying no significant differences. Similarly, the adhesion between the three formulas showed no significant differences, as demonstrated by Post Hoc test results with p-values greater than 0.05 ($p = 0.815$).

Following the preceding analysis of the physical quality of dragon fruit peel extract scrubs with varying concentrations of stearic acid as an emulsifier and viscosity enhancer, it was determined that the three formulas fulfilled the criteria for homogeneity, pH, and adhesion. However, only formula F2 met the standards for optimal topical preparation spreadability. Consequently, the physical quality of Formula F2 was then evaluated compared to the quality of commercially available preparations.

Table 5. Red Dragon Fruit Peel Extract Body Scrub Formula F2 and Comparator Product Physical Test Results

Sample	Average ± SD			
	Day 1	Day 7	Day 14	Day 63
Spreadability (cm)				
F2	6.27 ± 0.67[a]	8.67 ± 0.91[a]	8.20 ± 0.36[a]	6.90 ± 1.01[a]
P	6.40 ± 1.06[a]	6.93 ± 0.84[a]	7.20 ± 0.79[a]	6.87 ± 0.40[a]
Adhesion (second)				
F2*	2.14 ± 0.63[a]	1.94 ± 0.15[a]	1.55 ± 0.12[a]	1.32 ± 0.42[a]
P*	3.18 ± 0.55[b]	2.83 ± 0.23[b]	2.46 ± 0.14[b]	2.12 ± 0.16[b]

Information:
F2: Red dragon fruit peel extract body scrubs formula with stearic acid concentration of 10%. P: The comparator body scrub product from the market. The same letter code (a/b) on one line indicates no significant difference. The asterisk (*) on the samples indicates a significant difference.

The body scrub sample used for comparison exhibited a pH value of 6, identical to that of Formula F2. Additionally, the comparison product displayed similar texture and homogeneity to the tested formula. Table 5 shows that both Formula F2 and the comparator maintained stable spreadability over the 63-day storage period, as indicated by p-values greater than 0.05 from the Repeated Measures ANOVA test (F2: $p = 0.131$; Comparator: $p = 0.248$).

An unpaired t-test was conducted to compare the spreadability and adhesion between F2 and the comparator, as the data consisted of two independent groups and followed a normal distribution.[54] The spreadability comparison yielded a p-value of 0.167, indicating no significant difference between Formula F2 and the comparator ($p > 0.05$).

In contrast, a paired t-test revealed a significant difference in adhesion between Formula F2 and the comparator, with a p-value of 0.001 ($p < 0.05$). However, both samples demonstrated stable adhesion over the 63-day period, with the Repeated Measures ANOVA test showing no significant changes over time, indicated by p-values greater than 0.05 for adhesion at different time points (F2: $p = 0.051$; Comparator: $p = 0.069$).

Stearic acid functions as both a thickener and stabilizer, influencing the adhesion of the scrub to the skin by enhancing its viscosity. At higher concentrations, it forms a denser, creamier, and more wax-like texture, which improves the scrub's ability to remain on the skin for extended periods. This property is advantageous for body scrubs, as it facilitates more thorough exfoliation and smoother application during use.[55] Body scrubs are applied generously over the body and left to dry slightly before being gently massaged and rinsed off with water.[17] Therefore, the scrub must have the right consistency—not too runny, which would make it difficult to adhere properly to the skin, nor too thick, which would hinder smooth application over a large surface area. At moderate levels, stearic acid can provide a balance between thickness and spreadability. For instance, a concentration of around 14-16% gives a softer texture that easily spreads and adheres well without feeling too heavy. However, if used excessively, stearic acid can make the product feel too thick and less smooth, reducing its ability to glide on the skin.[56]

CONCLUSION

Based on the research findings, it can be concluded that variations in stearic acid concentration did not impact pH, homogeneity, or adhesiveness, but did affect the spreadability of the red dragon fruit peel body scrub. Among the formulations, the 10% stearic acid formula (F2) emerged as the most optimal, meeting all criteria for good physical quality. This formula exhibited compatibility with skin pH, excellent adhesion, and superior spreadability. Additionally, Formula F2 demonstrated stable physical properties, showing no significant difference in spreadability compared to commercial scrub products. These stable physical characteristics are expected to enhance the performance of the active ingredients, providing antioxidant benefits to the skin. Further research is recommended to investigate its potential as an innovative cosmetic product with improved antioxidant properties.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding this manuscript.

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