

DEVELOPMENT AND PHYSICOCHEMICAL CHARACTERIZATION OF AN ECO-FRIENDLY BODY SCRUB FROM AVOCADO PEEL (*Persea americana* Mill.)

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ABSTRACT

Continuous exposure to sunlight, environmental pollutants, and daily activities can adversely affect skin health, increasing the demand for effective skincare products. Body scrubs formulated with natural ingredients have gained considerable attention due to their exfoliating and antioxidant properties. Avocado (*Persea americana* Mill.) peel, an agricultural by-product, is rich in bioactive compounds with potential applications in cosmetic formulations. This study aimed to develop a body scrub containing avocado peel powder and evaluate its physicochemical characteristics, skin hydration effect, and consumer acceptability. An experimental laboratory study was conducted to formulate body scrubs incorporating avocado peel powder at varying concentrations. The formulations consisting of F0 (0%), F1 (2.5%), F2 (5.0%), and F3 (7.5%) avocado peel powder (*Persea americana* Mill.) were evaluated for organoleptic properties, homogeneity, spreadability, and pH. Skin hydration was measured before and after four weeks of product application, while consumer acceptability was assessed through a hedonic test involving trained panelists. All formulations demonstrated acceptable physicochemical characteristics, including uniform appearance, good homogeneity, appropriate spreadability, and pH values compatible with skin physiology. Significant improvements in skin hydration were observed across all formulations after four weeks of regular use. Among the tested formulations, Formula 1 (F1) received the highest hedonic scores, indicating the greatest level of panelist preference. *Conclusion:* Avocado peel powder exhibits promising potential as a natural exfoliating agent in body scrub formulations. The developed products possessed satisfactory physicochemical properties, enhanced skin hydration, and received high consumer acceptance, supporting the valorization of avocado peel as a sustainable and value-added ingredient in cosmetic applications.

Keywords: *avocado peel, body scrub, physicochemical characterization, skin hydration, sustainable cosmetics*

INTRODUCTION

The increasing demand for sustainable cosmetic products has accelerated the exploration of plant-derived ingredients that not only promote skin health but also contribute to the valorization of agricultural waste. In line with the principles of the circular economy, fruit by-products have attracted considerable attention as renewable sources of bioactive compounds with potential applications in cosmetic formulations (Nhani., *et al.* 2024). Their utilization offers a promising strategy to reduce environmental waste while creating value-added products with functional and commercial significance (Santoso., *et al.* 2024).

The skin is the largest organ of the human body and serves as the primary protective barrier against environmental stressors. Continuous exposure to ultraviolet (UV) radiation, air pollution, and other external factors increases the generation of reactive oxygen species (ROS),

leading to oxidative stress, collagen degradation, and premature skin aging. In addition, the accumulation of dead skin cells can reduce skin smoothness, impair moisture retention, and diminish overall skin appearance. (Suryani *et al.*, 2024).

Regular exfoliation is therefore essential to remove corneocytes, stimulate epidermal renewal, and improve the penetration of beneficial topical ingredients. Body scrubs are among the most widely used cosmetic products for skin exfoliation and body care. These formulations contain abrasive particles that mechanically remove dead skin cells while cleansing surface impurities and promoting smoother, brighter skin. Beyond their exfoliating function, modern body scrubs are increasingly expected to provide additional skin benefits, such as moisturizing and antioxidant protection, through the incorporation of natural bioactive ingredients (Iskandar *et al.*, 2023).

Avocado (*Persea americana* Mill.) peel is an abundant agricultural by-product generated from the widespread consumption of avocado fruit. Despite being commonly discarded, avocado peel is a rich source of biologically active compounds, including phenolic compounds, flavonoids, tannins, saponins, anthocyanins, and carotenoids (Sulistiyana *et al.*, 2022). These phytochemicals possess strong antioxidant activity capable of scavenging reactive oxygen species, thereby protecting skin cells from oxidative damage associated with premature aging. In addition, several studies have reported antimicrobial and anti-inflammatory properties of avocado peel, highlighting its potential as a multifunctional ingredient in topical cosmetic products. (Eka Putri Kusuma Wardani, Erna Fitriani, Panji Ratih Suci, 2021).

Previous studies have investigated avocado peel extracts in various cosmetic and pharmaceutical preparations, including moisturizing sticks, face spray gels, foundation creams, and solid soaps (Rizal *et al.*, 2024; Verawaty *et al.*, 2025; Hamdhani *et al.*, 2024; Haq *et al.*, 2025; Fanani *et al.*, 2021). These findings demonstrate the versatility of avocado peel-derived bioactive compounds in topical applications. However, research focusing on the direct utilization of avocado peel powder as a natural exfoliating agent in body scrub formulations remains limited. Unlike solvent extraction, the direct use of peel powder offers a simpler and more sustainable approach by minimizing processing steps while simultaneously exploiting its natural abrasive properties and preserving its phytochemical constituents.

Previous studies have reported the successful incorporation of avocado (*Persea americana* Mill.) peel extract into several topical cosmetic products, including face spray gels, antibacterial gels, foundation creams, moisturizing sticks, and solid soaps (Fanani *et al.*, 2021; Rizal *et al.*, 2024; Hamdhani *et al.*, 2024; Verawaty *et al.*, 2025; Haq *et al.*, 2025). These formulations demonstrated favorable physicochemical properties together with beneficial biological activities, such as antioxidant, antibacterial, moisturizing, and skin-conditioning effects. However, most previous studies have focused on avocado peel extracts rather than the direct use of avocado peel powder. Consequently, the potential of avocado peel powder as a natural exfoliating ingredient in body scrub formulations remains largely unexplored.

METHODS

This research employed an experimental laboratory-based design. The study was conducted from April to May 2026 at the Biology Laboratory and Pharmaceutical Technology Laboratory, Faculty of Health Sciences, Universitas dr. Soebandi, Jember, Indonesia.

Instruments and materials

The instruments utilized in this study included beakers (pyrex), water bath (Biobase), analytical balance (Ohaus), glass stirring rods, mortar and pestle (Onehealth), porcelain crucibles, 40-mesh sieve (B-ONE), blender (Philips), pH meter (JoanLab), skin analyzer (Minifridge), glass slides, spreadability testing apparatus, and cosmetic tubes.

The materials employed comprised stearic acid, cetyl alcohol, propylene glycol, glycerin, Tween 80, distilled water, virgin coconut oil (VCO), essential oil. All materials were of cosmetic grade. Avocado peel powder (*Persea americana* Mill.) as the active ingredient.

Procedures

Preparation of Avocado Peel Powder

Fresh avocado peels were manually separated from the pulp, thoroughly washed under running water, and cut into small pieces. The peel pieces were subsequently dried in an oven at 40°C until constant weight was achieved. The dried peels were pulverized using a blender and subsequently sieved through a 40-mesh sieve to obtain a fine, uniform powder (Lidyawati., *et al*, 2025)

Formulation of Body Scrub

Four body scrub formulations (F0, F1, F2, and F3) were prepared with varying concentrations of avocado peel powder (0%, 2.5%, 5%, and 7.5% w/w, respectively). The complete composition of each formulation is presented in **Table 1**. The formulation base was adapted from Widyasanti., *et al*. (2024), while the concentration variations were adopted from Purwandari., *et al* (2018). A commercial body scrub product (Brand X) was used as the positive control.

Table 1. Composition of avocado peel powder body scrub formulations

Ingredients	F0 (%)	F1 (%)	F2 (%)	F3 (%)	Function
Avocado peel powder	0	2,5	5	7,5	Active ingredient
Virgin Coconut Oil	6	6	6	6	Moisturizer
Stearic acid	15	15	15	15	Cream base
Cetyl Alcohol	1	1	1	1	Thickening agent
Propylenglycol	10	10	10	10	Humectant
Glycerin	5	5	5	5	Humectant
Tween 80	2	2	2	2	Emulsifier
Essential oil	5 drops	5 drops	5 drops	5 drops	Fragrance
Distilled water ad	Ad 100g	Ad 100g	Ad 100g	Ad 100g	Solvent

Preparation of Body Scrub

The preparation process began with weighing all ingredients according to the formulation composition. The ingredients were divided into oil and aqueous phases. The oil phase consisted of stearic acid, cetyl alcohol, and virgin coconut oil, while the aqueous phase contained propylene glycol, glycerin, and Tween 80. Both phases were heated separately at 70–75°C until completely melted. Subsequently, the two phases were combined and homogenized to form the body scrub cream base. Distilled water was gradually added during mixing, followed by the incorporation of avocado peel powder and essential oil until a homogeneous preparation was obtained (Widyasanti & Azara, 2024).

Evaluation of Body Scrub Characteristics

Organoleptic Evaluation

The organoleptic properties of the formulations were evaluated by observing their color, aroma, and texture characteristics (Widyasanti & Azara, 2024).

Homogeneity Test

The homogeneity test was performed by spreading 1 g of the formulation onto a glass slide to observe the presence of coarse particles and ensure uniform distribution of the preparation (Hilmi *et al*., 2023).

Spreadability Test

The spreadability test was conducted by placing 0.5 g of the formulation on a graduated glass plate. Spread diameters were measured separately after applying 50 g (B50) and 100 g (B100) loads. Measurements were performed in triplicate for each loading condition, and the results were expressed as mean $\pm$ standard deviation, following previously reported (Sulfiani *et al.*, 2023). The acceptable spreadability range for body scrub preparations is 5–7 cm (Firmansyah *et al.*, 2023)

pH Measurement

The pH value was determined using a pH meter. A 1% sample dispersion was prepared by dissolving 1 g of body scrub in 100 mL of distilled water. The acceptable pH range for cosmetic preparations according to SNI 16-4399-1996 is 4.5–8.0 (Ayuningdya *et al.*, 2023).

Skin Hydration Test

Skin hydration was evaluated using a skin analyzer. The formulation was applied to the dorsal hand area of panelists, and the hydration level was measured before and after application. A commercial body scrub product was used as a positive control (Hairiyah *et al.*, 2020). Skin hydration levels were categorized as dehydrated (0–29%), normal (30–50%), and hydrated (51–100%) (Suryani, *et al.*, 2024).

Hedonic Test

The preference test was conducted using a questionnaire evaluating color, aroma, and texture parameters. Panelists rated each parameter using a five-point hedonic scale: 1 (strongly dislike), 2 (dislike), 3 (moderately like), 4 (like), and 5 (strongly like) (Kusuma *et al.*, 2021).

Data Analysis

All quantitative data were statistically analyzed using SPSS (one-way ANOVA with LSD post-hoc or Kruskal–Wallis with Mann–Whitney) at $p < 0.05$, while organoleptic, homogeneity, and hydration data were assessed descriptively and presented graphically (Mardiansyah., *et al.*, 2024).

RESULT AND DISCUSSION

Organoleptic Evaluation

The organoleptic evaluation of the body scrub formulations was conducted by assessing their physical characteristics, including color, texture, and aroma. The observations revealed that the control formulation (F0) exhibited a white color, while the formulations containing avocado peel powder showed gradual color changes according to the concentration of the added powder. Formula FI produced a brown color, FII showed a lighter brown appearance, and FIII exhibited a darker brown color. The increased color intensity observed in formulations with higher concentrations of avocado peel powder was associated with the presence of natural pigments and bioactive compounds contained in avocado peel, which contributed to the darker appearance of the preparation (Thomas *et al.*, 2022, Nurisyah *et al.*, 2022). The texture analysis showed that F0 had a soft and smooth texture due to the absence of abrasive particles. In contrast, FI, FII, and FIII exhibited a granular texture derived from avocado peel powder. These particles function as natural exfoliating agents that provide a scrubbing effect by mechanically removing dead skin cells from the skin surface. The aroma evaluation indicated that F0 had a characteristic virgin coconut oil (VCO) odor, whereas FI, FII, and FIII showed a combination

of VCO and avocado peel powder aroma. The intensity of the avocado peel aroma increased proportionally with the higher concentration of powder incorporated into the formulation.

Homogeneity Test

The homogeneity test was performed to determine whether all components of the body scrub formulation were uniformly distributed throughout the preparation (Hikma *et al.*, 2022). The results demonstrated that all formulations showed good homogeneity, characterized by the absence of phase separation and an even distribution of ingredients. The presence of coarse particles was observed in F1, FII, and FIII due to the addition of avocado peel powder. These particles represent the characteristic properties of scrub materials and serve as mechanical exfoliating agents. The presence of these particles did not affect the homogeneity of the formulation because the powder remained evenly dispersed within the scrub base.

Spreadability Test

The spreadability test was conducted to evaluate the ability of the body scrub preparation to spread across the skin surface, which influences the ease of application and user comfort (Firmansyah *et al.*, 2023). The results demonstrated that increasing the concentration of avocado peel powder resulted in a reduction in spreadability values. This decrease was attributed to the higher amount of solid particles present in the formulation, which increased the consistency and viscosity of the preparation, thereby reducing its ability to spread (Al-Barghouthy, *et al.*, 2025).

Although the addition of avocado peel powder reduced the spreadability of the formulations, all preparations remained within the acceptable spreadability range of 5–7 cm. A similar finding was reported by irwani *et al.*, (2024), who observed a decrease in spreadability from 6.1 cm in F0 to 5.5 cm in F3 due to an increase in coconut pulp concentration. The higher amount of solid material resulted in a denser consistency; however, all formulations still met the required spreadability criteria.

Table 2. Spreadability Test Results of Body Scrub Formulations

Formulas	Load 50			Mean ± SD (cm)	Load 100			Mean ± SD (cm)
	R1	R2	R3		R1	R2	R3	
F0	6,2	6,3	6,4	6,3±0,1 ^a	6,7	6,6	6,8	6,7±0,1 ^a
F1	5,8	5,7	5,9	5,8± 0,1 ^b	6	6,1	6,2	6,1±0,1 ^b
F2	5,4	5,5	5,6	5,5±0,1 ^c	5,8	5,7	5,9	5,8±0,1 ^c
F3	5,2	5,3	5,1	5,2±0,1 ^d	5,3	5,5	5,4	5,4±0,1 ^d

Description: F0: base formulation; F1: formulation containing 2.5% avocado peel powder; F2: formulation containing 5% avocado peel powder; F3: formulation containing 7.5% avocado peel powder; B50: measurement using a 50 g load; B100: measurement using a 100 g load; R1, R2, and R3: replication 1, 2, and 3, respectively. Data are presented as mean ± standard deviation (SD) (n = 3). Different superscript letters in the same column indicate significant differences (p < 0.05)

Statistical analysis showed that the spreadability data were normally distributed and exhibited homogeneous variance. Therefore, the data were further analyzed using One-Way ANOVA. The results indicated a statistically significant difference among the formulations (p < 0.05). Subsequently, the Post Hoc analysis was performed to identify differences between individual formulations, and the results confirmed significant differences among each formulation. The spreadability test results are presented in Table 2.

pH Test

The pH test was conducted to determine the acidity level of the body scrub preparation and to evaluate its safety for topical application on the skin (Ayuningdya *et al.*, 2023). The results indicated that increasing the concentration of avocado peel powder in the formulation tended to decrease the pH value of the preparations. The reduction in pH values may be attributed to the presence of secondary metabolites in avocado peel powder, including flavonoids, tannins, and phenolic compounds, which possess acidic properties and can influence the pH of the formulation (Kaempe *et al.*,2023). Although all formulations exhibited a decrease in pH, the obtained values remained within the acceptable pH range for topical skin preparations, which is approximately 4.5–8.0 (Ayuningdya *et al.*, 2023).

A previous study by Hamdhani *et al.*, (2023) reported a similar trend, where the pH value decreased from 6.5 in the control formulation (F0) to 6.0 in F3. This decrease indicated that increasing the concentration of avocado peel ethanol extract contributed to changes in the pH characteristics of the formulation. Nevertheless, all formulations in the present study fulfilled the recommended pH requirements for skin preparations. All values are consistent with the acceptable pH range (4.5–8.0).

Statistical analysis showed that the pH data were normally distributed and had homogeneous variance; therefore, One-Way ANOVA was performed. The analysis revealed a significant difference among the formulations ($p < 0.05$). Further analysis using the Post Hoc test confirmed significant differences between each formulation. The results of the pH evaluation are presented in Table 3.

Table 3. pH Test Results of Body Scrub

Formula	pH			Mean $\pm$ SD
	1	2	3	
F0	6,5	6,4	6,2	6,4 $\pm$ 0,1 ^a
F1	6,0	5,8	5,9	5,9 $\pm$ 0,1 ^b
F2	5,6	5,5	5,4	5,5 $\pm$ 0,1 ^c
F3	4,9	5,0	5,2	5,0 $\pm$ 0,1 ^d

Description: F0: base formulation; F1: formulation containing 2.5% avocado peel powder; F2: formulation containing 5% avocado peel powder; F3: formulation containing 7.5% avocado peel powder. Data are expressed as mean $\pm$ standard deviation (SD) ($n = 3$). Different superscript letters in the same column indicate significant differences ($p < 0.05$)

Moisture Evaluation

The skin moisture evaluation was performed to determine the ability of body scrub formulations to improve skin hydration after repeated application for four weeks. The measurement results obtained using a skin analyzer showed an increasing trend in skin moisture levels after treatment in all formulation groups (F0, F1, F2, and F3), as well as in the positive control group (Suryani, *et al.*, 2024).

During the first week of observation, all treatment groups demonstrated an increase in moisture values after the application of the formulations. The moisture level increased from 37.8% to 40.8% in F0, from 34.8% to 39.4% in F1, from 26.2% to 28.4% in F2, and from 36.0% to 43.2% in F3. A similar pattern was observed in the following weeks, with gradual improvement in skin hydration after continuous use of the body scrub.

After four weeks of treatment, F3 showed the highest improvement in skin moisture levels, increasing from 44.2% before treatment to 49.6% after treatment. The baseline control group also showed an increase from 43.5% to 49.2%. The enhancement of skin hydration observed in the formulations may be attributed to the presence of virgin coconut oil (VCO),

which acts as an emollient by reducing transepidermal water loss and maintaining skin moisture. In addition, avocado peel powder contains bioactive compounds, including phenolic compounds and flavonoids, which may contribute to maintaining skin condition through antioxidant activity (Haq *et al.*, 2025). The relationship between rising humidity levels and increasing concentrations of avocado peel powder is not strictly linear. This deviation is attributed to inter-individual physiological differences among panelists, baseline variations in skin condition, and uncontrolled external variables present throughout the experimental period (Moniaga *et al.*, 2025).

The increase in moisture levels following the application of avocado peel powder-containing formulations indicates that the body scrub preparation has the potential to improve skin hydration. The higher moisture improvement observed in F3 compared with other formulations may be associated with the greater concentration of avocado peel powder incorporated into the preparation, which may enhance the moisturizing effect of the formulation.

Statistical analysis was further performed to determine whether differences in moisture levels among formulations were statistically significant. The obtained data were analyzed using an appropriate statistical test after evaluation of data normality and variance homogeneity. The results of the skin moisture evaluation are presented in Figure I.

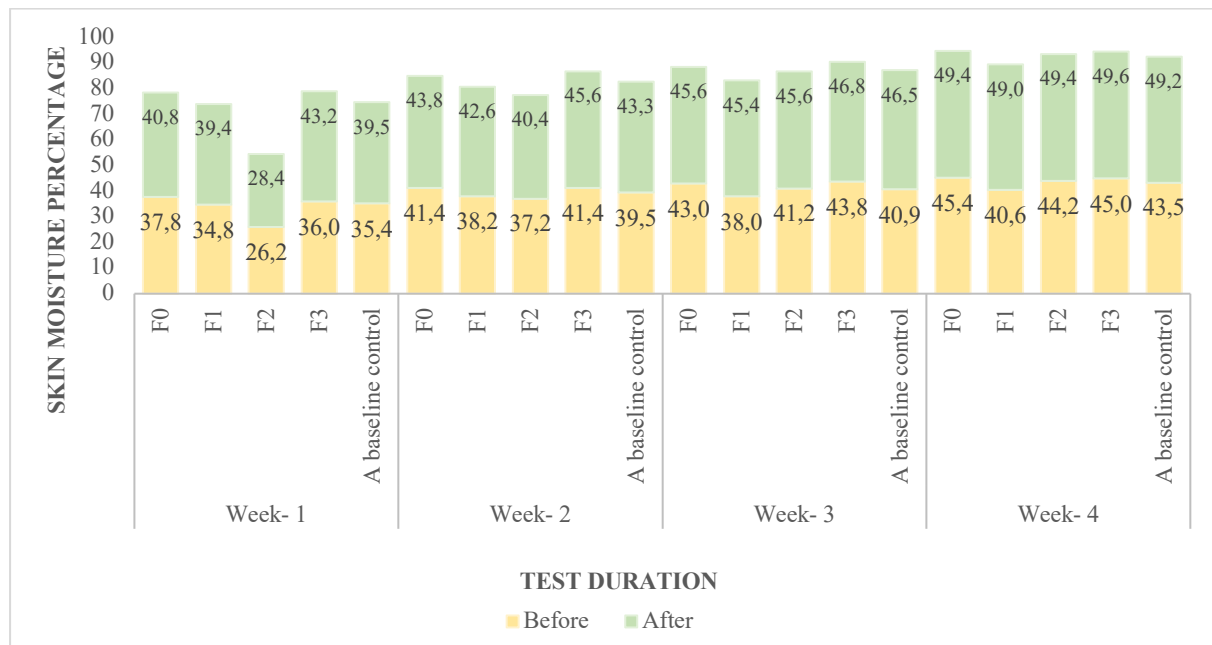


Figure 1. Graph of panelists' skin moisture levels before and after treatment

Hedonic test

A hedonic test was conducted to evaluate the panelists' acceptance of the formulated body scrub preparations. The panelists, aged between 18 and 25 years, were healthy, had no history of allergies, and voluntarily agreed to participate in the study (Kusuma *et al.*, 2021). The evaluation was carried out visually by applying the product to the skin. Panelists assessed three sensory characteristics—color, fragrance, and texture—using a structured questionnaire.

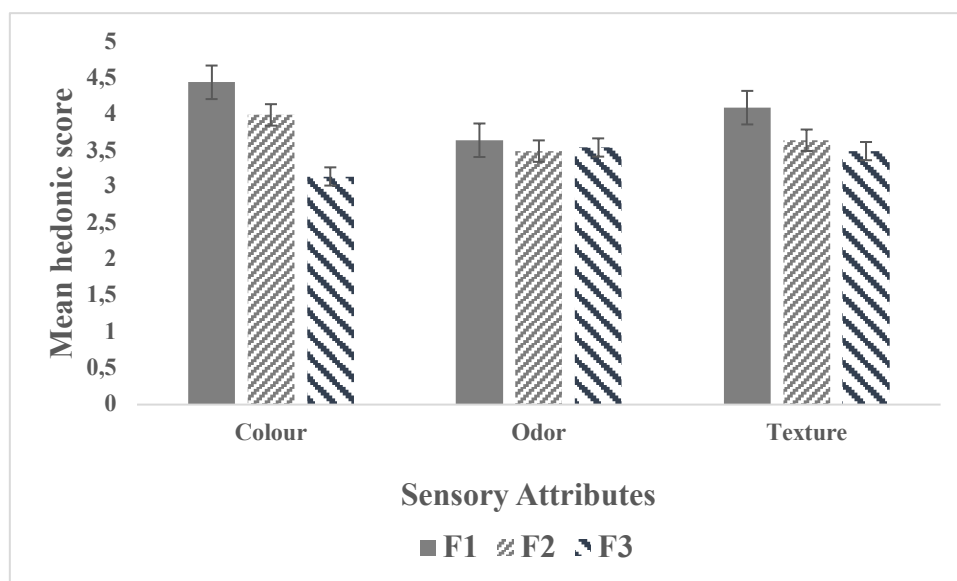


Figure 2. Graph of Hedonic Test Results

The hedonic test results revealed that color preference ranged from *like* to *strongly like*, fragrance fell within the *like* category, and texture ranged from *like* to *strongly like*. Among all formulations, F1 exhibited the highest acceptance rate. This was attributed to its moderately intense color and smoother texture. In contrast, the decreased preference scores for F2 and F3 were associated with higher concentrations of avocado peel powder, which resulted in darker coloration and a coarser product consistency (Sari *et al.*, 2025). The fragrance scores across the three formulations showed only minor differences, indicating that the scent remained generally acceptable to panelists (Ambarwati *et al.*, 2025).

These findings are consistent with Suryani *et al.*, (2026), who reported that a body scrub formulation containing 1% *Centella asiatica* extract (F1) was the most preferred due to its balanced color intensity, favorable aroma, and soft texture. Conversely, formulations with higher extract concentrations were less favored, as they produced a darker product and a more pronounced herbal scent. As the hedonic data were not normally distributed but met the homogeneity assumption, the Kruskal–Wallis test was performed. Significant differences were observed among formulations for color and texture ($p < 0.05$), whereas fragrance showed no significant difference ($p > 0.05$). Post hoc Mann–Whitney U analysis revealed significant differences between F1 and F3 and between F2 and F3 for color, while only F1 and F3 differed significantly for texture.

CONCLUSION

Avocado peel powder was successfully formulated into a body scrub with acceptable physicochemical characteristics. All formulations (F0–F3) met the required criteria for organoleptic properties, homogeneity, spreadability, and pH. All formulations also improved skin hydration after application. Among them, F3 (7.5% avocado peel powder) produced the highest skin hydration after four weeks (49.6%), indicating its potential as a moisturizing skincare product. However, the hedonic test showed that F1 (2.5%) was the most preferred formulation due to its more acceptable color and smoother texture.

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