

Evaluation of the sunscreen effectiveness of sunscreen formulations containing avocado seed ethanol extract as the active ingredient

[Uji efektivitas tabir surya berbahan aktif ekstrak etanol biji alpukat]

Vonny Setiaries Johan*, Yossie Kharisma Dewi, Royando Cibro, Mhd. Andry Kurniawan, Bintang Sipartogi Panjaitan

Department of Agriculture Technology, Faculty of Agriculture, University Riau, Pekanbaru, Riau, Indonesia

*Corresponding author email: vonny.setiaries@lecturer.unri.ac.id

Submitted: 8 December 2025, Revised: 10 February 2026, Accepted: 28 June 2026, DOI: 10.23960/jtihp.v31i2. 11-21.

ABSTRACT

Avocado (Persea americana Mill.) seeds contain antioxidant compounds, including phenolics and flavonoids, which are capable of neutralizing free radicals and absorbing ultraviolet (UV) radiation, making them a promising natural active ingredient for sunscreen formulations. This study aimed to determine the optimum concentration of avocado seed ethanol extract incorporated into a sunscreen cream based on antioxidant activity (IC_{50}), sun protection factor (SPF), and the physicochemical characteristics of the sunscreen formulation in accordance with the Indonesian National Standard (SNI 16–4339–1996). The experiment was arranged in a completely randomized design (CRD) with four extract concentrations (0.25%; 0.50%; 0.75%; and 1.00%) and four replications. The data were analysed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results demonstrated that increasing the concentration of avocado seed ethanol extract from 0.25% to 1.00% enhanced antioxidant activity, as indicated by a reduction in IC_{50} values from 143.09 ppm to 22.47 ppm, increased the SPF value from 10.43 to 15.32, and improved spread ability from 5.81 to 8.59 cm. Conversely, increasing the extract concentration reduced the pH from 7.95 to 6.59 and decreased the viscosity from 2,959.88 cP to 1,725.88 cP. The sunscreen cream containing 0.75% avocado seed ethanol extract exhibited the best overall performance, with a pH of 6.77, viscosity of 2,869.48 cP, SPF value of 15.21 (maximum protection category), spread ability of 6.53 cm, and an IC_{50} value of 45.71 ppm (very strong antioxidant activity). This sunscreen formulation complied with the requirements of the Indonesian National Standard (SNI 16–4339–1996) and was well accepted by the sensory panel based on aroma, color, and texture.

Keywords: Antioxidant, avocado seed, ethanol extract, sun protection factor, sunscreen

ABSTRAK

Biji alpukat (*Persea americana* Mill.) mengandung senyawa antioksidan seperti fenolik dan flavonoid yang mampu menetralkan radikal bebas serta menyerap radiasi ultraviolet (UV), sehingga berpotensi sebagai bahan aktif alami dalam formulasi tabir surya. Penelitian ini bertujuan untuk menentukan konsentrasi optimum ekstrak etanol biji alpukat yang diformulasikan ke dalam krim tabir surya berdasarkan aktivitas antioksidan (IC_{50}), nilai *sun protection factor* (SPF), serta karakteristik sediaan tabir surya yang memenuhi Standar Nasional Indonesia (SNI 16–4339–1996). Penelitian menggunakan rancangan acak lengkap (RAL) dengan empat konsentrasi ekstrak, yaitu 0,25%, 0,5%, 0,75%, dan 1% serta empat ulangan. Data dianalisis menggunakan Analisis Varians (ANOVA) dan dilanjutkan dengan *Duncan's Multiple Range Test* (DMRT) pada taraf 5%. Hasil penelitian menunjukkan bahwa konsentrasi ekstrak etanol biji alpukat dari 0,25% hingga 1% meningkatkan aktivitas antioksidan yang ditunjukkan oleh penurunan nilai IC_{50} dari 143,09 ppm menjadi 22,47 ppm, meningkatkan nilai SPF dari 10,43 menjadi 15,32, serta meningkatkan daya sebar dari 5,81 menjadi 8,59 cm. Sebaliknya, peningkatan konsentrasi ekstrak menyebabkan penurunan pH dari 7,95 menjadi 6,59 dan penurunan viskositas dari 2959,88 cP menjadi 1725,88 cP. Sediaan tabir surya yang mengandung ekstrak etanol biji alpukat 0,75% menunjukkan kinerja terbaik secara keseluruhan, dengan nilai pH 6,77, viskositas 2869,48 cP, nilai SPF 15,21 (kategori perlindungan SPF maksimum), daya sebar 6,53 cm, serta nilai IC_{50} sebesar 45,71 ppm (kategori aktivitas antioksidan sangat kuat). Sediaan tabir surya ini memenuhi persyaratan SNI 16–4339–1996, serta disukai oleh panelis berdasarkan atribut aroma, warna, dan tekstur.

Kata kunci: Antioksidan, biji alpukat, ekstrak etanol, *sun protection factor*, tabir surya

Introduction

Indonesia is located in the tropical region and receives constant sunlight exposure all year round. Sunlight is crucial physiologically for producing vitamin D, which is essential for maintaining bone health and supporting the immune system. However, prolonged exposure to sunlight, particularly in the absence of adequate photoprotection, may lead to both immediate skin damage (sunburn) and chronic structural changes referred to as photoaging. These adverse effects are mainly attributed to ultraviolet (UV) radiation, while blue light and infrared radiation have also been reported to contribute to photoaging (Merin et al., 2022). The skin's epidermis by itself cannot adequately defend against the impact of too much ultraviolet radiation, necessitating further protective actions. Physical shields involve wearing clothes, coats, and using umbrellas, whereas chemical defense is provided by applying sunscreen. Sunscreen is a product designed to safeguard the skin against the damaging effects of ultraviolet (UV) rays (Guan et al., 2021). Exposure to sunlight can also lead to the production of radicals, which initiate oxidative stress and potentially result in prolonged harm to skin cells. Consequently, it is essential to manage the radicals produced by sunlight to limit their detrimental effects on the skin. A promising strategy involves using substances rich in antioxidant compounds, as these agents can neutralize free radicals and offer defense against UV-related skin injury. Antioxidants work by supplying electrons to stabilize radicals, thus lowering their reactivity. Avocado seeds are a known natural source abundant in antioxidant compounds (Burhan et al., 2024).

Avocado seeds contain phenolic acids (gallic, protocatechuic, chlorogenic, caffeic, vanillic, ferulic), flavonoids (catechin, epicatechin, quercetin derivatives, kaempferol glycosides), procyanidins, and tannins (Nascimento et al., 2025). These properties can be evaluated through antioxidant activity assays and sun protection factor (SPF) measurements in sunscreen products (Thungmungmee dan Wisidsri, 2025). The sun protection factor (SPF) indicates how well a sunscreen shields the skin from the impact of sunlight. Suhaenah et al. (2019) reported that an ethanol extract of avocado seeds at a concentration of 1000 ppm exhibited an SPF value of 8.02, which falls within the maximum protection category according to SPF classification standards. However, the extract was not incorporated into a topical sunscreen formulation, and its effectiveness in a finished product was not evaluated. Therefore, additional research is necessary to develop formulations with avocado seed ethanol extract and to test their effectiveness.

Suradnyana et al. (2023) examined the use of seed extract in sunscreen products utilizing acetone as the solvent for extraction. Their results showed that the cream made from the acetone extract reached an SPF value of 3.629, classifying it as providing minimal protection. This variation in SPF values is believed to be affected by the solvent type used in the extraction process. Consequently, additional studies with solvents are required to improve the efficacy of avocado seed extract as demonstrated by both SPF ratings and antioxidant properties. Ethanol (96%) is widely regarded as an effective extraction solvent due to its high polarity, which facilitates the extraction of phenolic and flavonoid compounds from plant materials. Rivai et al. (2019) reported that ethanol was more effective than acetone in extracting phenolic and flavonoid compounds from plant matrices, resulting in higher antioxidant activity. Similarly, Burhan et al. (2024) demonstrated that the ethanol extract of avocado seeds exhibited strong antioxidant activity, with an IC_{50} value of 4.87 ppm. IC_{50} is defined as the concentration of an antioxidant required to inhibit 50% of free radical activity; lower IC_{50} values indicate stronger antioxidant capacity. This value was lower than that of the acetone extract reported by Suradnyana et al. (2023), which exhibited an IC_{50} value of 10.36 ppm, indicating that ethanol extraction produced a more potent antioxidant extract. The strong antioxidant activity of avocado seed ethanol extract suggests its potential application as an active ingredient in sunscreen cream formulations. Therefore, this study aims to evaluate the effectiveness of the ethanol extract of avocado seed as an active component in a cream-based sunscreen formulation and to assess its ability to protect the skin from UV radiation exposure.

Materials and methods

The materials used in this study consisted of avocado seeds, 96% ethanol, a cream base composed of stearic acid, cetyl alcohol, triethanolamine, glycerin, methylparaben, and distilled water. The equipment included an analytical balance, pH meter, hand mixer, oven, micropipette, 100 mL beaker, filter paper, hot plate, glass maceration jars, 100 mm glass funnel, colored bottles, latex gloves, tissue paper, cream jars, 500 mL pump bottles and droppers that were 15 cm and 8 cm long, basin, aluminum foil, viscometer (HAAKE Viscotester C, Thermo Scientific, Germany), thermometer (150°C), 500 mL measuring cylinder, rotary evaporator, 60-mesh sieve, label paper, glass slides, standard weight (125 g), sample cups, ruler, cuvettes, 10 mL volumetric flask, and a UV-Vis spectrophotometer (Shimadzu, Japan).

Research methods

The study was conducted experimentally using a completely randomized design (CRD) with four replications and four variations of avocado seed ethanol extract concentration in the cream-based sunscreen formulation, namely 0.25% (EBA1), 0.50% (EBA2), 0.75% (EBA3), and 1.00% (EBA4). The formulation of the sunscreen cream and the range of extract concentrations were adapted from Hartati (2022). The formulations used in this research can be seen in Table 1. The observation data were statistically analyzed using Analysis of Variance (ANOVA) in IBM SPSS Statistics software version 23. If $F_{\text{calculated}} \geq F_{\text{table}}$, then the concentration of avocado seed ethanol extract significantly affects the characteristics of the sunscreen and SPF value, so the analysis was then continued using Duncan's Multiple Range Test (DMRT) at a significance level of 5%.

Table 1. Formulations of the ethanol extract of avocado seed

Formulations of the ingredients for making sunscreen	Treatments			
	EBA1	EBA2	EBA3	EBA4
Avocado seed extract (ml)	0.28	0.57	0.86	1.14
Stearic acid (g)	12	12	12	12
Cetyl alcohol (ml)	0.2	0.2	0.2	0.2
Triethanolamine (ml)	0.08	0.08	0.08	0.08
Glycerin (ml)	2	2	2	2
Methylparaben (g)	0.1	0.1	0.1	0.1
Distilled water (ml)	ad 100	ad 100	ad 100	ad 100

Research procedures

(1) Production of avocado seed flour

The avocado seeds utilized in this research were sourced from fruit juice sellers in Pekanbaru City. The method for preparing seed flour followed Hayati et al. (2023) with slight modifications. The seeds were washed under running water until clean, the outer seed coat was removed, and the seeds were air-dried thoroughly. The dried seeds were then sliced and sun-dried until brittle. Subsequently, the dried avocado seeds were ground using a blender to obtain avocado seed flour (simplicia powder), which was then sieved through a 60-mesh screen to obtain a uniform particle size.

(2) Extraction of avocado seed flour

The seed flour was extracted using the method described by Hayati et al. (2023) with slight modifications. Flour derived from dried seeds was extracted through maceration using 96% ethanol as the solvent. A 500 g quantity of seed flour was placed in a glass vessel and immersed in 700 ml of 96% ethanol, ensuring complete coverage. The blend was stirred for 1×24 hours, over 3 days, to produce the filtrate. The leftover residue was subsequently reprocessed with 500 mL of 96% ethanol. Agitated for an additional 1×24 hours over 3 days. The solutions from the second extractions were passed through filter paper and merged. The solvent was then removed using an evaporator to produce a concentrated extract.

(3) Preparation of sunscreen cream

The formulation of the lotion followed Hartati (2022) which entailed combining the oil and water phases. The oil phase included stearic acid and cetyl alcohol, which were heated to 70°C until completely melted. The water phase contained triethanolamine, glycerin, methyl paraben, and distilled water heated between 70–75°C. The heated water phase was then gradually added to the oil phase with continuous stirring until a stable emulsion was formed, and the temperature decreased. After a stable cream base was obtained, avocado seed ethanol extract was incorporated at concentrations of 0.25%, 0.5%, 0.75%, and 1% according to each formulation. The mixture was subsequently homogenized using a hand mixer until a uniform and stable sunscreen cream was produced.

Research parameters

(1) pH test

The sunscreen formulation's pH assessment is intended to verify if the pH level is safe and non-irritating for the skin. Following Pratiwi et al. (2023), a pH meter was utilized to measure the pH. The electrode calibration involved pH 4 and pH 7 buffer solutions. Calibration was deemed successful when the pH readings on the display corresponded to the buffer standards and remained steady. Subsequently, the electrode was placed in the formulation, and the indicated pH value was noted.

(2) Viscosity test

The sunscreen's viscosity assessment is conducted to evaluate the cream's thickness to guarantee it can be applied smoothly. An ideal sunscreen possesses a texture that's not overly fluid nor excessively dense. The viscosity determination followed Omeh et al. (2025) with slight modifications, where 50 g of the cream sample was put into a jar and analyzed utilizing a viscometer with spindle No. 6 operating at 50 rpm. This method is commonly recommended for semi-solid cosmetic creams with viscosity in the range of 1,000–100,000 cP. A Brookfield-type rotational viscometer was used because sunscreen creams exhibit non-Newtonian, semi-solid behavior, and this instrument allows accurate viscosity measurement under controlled shear conditions.

(3) SPF test

The SPF evaluation is designed to assess the sunscreen's defense capability against UV-B rays. This assessment used the procedure of Kusumorini dan Zulkarnain (2024) with slight modifications. Five g of each formulation was added to a 10-ml volumetric flask and dissolved in 50 ml of 96% ethanol. The SPF determination was conducted using a UV-Vis spectrophotometer across wavelengths between 290 and 320 nm at 5 nm increments. The absorbance values, for each formulation were. Utilized to determine the SPF. The SPF was calculated using the following equation:

$$SPF = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

Description:

CF = Correction factor (10)

EE = Erythema effectiveness at wavelength λ

I = UV intensity at wavelength λ

Abs = Absorbance of the sample

The values of $EE(\lambda) \times I(\lambda)$ are constant. The value of $EE(\lambda)$ represents the effective erythema sensitivity at wavelength λ , while $I(\lambda)$ represents the UV intensity at wavelength λ . The combination of these values is used to calculate the SPF value.

(4) Spreadability test

The spreadability assessment was performed to verify if the sunscreen cream distributes uniformly upon application to the skin. This test followed the procedure described by Suradnyana et al. (2023). Employing the glass plate technique, a 0.5-g portion of cream was set on a glass plate and topped with another glass plate of a specific weight. Subsequently, 125-g weight was applied for 60 seconds, and the cream's spread area was then measured in horizontal and diagonal directions using a ruler.

(5) Homogeneity test

The homogeneity assessment was conducted to assess the consistency of particles throughout the lotion. This procedure followed the methodology outlined by Suradnyana et al. (2023). An amount of 0.5 g of the lotion was placed on a glass slide and was subsequently covered with another glass slide. The sample was visually inspected for any particles, white flakes, or separation of phases. A high-quality lotion should display a structure free from coarse particles and, with a thoroughly blended formulation (Liu et al., 2024).

(6) Antioxidant test

The antioxidant activity of the sunscreen formulation was evaluated to determine its potential to protect the skin against oxidative damage caused by solar radiation. The assay was performed according to the method described by Suradnyana et al. (2023), with minor modifications, using the DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging method. Briefly, 0.5 g of the cream sample was dissolved in 5 mL of ethanol and kept overnight at room temperature in the dark to facilitate extraction. Standard DPPH solutions with concentrations of 62.5; 125; 250; and 500 ppm were prepared in ethanol. Subsequently, 1.3 mL of the extract was mixed with 5 mL of DPPH solution, prepared by dissolving 0.0001 g of DPPH in 100 mL of ethanol. The reaction mixture was incubated in the dark for 30 min, after which the absorbance was recorded at 517 nm using a spectrophotometer. A DPPH control solution consisting of ethanol and DPPH was also measured at the same wavelength. Antioxidant activity is expressed as percent inhibition, calculated as follows :

$$\% \text{ inhibitor} = \frac{AB - AA}{AB} \times 100$$

Description :

AA = Absorbance of the sample after incubation,

AB = Absorbance of the control

The inhibitory concentration value (IC_{50}) represents the concentration of an antioxidant required to reduce 50% of DPPH free radicals. The IC_{50} value was calculated using the linear regression equation:

$$y = a + bx$$

Description :

y = % inhibition

x = concentration of the test solution

(7) Sensory analysis

The sensory assessment was conducted to evaluate the degree of panelist approval of the sunscreen. Sensory evaluation was performed according to Dewi et al. (2023) with slight modifications. Sensory evaluation was conducted using descriptive and hedonic tests by semi-trained panelists. The descriptive test involved 30 panelists, while the hedonic test involved 80 panelists. Samples were randomly coded and evaluated for aroma, color, and texture using questionnaires with predefined rating scales.

Results and discussion

Preparation, extraction, and formulation

Avocado seed flour was successfully prepared through washing, peeling, slicing, drying, and sieving processes, resulting in a dry and homogeneous powder with a uniform particle size suitable for extraction. Ethanolic extraction using 96% ethanol produced a concentrated dark-brown extract, indicating the presence of bioactive compounds such as phenolics and flavonoids, and demonstrating the effectiveness of ethanol as an extraction solvent. The extract was subsequently incorporated into oil-in-water sunscreen cream formulations at concentrations of 0.25%, 0.50%, 0.75%, and 1.00%. All formulations exhibited a uniform appearance without visible phase separation, indicating good emulsification and physical stability. These results confirm that the preparation, extraction, and formulation processes were successfully conducted, providing suitable materials and stable sunscreen cream formulations for further evaluation of physicochemical characteristics, antioxidant activity, and sun protection factor (SPF).

Physicochemical properties

Physicochemical properties are important parameters in evaluating the quality, stability, and applicability of sunscreen cream formulations. In this study, physicochemical evaluation included pH, viscosity, spreadability, and homogeneity. The results are presented in Table 2.

Table 2. Physicochemical properties of avocado seed extract–based sunscreen cream formulations

Treatment	pH $\pm$ SD	Viscosity (cP) $\pm$ SD	Spreadability (cm) $\pm$ SD	Homogeneity
EBA1 (0.25%)	7.95 ^b $\pm$ 0.03	2959.88 ^c $\pm$ 25.49	5.81 ^a $\pm$ 0.81	Homogeneous
EBA2 (0.50%)	7.76 ^b $\pm$ 0.38	2924.88 ^c $\pm$ 28.80	6.17 ^a $\pm$ 0.62	Homogeneous
EBA3 (0.75%)	6.77 ^a $\pm$ 0.07	2869.48 ^b $\pm$ 17.50	6.53 ^a $\pm$ 0.80	Homogeneous
EBA4 (1.00%)	6.59 ^a $\pm$ 0.29	1725.88 ^a $\pm$ 38.22	8.59 ^b $\pm$ 0.87	Homogeneous

Note : Homogeneity was evaluated descriptively by visual observation, while pH, viscosity, and spreadability were assessed using scoring tests and analyzed statistically. Values followed by different lowercase letters in the same column indicate significant differences ($p < 0.05$). SD=Standard deviation from four treatments.

The pH values ranged from 6.59 to 7.95, meeting the Indonesian National Standard (SNI 16–4339–1996) requirement (4.50–8.00) for topical sunscreen products. EBA1 and EBA2 showed no significant difference, as did EBA3 and EBA4. However, formulations containing higher concentrations of avocado seed ethanol extract (0.75–1.00%) exhibited lower pH values than those with lower extract concentrations, likely due to the presence of phenolic acids, such as gallic, ferulic, chlorogenic, and caffeic acids, which release H⁺ ions and increase formulation acidity (Setyawan et al., 2021; Nyakang et al., 2023).

Viscosity, which determines the thickness, flow behavior, and spreadability of sunscreen cream, ranged from 1,725.88 to 2,959.88 cP. EBA1 and EBA2 showed no significant difference, whereas EBA4 had the lowest viscosity. Increasing the concentration of avocado seed ethanol extract significantly reduced viscosity, likely because the additional liquid phase, phenolic compounds, and lower pH disrupted the emulsion structure and reduced TEA-stearate formation, weakening the emulsion network (Farooq et al., 2021; Ng et al., 2022; Sari et al., 2021). Similar findings have been reported for sunscreen creams containing *Eucheuma cottonii* extract (Alrosyidi & Syaifiyatul, 2021). Spreadability ranged from 5.81 to 8.59 cm. EBA1, EBA2, and EBA3 did not differ significantly, whereas EBA4 showed significantly greater spreadability. The improved spreadability at the highest extract concentration was attributed to the lower viscosity, allowing the cream to spread more easily and uniformly on the skin surface. Similar results were reported by Burhan et al. (2024), who found that increasing avocado seed ethanol extract concentration in peel-off gel mask formulations increased spreadability values. All sunscreen cream formulations were homogeneous, with no visible coarse particles, phase separation, or uneven color distribution, indicating uniform dispersion of the active ingredients and stable emulsions. The stability was attributed to amphiphilic phenolic and flavonoid compounds in the avocado seed extract, which enhanced oil–water interactions (Fainassi et al.,

2021), and to the stearic acid–triethanolamine (TEA) emulsifying system, which reduced interfacial tension and prevented phase separation (Agnesa et al., 2022; Liu et al., 2024). Good homogeneity ensures uniform distribution of active compounds, contributing to consistent UV protection (Suradnyana et al., 2023), in agreement with the findings of Burhan et al. (2024).

Functional performance

Table 3 shows that Sun protection factor (SPF) values ranged from 10.43 to 15.32. Functional performance is an important aspect in evaluating sunscreen formulations because it reflects the product's ability to protect the skin from ultraviolet radiation and oxidative damage. In this study, functional performance was evaluated through sun protection factor (SPF) and antioxidant activity (IC_{50}). The results are presented in Table 3.

Table 3. Functional performance of avocado seed extract–based sunscreen cream formulations

Treatment	SPF $\pm$ SD	IC_{50} (ppm) $\pm$ SD
EBA1 (0.25%)	10.43 ^a $\pm$ 1.31	143.09 ^c $\pm$ 9.75
EBA2 (0.50%)	13.55 ^b $\pm$ 1.20	53.01 ^b $\pm$ 8.80
EBA3 (0.75%)	15.21 ^c $\pm$ 0.06	45.71 ^b $\pm$ 2.32
EBA4 (1.00%)	15.32 ^c $\pm$ 0.18	22.47 ^a $\pm$ 3.88

Note : Values followed by different lowercase letters in the same column indicate significant differences ($P < 0.05$).

SD=Standard deviation from four treatments. $IC_{50} < 50$ ppm = very strong, 50–100 ppm = strong, 101–150 ppm = moderate, ≥ 150 ppm = weak.

SPF values, which reflect protection against UV-B radiation, were significantly affected by avocado seed ethanol extract concentration. EBA1 had the lowest SPF value and differed significantly from the other formulations, whereas EBA3 and EBA4 showed no significant difference, indicating that increasing the extract concentration beyond 0.75% did not further enhance SPF. All formulations were classified as providing medium protection. The higher SPF values were attributed to the increased phenolic and flavonoid contents, particularly catechins, which absorb UV radiation and exhibit antioxidant activity (Setyawan et al., 2021; Bangar et al., 2022; Li et al., 2023; Nascimento et al., 2025). The inverse relationship between SPF and IC_{50} further suggests that improved UV protection was associated with stronger antioxidant activity. Antioxidant activity, expressed as IC_{50} , ranged from 22.47 to 143.09 ppm, indicating moderate to very strong antioxidant capacity, with EBA4 exhibiting the lowest IC_{50} value and significantly stronger antioxidant activity than the other treatments. The improvement in antioxidant activity with increasing avocado seed ethanol extract concentration can be attributed to the higher levels of phenolic and flavonoid compounds, whose hydroxyl groups donate hydrogen atoms to neutralize free radicals, as well as the presence of tannins and saponins that may exert synergistic antioxidant effects (Kingne et al., 2019; Bangar et al., 2022). Similar findings were reported by Al-Baarri et al. (2025), who observed that higher extract concentrations increased phenolic content and antioxidant activity. Moreover, the concurrent increase in SPF values and decrease in IC_{50} values suggest that the phenolic and flavonoid compounds contribute not only to free radical scavenging but also to UV protection, thereby enhancing the overall photoprotective performance of the sunscreen formulation.

Sensory acceptability

Sensory acceptability is an important parameter in evaluating consumer preference toward sunscreen cream formulations. In this study, sensory evaluation was conducted through descriptive and hedonic tests covering aroma, color, and texture attributes. In addition, homogeneity observation was also performed to support the visual quality evaluation of the sunscreen cream formulations.

Table 4. Sensory acceptability of avocado seed extract–based sunscreen cream formulations

Observation	EBA1 (0.25%)	EBA2 (0.50%)	EBA3 (0.75%)	EBA4 (1%)
Descriptive test				
Aroma	1.23 ^a	1.80 ^b	2.03 ^b	2.90 ^c
Color	1.50 ^a	1.80 ^{ab}	2.07 ^b	2.83 ^c
Texture	2.57 ^b	2.43 ^b	2.03 ^a	1.97 ^a
Hedonic test				
Aroma	3.45 ^c	3.24 ^c	2.95 ^b	2.56 ^a
Color	3.48 ^a	3.63 ^a	4.00 ^b	4.04 ^b
Texture	4.39 ^c	4.09 ^b	3.95 ^{ab}	3.84 ^a

Note : Values followed by different lowercase letters in the same row indicate significant differences according to DMRT at a 5% significance level. Descriptive scores: Aroma: 1. Slightly avocado seed aroma; 2. Avocado seed aroma; 3. Very strong avocado seed aroma. Color: 1. Orange-white; 2. Yellow-orange; 3. Orange. Texture: 1. Slightly thick; 2. Thick; 3. Very thick. Hedonic scores: 1. Strongly dislike; 2. Dislike; 3. Slightly like; 4. Like, 5. Strongly like. Bold text indicates results meeting SNI and the quality standards applied.

The descriptive aroma scores ranged from 1.23 to 2.90, indicating aroma characteristics from slightly avocado seed aroma to very strong avocado seed aroma. The EBA4 treatment was significantly distinct from all treatments. According to the assessment by the panelists, higher amounts of avocado seed ethanol extract led to a more pronounced avocado seed scent in the sunscreen. The sunscreen's fragrance comes from the ethanol extract of the seed utilized as the base ingredient. This extract typically has a herbal and somewhat pungent odor. This particular smell is linked to the substances found in avocado seeds. The avocado seed extract is rich in elements like flavonoids, tannins, phenolics and saponins, which are responsible for its characteristic fragrance. As stated by Karrar et al. (2022) the ethanol extract derived from seeds has a characteristic scent commonly identified as herbal and somewhat pungent, noticeable through the olfactory sense. The color of sunscreen from all treatments is shown in Figure 1.

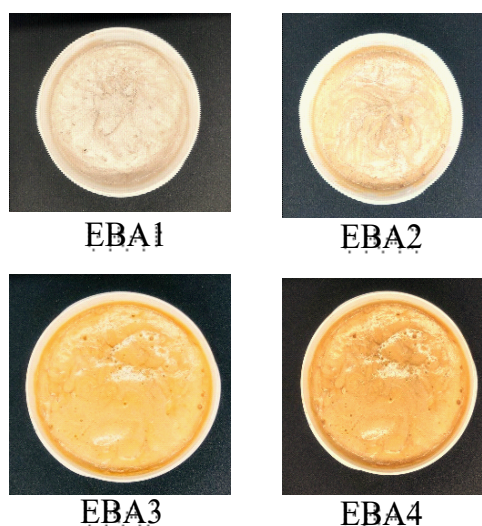


Figure 1. Avocado seed sunscreen for all treatments

The hedonic aroma scores ranged from 2.56 to 3.45, indicating moderate to good panelist acceptance. EBA1 did not differ significantly from EBA2 but showed significantly higher aroma acceptance than EBA3 and EBA4. Increasing concentrations of avocado seed ethanol extract reduced aroma preference, likely because its characteristic herbal, slightly bitter, and pungent volatile compounds became more dominant (Arum & Suroso, 2022). The cream base partially masked these notes, but panelists generally preferred sunscreen formulations with a milder, less intrusive aroma. The descriptive color scores ranged from 1.50 to 2.83, corresponding to orange-white to orange appearance. EBA1 did not differ significantly from EBA2

but differed significantly from EBA3 and EBA4. Descriptive test results indicated that higher concentrations of avocado seed ethanol extract produced a more intense orange color.

The orange color of the avocado seed extract is attributed to phenolic and flavonoid compounds that undergo partial oxidation, producing orange–brown pigments through quinone formation (Tilley et al., 2023). Although partial oxidation occurs, higher extract concentrations still retain sufficient phenolic and flavonoid contents to maintain strong antioxidant activity. Accordingly, the more intense orange color in EBA4 reflects a higher level of bioactive compounds rather than reduced antioxidant capacity. Hedonic color scores ranged from 3.48 to 4.04 ("liked" to "liked very much"), with EBA4 showing significantly higher acceptance than EBA1 and EBA2, while not differing significantly from EBA3. Panelists preferred the bright orange appearance of EBA4 because it was more visually attractive.

The descriptive texture scores ranged from 1.97 to 2.57, indicating thick to very thick cream consistency. EBA1 and EBA2 did not differ significantly but showed significantly thicker textures than EBA3 and EBA4. The lower viscosity at higher extract concentrations was likely caused by polar components in the avocado seed ethanol extract that disrupted the emulsion structure (Farooq et al., 2021). Hedonic texture scores ranged from 3.84 to 4.39, with EBA1 receiving the highest preference due to its thicker and more comfortable consistency. Although thick textures enhance stability, excessive viscosity may reduce spreadability, whereas low viscosity can decrease adhesion and emulsion stability (Shkreli et al., 2022). Overall, EBA3 provided the best balance between acceptable texture, SPF, and antioxidant activity.

Overall evaluation and optimal formulation selection

The selection of the optimal sunscreen formulation was based on a comprehensive evaluation of physicochemical properties, functional performance, and sensory acceptability. Although increasing concentrations of avocado seed ethanol extract generally enhanced SPF and antioxidant activity, the optimal formulation was determined by balancing efficacy, stability, and consumer acceptance rather than maximizing a single parameter. Formulation EBA3 (0.75%) demonstrated the most balanced performance across all evaluated parameters. This formulation exhibited a pH value (6.77) within the acceptable range for topical application, ensuring skin compatibility. Its viscosity (2869.48 cP) provided a stable cream consistency without compromising spreadability (6.53 cm), indicating good applicability and user comfort. In terms of functional efficacy, EBA3 achieved a high SPF value (15.21), categorized as providing protection, along with strong antioxidant activity (IC_{50} of 45.71 ppm), indicating potent free radical scavenging ability.

Although EBA4 (1%) showed the highest SPF and antioxidant potency, it was associated with lower viscosity, darker color intensity, and reduced sensory preference, which may negatively affect consumer acceptance. Sensory evaluation results further supported EBA3 as the most favorable formulation, as it presented acceptable color, aroma, and texture with overall hedonic scores in the liked to slightly liked range. Therefore, EBA3 was selected as the optimal formulation due to its balanced physicochemical stability, effective sun protection, antioxidant potency, and satisfactory sensory attributes.

Conclusion

The study demonstrated that variations in avocado seed ethanol extract concentration significantly influenced the physicochemical properties, functional performance, and sensory characteristics of the sunscreen cream, although the responses of several parameters were more evident at specific concentration levels. Among all formulations, EBA3 (0.75%) was identified as the optimal formulation based on an overall evaluation of efficacy, stability, and consumer acceptability. Formulation EBA3 exhibited a skin-compatible pH (6.77), appropriate viscosity (2869.48 cP), effective sun protection (SPF 15.21), adequate spreadability (6.53 cm), homogeneous cream appearance, and strong antioxidant activity (IC_{50} of 45.71 ppm). Sensory descriptive analysis indicated an orange color, avocado seed aroma, and thick texture, while hedonic evaluation showed that color was liked and aroma and texture were slightly liked.

by panelists. Therefore, EBA3 represents the most balanced formulation, providing effective protection and antioxidant potency while maintaining acceptable physical stability and sensory quality.

References

- Agnesa, E., N. D. Dinda Fransiska, I. Anggraini, A. Reviansyah, dan C. Banon. 2022. Pembuatan dan karakterisasi Krim tabir surya berbahan aktif ekstrak etanol daun suruhan (*Peperomia pellucida* L.). Kunth). *Jurnal Multi Disiplin Dehasen*. 1(1): 765–772.
- Al-Baarri, A. N., H. B. P. Putra, S. Mulyan, A. M. Legowo, A. D. Ananda, A. S. Handaruwulan, S. Dewi. 2025. Effect ginger (*Zingiber officinale* Rosc.) extract addition on antioxidant activity, phenol total content, overrun, sensory, and shelf life of ice puter. *Jurnal Teknologi dan Industri Hasil Pertanian*. 30(2): 112–122.
- Alrosyidi, A. F., dan H. Syaifiyatul. 2021. Formulasi, evaluasi mutu fisik, dan uji SPF krim tabir surya berbahan dasar rumput laut *E. cottonii*. *Majalah Farmasi dan Farmakologi*. 25(April): 15–19.
- Arum, D. A., dan S. Suroso. 2022. Utilization of avocado (*Persea americana* Mill.) seeds and cinnamon (*Cinnamomum burmannii*) as a functional powder drinks. *Journal of Science and Technology Research for Pharmacy Research*. 2(2): 10–22.
- Bangar, P. S., K. Dunno, B. S. Dhull, A. K. Siroha, S. Changan, S. Maqsood, dan A. V. Rusu. 2022. Avocado seed discoveries : Chemical composition, biological properties, and industrial food applications. *Food Chemistry: X*. 16(November): 100507.
- Burhan, A. A. Q., N. Kurniasih, dan T. D. Rosahi. 2024. Uji antioksidan ekstrak etanol biji alpukat (*Persea americana* Mill.) serta aplikasinya sebagai masker gel peel-off. *Dalam Prosiding Seminar Nasional Kimia*. 1(2): 25–33.
- Dewi, Y. K., Y. Nopiani, V. S. Johan, E. Saputra, M. Idhamsyah, dan P. Ayuni. 2023. Karakteristik gel hand sanitizer ekstrak limbah kulit nanas dan serai wangi. *Jurnal Teknologi Pertanian Andalas*. 27(1): 45–53.
- Fainassi, F., N. Taarji, F. Benkhalti, A. Hafidi, M. A. Neves, H. Isoda, dan M. Nakajima. 2021. Emulsion formation and stabilizing properties of olive oil cake crude extracts. *Processes*. 9: 1–13.
- Farooq, S., A. Abdullah, H. Zhang, dan J. Weiss. 2021. A comprehensive review on polarity, partitioning, and interactions of phenolic antioxidants at oil – water interface of food emulsions. *Comprehensive Reviews In Food Science And Food Safety*. (September 2020): 1–28.
- Guan, L. L., H. W. Lim, dan T. F. Mohammad. 2021. Sunscreens and photoaging : a review of current literature. *American Journal of Clinical Dermatology*.
- Hartati, A. 2022. Aktivitas antioksidan dan tabir surya krim ekstrak biji alpukat (*Persea americana* Mill.) dan ekstrak tongkol jagung (*Zea mays* L.). *Jurnal Kesehatan*. 13(3): 485–491.
- Hayati, M., C. S. Nusantara, dan S. Wulandari. 2023. Formulasi dan uji fisik sediaan lip balm dari ekstrak biji alpukat (*Persea americana* mill) sebagai pelembab bibir. *INPHARMED Journal (Indonesian Pharmacy and Natural Medicine Journal)*. 7(2): 84–95.
- Karrar, E., I. A. M. Ahmed, W. Wei, F. Sarpong, C. Proestos, R. Amarowicz, X. Wang. 2022. Characterization of volatile flavor compounds in supercritical fluid separated and identified in Gurum (*Citrulluslanatus* Var. *colocynthoide*) Seed Oil Using HSME and GC–MS. *Molecules*. 27: 1–10.
- Kingne, F. K., F. T. Djikeng, H. D. Tsafack, M. S. L. Karuna, dan H. M. Womeni. 2019. Phenolic content and antioxidant activity of young and mature mango (*Mangifera indica*) and avocado (*Persea americana*) leave extracts. *International Journal of Phytomedicine*. 10(4): 181.
- Kusumorini, N., dan A. K. Zulkarnain. 2024. Formulation of a lotion with ethanol extract of *Curcuma manga* Val. as a UV B sunscreen and activity test by UV-Vis Spectrophotometry. *Indonesian Journal of Pharmacy/Majalah Farmasi Indonesia*. 35(3).
- Liu, F., W. He, X. Huang, J. Yin, dan S. Nie. 2024. The emulsification and stabilization mechanism of an oil-in-water emulsion constructed from tremella polysaccharide and citrus pectin. *Foods*. 13(10).
- Merin, K. ., M. Shaji, dan R. Kameswaran. 2022. A review on sun exposure and skin diseases. *Indian Journal*

of Dermatology. 67(5).

- Nascimento, A. P. S., M. E. M. Duarte, A. P. T. Rocha, dan A. N. Barros. 2025. Valorization of avocado (*Persea americana*) peel and seed : functional potential for food and health applications. *Antioxidants*. 14: 1–20.
- Nyakang, C. O., E. Marete, R. Ebere, dan J. M. Arimi. 2023. Physicochemical properties of avocado seed extract model beverages and baked products incorporated with avocado seed powder. *International Journal of Food Science*. 20(3): 1–9.
- Omeh, R. C., I. J. Ali, C. C. Adonu, J. I. Ogbonna, L. O. Ugorji, C. C. Mbah, G. C. Onunkwo. 2025. Green synthesis of zinc oxide nanoparticles characterization and use for formulation of sunscreen topical creams. *Tropical Journal of Natural Product Research*. 9(6).
- Pratiwi, P., K. Ayu, N. P. P. Cahya Anggreni, N. P. R. Dharma Yanti, N. N. W. Udayani, dan K. Agus Adrianta. 2023. Perbandingan flavonoid total ekstrak sirih cina (*Peperomia pellucida* L. Kunth) dengan variasi konsentrasi etanol menggunakan spektrofotometri Uv-Vis. *Journal Syifa Sciences and Clinical Research*. 5(3): 392–400.
- Rivai, H., Y. T. Putri, dan R. Rusdi. 2019. Qualitative and quantitative analysis of the chemical content of hexane, acetone, ethanol, and water extract from avocado seeds (*Persea americana* Mill.). *Scholars International Journal of Traditional and Complementary Medicine*. 2(3): 25–31.
- Sari, N., E. Samsul, dan A. C. Narsa. 2021. Pengaruh trietanolamin pada basis krim minyak dalam air yang berbahan dasar asam stearat dan setil alkohol. In *Proceeding of Mulawarman Pharmaceuticals Conferences* (hal. 70–75).
- Setyawan, H. Y., S. Sukardi, dan C. A. Puriwangi. 2021. Phytochemicals properties of avocado seed: A review. *IOP Conference Series: Earth and Environmental Science*. 733(1).
- Shkreli, R., R. Terziu, L. Memushaj, dan K. Dharmo. 2022. Formulation and stability evaluation of a cosmetics emulsion loaded with different concentrations of synthetic and natural preservative. *Journal of Biological Studies*. 5(1): 38–51.
- Suhaenah, A., H. Widiastuti, dan M. Arafat. 2019. Potensi ekstrak etanol biji alpukat (*Persea americana* Mill.) sebagai tabir surya. *Journal of Pharmaceutical Sciences*. 2(2).
- Suradnyana, I. G. M., D. Juliadi, dan N. M. D. S. Suena. 2023. Formulasi serta uji aktivitas antioksidan dan tabir surya krim ekstrak aseton biji buah alpukat. *Jurnal Ilmiah Medicamento*. 9(1): 42–51.
- Thungmungmee, S., dan N. Wisidsri. 2025. Protective effects of avocado peel and seed extracts against UVB-damaged fibroblasts for the development of an anti-photoaging nanoemulgel.
- Tilley, A., M. P. Mchenry, J. A. Mchenry, dan V. Solah. 2023. Enzymatic browning : The role of substrates in polyphenol oxidase mediated browning. *Current Research in Food Science*. 7(March): 100623.