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Eco-friendly Sunscreen: *Aloe vera* and Garlic-Shallot Peel Extract Formulation for Enhanced SPF

Sri Mulyani[1,2]*, Arumsasi Putri Nugrahani[1], Karima Majid[1], Elfi Susanti VH[1], Sri Retno Dwi Ariani[1], Suryadi Budi Utomo[1], Muhammad Hizbul Wathon[1] , Widiastuti Agustina Eko Setyowati[1]

[1]Chemistry Education, Faculty of Teacher and Training Education, Universitas Sebelas Maret, Surakarta, Indonesia
[2]Center for Research and Development of Biotechnology and Biodiversity, Universitas Sebelas Maret, Surakarta, Indonesia

*Corresponding author email: srimulyaniuns@staff.uns.ac.id

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ABSTRACT. In the past 5 years, research has reported that chemical sunscreen products pose risks of irritation and environmental impact, necessitating safer natural alternatives, such as eco-friendly sunscreen. This study aimed to formulate a natural sunscreen by combining *Aloe vera* gel with garlic-shallot peel waste extracts and evaluate their solar protection factor (SPF), physical stability, overall quality, and organoleptic-hedonic test. The *Aloe vera* and extracts of garlic and shallot peels were prepared using modified infusion and solvent extraction techniques. The sunscreen formulas were created in nine variations with different concentrations of natural ingredient combinations. SPF values were determined in vitro using UV/Vis spectrophotometry, and the physical stabilities were tested using the cycling method. Overall quality tests were performed using the method as described in the standard and requirements for sunscreen products in Indonesia (SNI 16-4399-1996), and the procedure for determining the organoleptic-hedonic test referred to the organoleptic and/or sensory testing instructions (SNI 01-2346-2006). The results showed that all nine formulations met most of the quality standards of sunscreen. However, the panelist preferred formulas without garlic and shallot extracts due to the prominent odor of garlic and shallot. Further studies will be performed by combining them with fragrances that panelists prefer to cover the deficiencies in unpreferred odors. Formulas with garlic and shallot peel extracts have ultra-protection SPF values, though their effectiveness decreased with increased *Aloe vera* concentrations. These results indicate that garlic and shallot peel waste have the potential as sustainable, environmentally friendly sunscreen ingredients with high UV protection capabilities.

Keywords: *Aloe vera*, garlic peel, shallot peel, SPF, sunscreen

INTRODUCTION

The skin has a vital protective function, with the melanin layer acting as a natural UV shield. The epidermis absorbs some UV-A rays, the stratum corneum absorbs 70% of UV-B rays, and the deeper layers absorb an additional 20% (Yusharyahya, 2021). Although UV rays help produce vitamin D, essential for bone and immune health, excessive exposure can damage it into toxic steroids, which cause oxidative stress and the formation of free radicals. It can lead to skin damage, such as dryness, wrinkles, and even skin cancer (Putri et al., 2019; Oktaviasari & Zulkarnain, 2017). Sunscreens provide extra protection, with chemical types absorbing UV rays and physical types such as titanium dioxide reflecting them. The SPF value is an indicator to measure how effective and how long sunscreen is in protecting the skin. Sunscreen with a high SPF value has a high level of protection in protecting the skin from UV rays (Widyawati et al., 2019).

Chemical-based sunscreen formulations dominate the market, while sunscreens with natural additives are rarely commercially available. Although chemical sunscreens effectively protect the skin from UV rays, they have limitations, such as the potential for skin irritation, allergies, and negative environmental impact (Burns et al., 2022; DiNardo & Downs, 2018). Therefore, the development of natural alternatives, which are considered safer, have good tolerance to the skin, are more environmentally friendly, and offer additional benefits, such as antioxidant properties (Cartika et al., 2022). Antioxidants, such as flavonoids, can be used as sunscreens because they contain chromophore groups that absorb UV-A and UV-B rays (Noviardi et al., 2019).

Aloe vera, garlic, and shallots are plants rich in antioxidants. *Aloe vera* is a plant that is easily found in various places and has many benefits. It is known for its rich active compounds and moisturizing properties. *Aloe vera* is considered to have a high water content and 75 active compounds, including phenolics with antioxidant and anti-inflammatory properties (Septiani et al., 2020; Hamman, 2008). Garlic (*Allium sativum*) and shallot (*Allium cepa var. ascalonicum*) peels are waste that contain rich antioxidants and active compounds such as alkaloids, flavonoids, and quercetin (Wijayanti et al.,2017; Octaviani et al., 2019). Despite their high antioxidant content, garlic and shallot peels remain underutilized in cosmetic applications, representing a missed opportunity for sustainable innovation in sunscreen formulation.

Until now, there has been no information about combining garlic peel extract and shallot peel extract with *Aloe vera* gel in skin care. Therefore, this study aims to introduce innovation by utilizing agricultural waste from garlic and shallot peels as active ingredients, combined with *Aloe vera* gel, to create natural sunscreen. This innovation supports sustainability principles, adds value to agricultural waste, and results in a functional product that offers protection and effective skin care.

EXPERIMENTAL SECTION

Materials

Garlic peel and shallot peel were obtained from the Pasar Gede market in Surakarta, Central Java Province, Indonesia, and *Aloe vera* from agricultural land in the Klaten, Central Java Province, Indonesia. The chemical materials used in this study were purchased from Merck, including methanol, ethanol, liquid paraffin, cetyl alcohol, stearic acid, nipasol, nipagin, allantoin, PEG-40 hydrogenated castor oil, TEA, glycerin, propylene glycol, titanium dioxide (TiO_2). This study also used materials purchased from other producers, such as distilled water, methylene blue, standard buffer solutions, filter paper, aluminum foil, plastic wrap, and avocado oil.

Preparation of Garlic Peel and Shallot Peel Extracts

Garlic peel and shallot peel extracts were prepared using the maceration method according to Octaviani, et al. (2019) with modifications. Garlic peel powder 100 g was macerated with 1 liter of 70% ethanol for 24 hours in a dark bottle and then filtered. The residue obtained was macerated four times again. Filtrates obtained were collected and evaporated using a rotary evaporator at 60 °C. Shallot peel was extracted using methanol using the same maceration procedure described above. The resulting extracts were then saved in a refrigerator for further use.

Phytochemical Screening of Shallot Peel Extract and Garlic Peel Extract

Qualitative phytochemical screening was carried out per standard methods described by Harborne (1998) and Nortjie et al. (2022). Detection of alkaloids was performed using Wagner's reagent, detection of flavonoids using Mg powder and concentrated HCl, detection of saponins using hot water and foam formed, and detection of tannins using 1% $FeCl_3$ reagent.

Preparation of *Aloe Vera* Gel

The *Aloe vera* gel was prepared using a modified infusion method from Dewi & Marniza (2019). First, *Aloe vera* leaves were washed to remove latex, with the base cut and left for 15 minutes to drain the yellow latex. The leaves were rinsed, cut into 10 cm pieces, and peeled. The gel was washed, blended smoothly, filtered, and preserved. Finally, the gel was sterilized in an autoclave at 120 °C for 15 minutes and stored in a closed container at a low temperature.

Preparation of Sunscreen Cream Formulation

The formulation of the sunscreen cream is shown in **Table 1**. The preparation of the sunscreen cream base followed Puspitasari & Setyowati (2018) method with modifications. First, the oil phase was prepared by heating liquid paraffin, avocado oil, cetyl alcohol, stearic acid, nipasol, and PEG-40 hydrogenated castor oil in a water bath at 70°C until thoroughly melted, then stirred. Meanwhile, the water phase was heated by combining TEA, glycerin, propylene glycol,

Table 1. Sunscreen cream formulation

Ingredients	Total Composition (gram)								
	F0 (-)	F0 (+)	F1	F2	F3	F4	F5	F6	F7
Emollient (a mixture of liquid paraffin, avocado oil, PEG-40 hydrogenated castor oil, and allantoin)	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Emulsifier (a mixture of cetyl alcohol, stearic acid, and TEA) and Humectant (a mixture of glycerin and PG)	21	21	21	21	21	21	21	21	21
Preservative (a mixture of nipasol and nipagin)	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225
Titanium dioxide	-	1.5	-	-	-	-	-	-	-
Garlic peel extract	-	1	1	1	1	1	-	-	-
Shallot peel extract	-	1	1	1	1	1	-	-	-
Aloe vera gel	-	1	-	1	3	5	1	3	5
Distilled water	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100

nipagin, allantoin, and distilled water to 70°C, stirring until blended. The oil phase was then gradually added to the water phase while continuously mixing until a semi-solid cream base formed. Once at 70°C, extracts and gel were incorporated into the water phase.

SPS value Measurement and Protection Duration Calculation

SPF values were measured in vitro using UV-Vis spectrophotometry with chloroform and 96% ethanol blank solution, according to Pratama & Zulkarnain (2015) and Yuliati et al. (2023). About 0.2 grams of sunscreen was dissolved in 50 ml of the chloroform-ethanol mixture (1:1), and measure the absorbance at 5 nm intervals across 290-320 nm. The SPF value was calculated using the formula:

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

Description:

CF = Correction factor (valued at 10)
EE = Erythemal effect of radiation at the wavelength
I = Spectrum of simulated solar radiation
Abs = Absorbance value of the sunscreen cream formulation

Physical Testing of Sunscreen Cream Formulation

Physical testing followed the procedure outlined in SNI 16-4399-1996 for sunscreen (DSN, 1996). Details of the procedure for each physical test conducted were described in the following reference: (1) physical stability testing using two methods, the cycling method followed the procedure Lumentut et al. (2020) carried out and the storage method at a temperature of 4 °C and a room temperature (28 ± 2 °C) followed the procedure performed by Noviardi et al. (2019); (2) spreadability testing and pH testing followed the Noviardi et al., (2019) procedure; (3) physical observation and homogeneity testing followed the procedure outlined in Puspitasari et al. (2018); and (4) cream type testing used dye dispersion and dilution with distilled water methods follows Usman & Muin (2020) procedure.

Organoleptic Test of Sunscreen Cream Formulas Using Scoring and Hedonic Methods

The organoleptic/sensory test used the scoring and hedonic (preference) methods according to the organoleptic and/or sensory testing instructions in SNI 01-2346-2006 (BSN, 2006). This test was conducted to observe the physical appearance of the sunscreen cream formulation based on physical assessments by 30 untrained panelists, including color, odor, shape, and texture. Scoring and preference methods used scales 1 to 9. The data were then tabulated and analyzed using IBM SPSS Statistics 25.

Data Analysis

The test results of the cream physical were evaluated against SNI 16-4399-1996 standards for sunscreen (DSN, 1996). Organoleptic test for the scoring method and hedonic method were analyzed using the One-Way ANOVA with a 95% confidence level to observe significant differences between sunscreen cream formulations, followed by Duncan's test to examine the average differences for each treatment (Novita et al., 2017). SPF values were assessed with a 95% confidence level, applying non-parametric tests because data did not meet normality or homogeneity requirements.

RESULTS AND DISCUSSION

This study aimed to formulate and evaluate sunscreen creams combining *Aloe vera* gel with garlic and shallot peel extracts, focusing on their SPF values, physical stability, overall quality, and hedonic test results. The results presented below highlight the effectiveness of these natural ingredients in meeting the study's objectives and their potential for sustainable sunscreen development.

The Results of The Phytochemical Test for Shallot Peel and Garlic Peel Extracts

The phytochemical screening results revealed that the methanol extract of shallot peels and the ethanol extract of garlic peels contain alkaloids, flavonoids, saponins, and tannins. Most results were identical when we compared them to other researchers, even though they used a different solvent (**Table 2**). The presence of these compounds supports the potential of the extracts as active ingredients for the development of natural health and cosmetic products.

Alkaloids are commonly found in plant tissues (Maisarah et al., 2023) and exhibit anti-inflammatory and anti-aging activities (Singh et al., 2025). Flavonoids, a class of phenolic compounds, function as antioxidants by donating hydrogen atoms or chelating metal ions, contribute to photoprotective and anti-inflammatory activities (Čižmárová et al., 2023), and exist freely as aglycones or glycosides (Purwaningsih & Deskawati, 2021). Saponins are soluble in polar solvents and possess relatively high molecular weights (Yuliati et al., 2023). The saponins are triterpene glycosides, have potential as anti-inflammatory agents and provide a natural emulsifying effect that is beneficial in topical formulations, enhancing the stability of active ingredients (Sharma et al., 2023). Tannins are the polyphenol class, characterized by their polar nature (Putri & Lubis, 2020), and exhibit astringent activity, which can help tighten skin pores (Desiyana et al., 2016).

Preparation Results of the Garlic Peel and Shallot Peel Extract, and *Aloe vera* Gel

The resulting weight of the thickened ethanol extract of garlic peel was 15.25 grams with an extract yield of 15.25%. The ethanol extract of garlic peel has a thick texture, brownish-yellow color, and a characteristic garlic peel odor. The resulting weight of the thickened methanol extract of shallot peel was 9.70 grams, with an extract yield of 9.7%. The methanol extract of shallot peel has a semi-solid texture, deep reddish-brown color, and a characteristic shallot peel odor. The resulting *Aloe vera* gel has a thick, slightly liquid consistency, is yellowish white in color, and has the characteristic odor of *Aloe vera*.

Physical Testing of Sunscreen Cream Formulas

Physical observation, homogeneity, and pH of sunscreen cream formulas

The sunscreen cream was made into nine formulas (**Figure 1**), with one formula as the cream base (F0), seven formulas (F1 until F7) made with varying concentrations of active ingredients to determine the best sunscreen cream formula with the optimal combination of active ingredients, and one formula with TiO_2 as a positive control, F0(+).

All sunscreen cream preparations have a semi-solid (paste) form and a soft texture, indicating that the sunscreen cream preparations are stable and meet the required standards. Variations in the formulas' color and odor are influenced by adding *Aloe vera* gel and garlic-shallot peel extract, as observed in **Figure 1** and **Table 3**. The sunscreen base, F0(-), is bright white and odorless because it contains no garlic-shallot peel extracts.

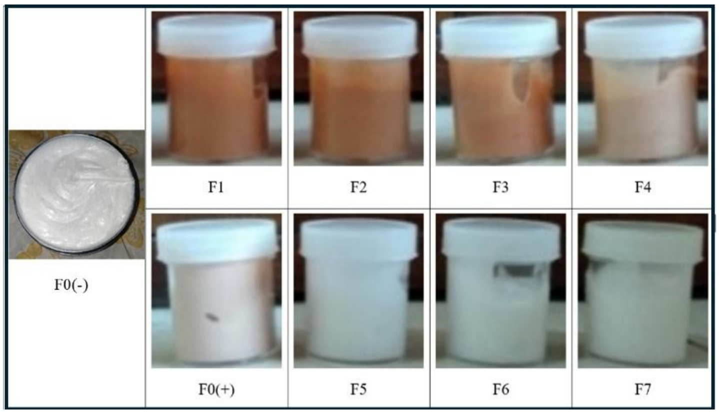
The homogeneity test conducted on the nine sunscreen formulas showed no clumps or spots, indicating that the formulas were homogeneous. The pH test results presented in Table 3 revealed that the pH values of the formulas ranged from 5.2 to 6.8. These results comply with the SNI 16-4399-1996 standard for sunscreen cream products in Indonesia., which specifies that a good-quality cream should be free from grains, clumps, or spots when applied or rubbed, and its pH should fall within the range of 4.5 to 7.5. These results indicate that the sunscreen formulas are safe for use on the skin without causing dryness or potential irritation.

The pH test results indicated that increasing the concentration of extracts in the cream formulas tends to lower the pH value. These results may be attributed to the presence of flavonoid compounds in the methanol extract of shallot peel, the ethanol extract of garlic peel, and *Aloe vera* gel, which act as weak acids, thereby reducing the pH of the sunscreen cream formulas or making them more acidic (Puspita et al., 2021).

Table 2. Phytochemical screening test results of shallot and garlic peels extracts compared with other researchers

No	References	This research		Verma et al., 2018			Wijayanti & Rosyid, 2015	Dalhat et al., 2018
	Compound Groups	Shallot Peel Methanol Extract	Garlic Peel ethanol Extract	Shallot Peel Methanol Extract	Shallot Peel Ethanol Extract	Shallot Peel Aqueous Extract	Garlic Peel Ethanol Extract	Garlic Peel Aqueous Extract
1.	Alkaloid							
	Mayer	X	X	X	X	X	X	X
	Wagner	X	X	-	-	-	+	+
	Dragendroff	+	+	X	X	X	X	X
2.	Flavonoid	+	+	+	+	+	+	+
3.	Saponin	+	+	-	-	-	+	X
4.	Tannin	+	+	+	+	+	X	+
5.	Steroid	-	-	-	-	-	-	X
6.	Triterpenoid	-	-	X	X	X	X	X

Note: (+) detected to contain the compound, (-) not detected to contain the compound, (x) test not performed



Description:
F0 (-) = Sunscreen Base (SSB)
F0 (+) = SSB + EKBP 1% + EKBM 1% + AV 1% + TiO2
F1 = SSB + EKBP 1% + EKBM 1% + AV 0%
F2 = SSB + EKBP 1% + EKBM 1% + AV 1%
F3 = SSB + EKBP 1% + EKBM 1% + AV 3%
F4 = SSB + EKBP 1% + EKBM 1% + AV 5%
F5 = SSB + AV 1%
F6 = SSB + AV 3%
F7 = SSB + AV 5%
EKBP : Garlic peel ethanol Extract
EKBM : Shallot peel methanol Extract
AV : *Aloe vera* Gel

Figure 1. The nine sunscreen cream formulas

Table 3. pH, color, and odor of sunscreen cream formulas

Formulas	pH	Color	Odor
F0 (-)	6.8 ± 0.06	Bright white	Odorless
F0 (+)	6.4 ± 0.06	Light brown	Slightly pungent
F1	5.6 ± 0.00	Dark brown	Pungent
F2	6.3 ± 0.06	Dark brown	Pungent
F3	6.0 ± 0.00	Dark brown	Pungent
F4	5.9 ± 0.06	Brown	Pungent
F5	5.7 ± 0.06	Bright white	Mildly pungent
F6	5.5 ± 0.00	Bright white	Mildly pungent
F7	5.2 ± 0.06	Bright white	Mildly pungent

The results of the sunscreen cream stability test

The stability test by storing sunscreen at room temperature showed that after 28 days, all formulas had no changes in shape, texture, odor, homogeneity, and pH, and no separation of the cream emulsion occurred. These results indicated that the sunscreen cream product is stable. However, formulas F1, F2, F3, and F4 experienced a color change, becoming darker. This phenomenon was due to oxidation of the active ingredients, such as methanol extract of shallot peel and ethanol extract of garlic peel, which caused the color change in the cream. Storage at room temperature resulted in a more significant decrease in antioxidant activity compared to storage at low temperatures, which caused oxidation in the cream (Nalawati & Wardhana, 2022).

The cream stored at 4 °C showed that after 28 days of observation, all sunscreen cream formulas did not experience significant physical changes in shape, texture, odor, or color, which remained relatively constant. These results showed that storage at low temperatures can inhibit enzyme activity and other chemical reactions in the active ingredients, thus preventing damage without causing undesirable changes. Additionally, there were no changes in the sunscreen cream's pH, phase separation, or homogenization (Wulansari et al., 2020).

From the results of the 6-cycle test, formulas F1, F2, F3, and F4 experienced a color change, becoming darker. All formulas showed no texture, odor, or homogeneity changes, and no phase separation of the cream occurred. However, all cream formulas experienced a slight change in shape, becoming more fluid, although the change was insignificant. Also, there was a slight change in pH for all formulas after the cycling test, but the change was insignificant, and the sunscreen was still within the safe pH range.

Results of spreadability and cream type test of sunscreen cream formulas

The greater the spreadability of the cream, the wider the contact between the skin and the cream, allowing for faster absorption of the cream into the skin (Rikadyanti et al., 2021). Sunscreen cream is considered to have good spreadability if its spreadability ranges between 5-7 cm (DSN, 1996; Ulaen et al., 2012). The spreadability data of the sunscreen cream is shown in **Table 4**.

The results in **Table 4** showed that increasing the concentration of *Aloe vera* gel in creams containing garlic and shallot peel extracts (F1-F4) and those that did not include them (F5-F7) decreased the spreadability of the cream. Creams F5-F7 still meet the ideal spreadability requirements according to SNI 16-4399-1996 because their range spreadability value is 5-7 cm, while creams F1-F4 did not meet them because the spreadability is below 5. The higher the *Aloe vera* gel content, the more it increased the cream viscosity, and adding shallot and garlic peel extracts increased the cream viscosity. This result aligns with research by Nuraini et al. (2023) that the more viscosity of the cream preparation, the lower the cream's spreadability.

Based on the cream type test results, all sunscreen cream formulas fall into the oil-in-water (O/W) cream type, where the blue color of methylene blue is perfectly dispersed in the cream without any lumps, and it convey to SNI 16-4399-1996. In addition, the sunscreen cream formula also mixes evenly with distilled water, indicating that the sunscreen cream is of the oil-in-water (O/W) type (Rikadyanti et al., 2021). O/W type creams can be easily washed off with water. When applied to the skin, the water in the formulation evaporates, increasing the concentration of water-soluble ingredients and enhancing their absorption into the skin tissue (Yuni et al., 2023). The O/W type formula provides a hydrating effect on the skin, enhancing skin permeability and reducing the risk of inflammation (Sangande et al., 2021).

Results of Organoleptic Test Using Scoring Method and Hedonic Method

The organoleptic test results using the Scoring method can be seen in **Table 5**, and the Hedonic method in **Table 6.** From the color parameter, the panelists preferred formulas F0(-), F5, F6, and F7, with the highest final impression score of 7-8 (very much liked). These four sunscreen creams were bright white compared to other brown formulas. The brown color in the sunscreen cream was considered less appealing. Formula F0(-) from the odor parameter received the best score, with the highest final impression score of 5 (neutral). This result is because the F0(-) tends to be odorless due to the absence of added extracts and gel.

Table 4. Results of spreadability test of sunscreen cream

Burden	Test Result								
	F0(-)	F0(+)	F1	F2	F3	F4	F5	F6	F7
Without Burden									
Average (cm)	5.3±0.0	4.1±0.0	4.8±0.0	4.6±0.0	4.5±0.0	4.4±0.0	5.5±0.0	5.2±0.1	5.0±0.0
Spread Area (cm^2)	22.1±0.0	13.2±0.0	18.1±0.0	16.6±0.0	15.9±0.0	15.2±0.0	23.7±0.0	21.2±0.0	19.6±0.0
50 gr Burden									
Average (cm)	5.4±0.0	4.2±0.0	4.9±0.1	4.7±0.1	4.6±0.0	4.4±0.0	5.7±0.1	5.3±0.1	5.2±0.0
Spread Area (cm^2)	22.9±0.0	13.8±0.0	18.8±0.0	17.3±0.0	16.6±0.0	15.2±0.0	25.5±0.0	22.1±0.0	21.2±0.0
100 gr Burden									
Average (cm)	5.5±0.0	4.3±0.0	4.9±0.1	4.8±0.0	4.7±0.0	4.5±0.0	5.8±0.1	5.4±0.0	5.3±0.0
Spread Area (cm^2)	23.7±0.0	14.5±0.0	18.8±0.0	18.1±0.0	17.3±0.0	15.9±0.0	26.4±0.0	22.9±0.0	22.1±0.0
150 gr Burden									
Average (cm)	5.7±0.1	4.4±0.0	5.1±0.0	5.0±0.0	4.8±0.0	4.6±0.1	6.0±0.0	5.5±0.1	5.4±0.0
Spread Area (cm^2)	25.5±0.0	15.2±0.0	20.4±0.0	19.6±0.0	18.1±0.0	16.6±0.0	28.3±0.0	23.7±0.0	22.9±0.0
200 gr Burden									
Average (cm)	5.8±0.0	4.5±0.1	5.2±0.1	5.1±0.1	4.9±0.0	4.7±0.0	6.3±0.1	5.6±0.1	5.5±0.0
Spread Area (cm^2)	26.4±0.0	15.9±0.0	21.2±0.0	20.4±0.0	18.8±0.0	17.3±0.0	31.1±0.0	24.6±0.0	23.7±0.0

Table 5. Organoleptic test results using the scoring method

Parameter	Anova Test	Duncan Test
Color	Significantly different between formulas	Formula F0(-) and F2 show a significant difference between their formulas. F0(-) received the highest score of 9 from the panelists, indicating a bright white color. In contrast, F2 received the most scores of 1 from the panelists, indicating that they agreed formula F2 has a very dull, dark brown color.
Odor	Significantly different between formulas	Formula F6 received the highest score of 9 from the panelists, indicating their acceptance of the strong, characteristic odor of the extract and gel in formula F6.
Form	No significant difference between formulas	Since there was no significant difference between the sunscreen cream formulas, further Duncan testing was not conducted
Texture	Significantly different between formulas	Formulas F4 and F7 have a highly significant difference between them. Panelists only accepted F4 and F7 in terms of the sunscreen cream's texture, with the highest score of 9, indicating a very smooth texture.

Note: Scala from 1 to 9

Table 6. Organoleptic test result using the hedonic method

	Hedonic quality scale for each formula								
Parameter	F0(-)	F0(+)	F1	F2	F3	F4	F5	F6	F7
Color	8	4	2	2	1	1	7	7	7 - 8
Odor	5	4	2	2	1 - 2	1	4	4	3 - 4
Form	8	7 - 8	6	7	6	5 - 6	7 - 8	8	8
Texture	8 – 9	8	7	7	7	6	8	8	8

Note: Scala from 1 to 9

On the other hand, the other formulas added active ingredients (shallot-garlic peel extracts and *Aloe vera* gel), strengthening the sunscreen cream's odor. From the form parameter, all sunscreen cream formulas tended to be liked by the panelists, with the highest final impression score of 8 (very much liked) for formulas F6, F7, and F0(-). This result is because the sunscreen cream had the form expected by the panelists, a paste or semi-liquid form that was not too thick, making it easier to apply to the skin. From the texture parameter, all sunscreen cream formulas were also generally liked by the panelists, with the highest final impression score of 8 (very much liked) for formulas F0(-), F0(+), F5, F6, and F7. This result is because the sunscreen cream had the texture that the panelists expected for a cream, being soft and easy to apply to the skin.

SPF Test Result

By measuring the SPF value, it can be determined how effectively sunscreen prevents peel damage from UV rays. The higher the SPF value of a sunscreen product, the more effective it is in protecting the skin from the harmful effects of UV rays. The SPF value for each sunscreen cream formulation can be calculated using the Mansur formula from the absorbance data obtained. The SPF measurement results are shown in **Table 7** and **Figure 2**.

In general, the higher the concentration of active ingredients added to the sunscreen cream formula, the higher the SPF value of the sunscreen (Hendrawati et al., 2020). Formula F0(+) has the highest SPF value among the other formulas due to the addition of a UV filter, which increases the SPF value of the sunscreen cream. The UV filter prevents UV rays from penetrating the skin by forming a white coating layer. This result is in line with the research by Taufikurohmah et al. (2018), which stated that sunscreen from TiO2 nanomaterials has an SPF value of 23 with a concentration of nano TiO_2 used at 20 ppm.

Formula F2, containing a 2% mixture of garlic and shallot peel extracts and 1 % *Aloe vera* gel, is the best combination of active ingredients because it has SPF value with ultra protection type higher than formula F3 and F4. However, its SPF value is lower than formula F1, which only contains 1% shallot peel methanol and 1% garlic peel ethanol extract. Adding *Aloe vera* gel reduces the SPF value of sunscreen cream containing shallot and garlic peel extracts. Although the SPF value of cream containing only *Aloe vera* gel increases with the increase in *Aloe vera* gel, the value is only below one or does not protect against UV rays.

The sunscreen activity in the cream formula is caused by adding methanol extract from shallot peel and ethanol extract from garlic (*Allium sativum*) peel, which contain secondary metabolite compounds such as flavonoids. The active flavonoid compound can reduce melanogenesis and hyperpigmentation in the skin due to the chromophore group (conjugated double bonds) that can absorb both UVA and UVB rays, thereby reducing the intensity of melanin formation and accumulation in the skin (Rahayu et al., 2017). Shallot variant peel extract also wholly blocks UV radiation below 400 nm (Nizamov et al., 2025), thus protecting skin from UV rays.

Table 7. In vitro SPF test results

Formulation	SPF Value	SPF Label	Protection Type
F0(-)	0.14 ± 0.00	0	No protection
F0(+)	37.79 ± 0.46	38	Ultra protection
F1	30.48 ± 0.22	30	Ultra protection
F2	29.31 ± 0.22	29	Ultra protection
F3	28.68 ± 0.17	29	Ultra protection
F4	25.06 ± 0.07	25	Ultra protection
F5	0.16 ± 0.01	0	No protection
F6	0.19 ± 0.04	0	No protection
F7	0.21 ± 0.00	0	No protection

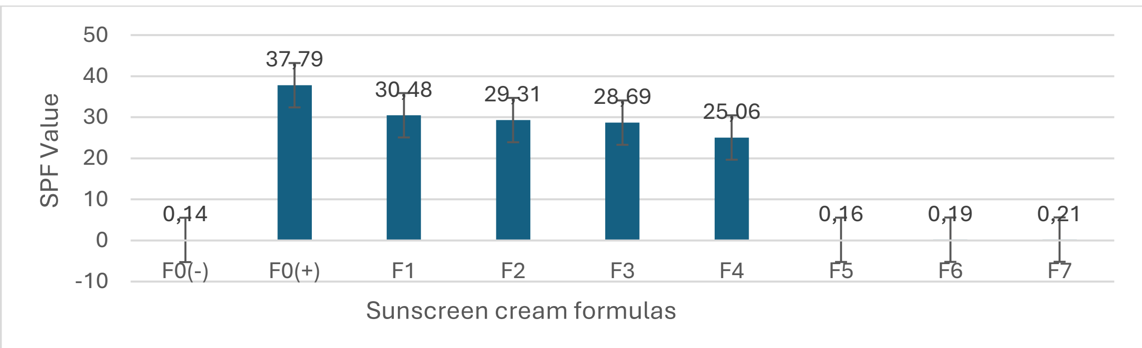


Figure 2. SPF value graph

Formula F5, F6, and F7 adding only *Aloe vera* gel without shallot and garlic peel extracts have SPF values of less than one, so they cannot be categorized as sunscreen because they cannot protect the skin. This low SPF value is due to the decreased antioxidant activity of *Aloe vera* gel during the gel production process and sunscreen formulation process (Miranda et al., 2009). Although *Aloe vera* gel has a low SPF value, it has strong anti-inflammatory properties because it contains bioactive compounds such as aloin and saponin (Ambarwati et al., 2020).

The aloin in *Aloe vera* contributes to its ability to modulate the skin's response to UV radiation, which may indirectly affect the effectiveness of topical sunscreens. *Aloe vera* can reduce inflammation caused by UV exposure (Sánchez et al., 2020). *Aloe vera* also has immunostimulant effects, which can alter the skin's immune response to UV radiation. These changes may affect the skin's natural defense mechanisms against UV damage, thereby affecting the overall effectiveness of sunscreens (Pugh et al., 2001). The interaction between *Aloe vera* and the skin's response to UV radiation suggests that while aloe vera may provide soothing and healing properties, it may also disrupt the protective barrier sunscreens designed to provide through antioxidant mechanisms, where aloin increases the activity of catalase, superoxide dismutase, and glutathione peroxidase enzymes and reduces the production of ROS (Liu et al., 2015). Flavonoids in shallot-garlic peel extracts may absorb UV rays and act as antioxidants, protecting cells from oxidative damage (Fonseca et al., 2023). The action mechanism of flavonoid antioxidants is to transfer hydrogen atoms to free radicals (Hassanpour & Doroudi, 2023). Combining garlic-shallot peel extracts with *Aloe vera* gel in a sunscreen formula probably causes flavonoids to compete with aloin in UV absorption, potentially reducing antioxidant activity and UV protection efficiency. In addition, the water content in aloe vera gel ranges from 98.5-99.5% (Hamman, 2008), so adding aloe vera gel to sunscreen cream will affect the decrease in sunscreen effectiveness, just like sweat. Sweat reduces sunscreen effectiveness through two mechanisms: disrupting the thickness and uniformity of the sunscreen layer (Keshavarzi et al., 2021). Therefore, it is necessary to understand the complementary role of *Aloe vera* and sunscreen in skin care to maximize skin protection.

The differences in significance between groups were analyzed using Kruskal-Wallis's method, followed by the Mann-Whitney test to determine the difference in SPF values between each sunscreen cream formula. The results of the Kruskal-Wallis's test showed a significant value of less than 0.05, which was 0.001, indicating a significant difference in SPF values between sunscreen cream formula groups. The results of the Mann-Whitney test showed that almost all SPF values had significant differences between formulas, with a significant value of 0.05 ($p\text{-value} \leq 0.05$). However, for formulas F5 and F6, as well as F6 and F7, there was no significant difference in SPF values ($p\text{-value} > 0.05$), indicating that the SPF value of F5 was no different from F7, and the SPF value of F6 was no different from F7.

Based on the evaluation results of nine sunscreen creams developed in this study show that the formulas containing shallot and garlic peel extracts (formulas F1 - F4) have an ultra-protection SPF value and contribute significantly to the physical and chemical stability of the formula. However, these formulas have a spreadability that does not meet the standard and still have a pronounced odor and a darker color. These results may limit consumer acceptance, so further refinement and optimization are needed in future formulas. These results also showed garlic and shallot skin waste has commercialized potential as an environmentally friendly sunscreen ingredient with high UV protection capabilities.

CONCLUSIONS

This study concluded that the sunscreen cream formulas made from a combination of garlic peel ethanol extract, shallot peel methanol extract, and *Aloe vera* gel met most of the SNI 16-4399-1996 standards for sunscreens, except for spreadability, as some formulas only spread less than 5 cm. Organoleptic tests showed significant differences in most parameters, with the highest color, shape, and texture scores for formulas F0(-), F6, and F7. Stability tests showed no emulsion separation, although color changes were seen in formulas F1-F4. Finally, in-vitro SPF tests identified formula F0(+) with the highest SPF value of 38, which offered ultra protection for about 7.62 hours. Adding *Aloe vera* gel decreased the SPF values of sunscreen creams containing shallot and garlic peel extracts.

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