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Formulation and SPF Value Determination of Spray Preparations From Depok Starfruit Extracts (Averrhoa Carambola L.)

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Abstrak

Sunscreen digunakan untuk melindungi kulit dari radiasi sinar UV. Salah satu bahan alami yang berpotensi sebagai sunscreen adalah ekstrak belimbing depok(*Averrhoa carambola L.*) yang mengandung senyawa flavonoid. Belimbing depok yang berasal dari Depok, Indonesia, diekstraksi dengan larutan air dan diuapkan menggunakan *rotary evaporator* untuk memperoleh hasil yang kental. Telah dilakukan skrining fitokimia ekstrak bersamaan dengan kromatografi lapis tipis. Formulasi sunscreen dibuat terlebih dahulu dengan melarutkan bahan ke dalam masing-masing fase air dan minyak, dilanjutkan dengan mencampurkan kedua fase tersebut dengan ekstrak. Tiga formulasi dibuat dengan konsentrasi ekstrak berbeda yaitu 2, 4, 6% b/v. Seluruh formulasi diamati secara fisik melalui penilaian organoleptik, homogenitas, pH, pola penyemprotan, daya sebar lekat dan dilanjutkan dengan penilaian stabilitas pada suhu penyimpanan 4° & 40°C selama 24 jam. Ekstrak dan seluruh formulasi dievaluasi menggunakan spektrofotometer UV-Vis dalam rentang panjang gelombang 290-320 nm pada interval 5 nm untuk penentuan nilai SPF. Semua pengukuran diulang tiga kali. Hasil ekstrak menunjukkan kandungan flavonoidnya. Ketiga formulasi menunjukkan karakteristik fisik dan stabilitas penyimpanan yang baik. Formulasi semprot yang mengandung ekstrak belimbing wuluh konsentrasi 2% memberikan perlindungan maksimal (SPF 14.09). Formulasi dengan ekstrak 4% menawarkan perlindungan ultra (SPF 16.66), sedangkan formulasi dengan ekstrak 6% memberikan perlindungan ultraviolet yang lebih tinggi (SPF 18.33). Di antara seluruh konsentrasi yang diuji, formulasi dengan konsentrasi ekstrak 6% menunjukkan nilai SPF tertinggi, yaitu 18,33, menawarkan perlindungan ultra terhadap sinar matahari. Penelitian ini menunjukkan bahwa formulasi semprotan dengan ekstrak belimbing wuluh sebagai bahan sunscreen alami mempunyai kemampuan dalam menyerap sinar ultraviolet tingkat tinggi.

Kata Kunci: Averrhoa Carambola L, Belimbing, sunscreen, SPF, Spray

Abstract

Sunscreen is used to protect the skin from UV radiation. One of the natural ingredients potentially used in sunscreen is starfruit (Averrhoa carambola L.) extract, which contains flavonoid compounds. The starfruit, originated from Depok, Indonesia, was extracted with aqueous solution and rotary evaporated to obtain a viscous yield. Extract's phytochemistry screening in tandem with thin layer chromatography was performed. The sunscreen formulation was firstly prepared by dissolving the materials into each aqueous and oil phase, continued by mixing both phases with the extracts. Three formulations were prepared with different extracts concentration of 2, 4, 6% w/v. All formulations were observed physically through organoleptic assessment, homogeneity, pH, spray pattern, adhesive spreadability continued by stability assessment in 4o & 40oC storage temperature for 24 hrs. Both extracts and all formulations were evaluated using a UV-Vis spectrophotometer within the wavelength range of 290-320 nm at 5 nm intervals for SPF value determination. All measurements were repeated three times. The extract yield revealed its flavonoid content. All three formulations exhibited good physical characteristics and storage stability. The spray formulation containing 2% concentration of starfruit extract provided maximum protection (SPF 14.09). Formulations with 4% extract offered ultra protection (SPF 16.66), while formulations with 6% extract provided even higher ultraviolet protection (SPF 18.33). Among all tested concentrations, the formulation with 6% extract concentration demonstrated the highest SPF value, which is 18.33, offering ultra protection against sunlight. This study demonstrates that the spray formulation with starfruit extract as a natural sunscreen ingredient has the ability to absorb high levels of ultraviolet rays.
Keywords: *Averrhoa Carambola L, Starfruit, sunscreen, SPF, Spray*

INTRODUCTION

Exposure to high ultraviolet radiation can cause skin burns, skin redness, skin darkening, and can even cause skin cancer (Adzhani, Darusman, dan Aryani, 2022). UV radiation can also cause oxidation, which causes aging due to ROS. Therefore, the development of skin cancer as carcinoma and malignant melanoma are the main long-term side effects of UV exposure to the skin. Melanoma, the third type of skin cancer, is a more dangerous type and causes many deaths (Mota et al., 2020).

Most of the three types of skin cancer are caused by exposure to UV rays. The use of sunscreen can absorb, scatter, and reflect UV radiation in areas of the body that are often exposed (Minerva, 2019). This radiation has the ability to penetrate the deeper layers of the skin until it reaches the dermis, which is responsible for skin changes that are associated with aging (Mota et al., 2020).

Plants contain antioxidants that are high enough to minimize the effects of UV radiation. Belimbing Depok is a plant that has antioxidant activity (Pertiwi, 2018).

This antioxidant activity is produced from the compounds contained in the depok starfruit, including the flavonoid compounds of the flavonol group, which have a similar structure to quercetin, which is substituted for 3-OH. The active ingredients contained that act as sunscreens are phenolic compounds, polyphenols, flavonoids, tannins, and vitamin C (Pasha dan Susilo, 2021). Sunscreens with spray preparations that are easy to apply can enable users to reuse sunscreen more often (Ou-Yang et al., 2017).

RESEARCH METHOD

The research was conducted on the Depok starfruit plant which had been determined by BRIN, and in the pharmacognosy laboratory and chemistry laboratory, Faculty of Pharmacy, Jakarta Global University.

The tools used were a UV VIS spectrophotometer (Shimadzu UV-1780), rotary evaporator (Buchi R-100), and TLC cabinet (CAMAG UV 245-266).

Examination of Simplicia Characteristics

1. Plant Determination

The depok starfruit used for research comes from plantations in the Depok area, West Java. The fruits taken as samples were seedless fruits that were almost ripe and in good condition and were determined at BRIN Cibinong, West Java.

2. Macroscopic Observation

Macroscopic test by observing the shape of the simplicia is measured for its length using a ruler and the outer form of the simplicia. Colour is observed using a magnifying glass. Smell and taste are observed with the senses (Depkes RI, 2000).

Extraction of Belimbing Depok

The depok starfruit prepared the extract and then weighed as much as 2 kg. Depok starfruit is washed thoroughly, and then depok, starfruit is mashed using a juicer. After that, it was concentrated using a rotary evaporator at 50 °C (Astiti, Sudirga, dan Ramona, 2019), then the extraction results were stored at 4 °C (Vargaz-Madrizv et al., 2021). Extract yield formula according to (Depkes RI, 2008).

1. Organoleptic Testing

Organoleptic testing includes shape, color, smell and taste. The extract was placed in the container and then observed the shape of the extract, the color contained in the extract, the smell and taste of the extract using the five senses (Depkes RI, 1980).

2. Simplicia Quality Standard Examination
    a. Determination of Drying Shrinkage

       A total of 3 porcelain crucibles were heated at 105°C for 5 hours. After heating, the crucible containing the simplicia was placed in a desiccator for 15 minutes and weighed again. The drying process is continued and considered again at intervals of 1 hour until the difference between successive weighings is no more than 0.25% (Febriyenti et al., 2018).
    b. Determination of Total Ash Content

       3 porcelain crucibles were heated at 105°C for 30 minutes and then tared. Then, the simplicia was weighed as much as 6 grams and divided into three different porcelain crucibles (each crucible contained 2 grams of simplicia). After that, each crucible was put into the furnace and then ignited at 600°C for 7 hours. After igniting the crucible containing the simplicia, it is placed in a desiccator for 15 minutes and weighed again (Febriyanti et al., 2018).
    c. Determination of Acid Insoluble Ash Content

       Boil the ash obtained to determine total ash content with 25 mL of dilute hydrochloric acid LP for 5 minutes. Collect the insoluble matter in acid, filter through ash-free filter paper, rinse with hot water, and heat in a crucible to constant weight. The ash content that does not dissolve in the acid is calculated against the importance of the test material, expressed in % w/w. Judging from the quality standards, all treatments still met the criteria, at most 1.7% (Depkes RI, 2008).

Phytochemical Screening Test

1. Alkaloid Test

1 mL of liquid extract was added to 5 mL of chloroform and two drops of NH_4OH and then put into a tube with a closed reaction. Then, the chloroform extract in a test tube was shaken with 6 mL of 2M H_2SO_4, and the acid layer was separated into another test tube. The acid layer is then dripped onto the drip plate and added to the Mayer, Wagner and Dragendorf reagents, which will cause precipitates of white, brown and orange-red, respectively (Eliyanoor, 2017).

2. Flavonoid Test

As much as 1 mL of depok starfruit extract was put into a test tube, and then added two drops of 10% NaOH and shaken vigorously. Positive samples contain flavonoids when the solution changes colour to yellow, red, or brown (Adithya et al., 2017).

3. Saponin Test

Put 0.5 g of extract into a test tube, add 10 ml of hot water, cool, and shake vigorously for 10 seconds. (If the substance being examined is in the form of a liquid preparation, dilute 1 ml of extract with 10 ml of water and shake vigorously for 10 seconds), a firm foam of 1 cm to 10 cm high is formed for 10 minutes. With the addition of 1 drop of 2N HCl, the foam did not disappear (Eliyanoor, 2017).

4. Tanin Test

The tannin test was carried out by diluting 1 mL of the sample with 2 mL of distilled water and adding FeCl3 reagent to form a black-blue or black-green colour (Ratnasari et al., 2022).

5. Triterpenoid Test

15 mg of the extracted sample was dissolved in 15 ml of solvent and then put into a 1 ml test tube. Ten drops of concentrated sulfuric acid were added to the test sample. A positive reaction occurs in red or purple (Iskandar, 2020).

Thin Layer Chromatography

The determination of flavonoid compounds used the stationary phase GF254 and the mobile phase a mixture of n-Butanol: acetic acid: aquadest (4:1:5). The GF254 silica gel TLC plate was activated by baking at 100°C for 30 minutes. The reference solution used was 26 26 quercetin 0.05% in ethanol p.a. Dab the test solution and the reference solution at a distance of 1.5-2 cm from the bottom edge, letting the mobile phase spread to the creepage distance limit. Remove and dry the plate, observing the spots with short wave UV visible light 254 nm and then with long wave UV 366 nm (Ketut Linda et al., 2023). Then sprayed using 3 to identify flavonoids (Nurfitriyana et al., 2022).

Formula Design

Table 1. Formula Design

Ingredient Name	Formula (%)			Fungsi
	I	II	III	
depok starfruit extract	2	4	6	Active substance
Cetyl alcohol	1	1	1	Emulsifier
Glycerin	10	10	10	Humectan
Stearic acid	2,5	2,5	2,5	Emulsifier
Liquid paraffin	3,8	3,8	3,8	Emulsifier
Methyl paraben	0,18	0,18	0,18	Antimicroba
Propylparaben	0,02	0,02	0,02	Antimicroba
Bubblegum oil	qs	qs	qs	Fragrance
Aquadest ad	100 ml	100 ml	100 ml	Solvent

Sumber: (Salsabila, 2021)

Oil-soluble materials (stearic acid, cetyl alcohol, liquid paraffin) are added to the evaporating cup. Materials that dissolve in water (glycerin, distilled water) are put into a beaker. The oil and water phases are heated and stirred separately at 70-75°C until homogeneous, then mixed at 70°C while stirring until both phases are homogeneous. Then, the homogeneous stirrer of methyl and propyl paraben was added to the mixture, and stirring was carried out until it became homogeneous. Add the depok starfruit extract to the mixture and stir until it is homogeneous.

Preparation Evaluation

1. Organoleptic Observations

Organoleptic testing is carried out to see whether the finished preparation is physical by observing using the five senses after manufacture. This is what is observed, namely from the color, shape, and smell, whether there is a change or not, and whether separation occurs or not (Wardani et al., 2022).

2. Homogeneity Examination

The homogeneity examination is conducted by applying the specimen onto the object glass and then covering it with another glass slide, pressing it until the entire surface is evenly coated (Wardani et al., 2022).

3. pH measurement

pH testing is conducted to observe the pH stability to ensure that it remains within the specified pH range for topical preparations (4.5 – 7), thereby ensuring that the formulation will not cause skin irritation. The pH of the formulation is measured using universal indicator paper (Wardani et al., 2022).

4. Observation of Spray Pattern

The spray pattern is observed by spraying the formulation from the bottle at distances of 5, 10, 15, and 20 cm onto a piece of plastic film. The testing is performed with three repetitions, and the observation includes the spray pattern formation, diameter, and weight per spray (Rifki Pratama et al., 2020).

5. Observation of Adhesive Spreadability

This observation is conducted by spraying the formulation on the back of the hand from a distance of 3 cm. Then, it is timed for 10 seconds, and the observation is made to determine whether the formulation adheres (Wardani et al., 2022).

Activity Test

1. Sample Preparation

The samples prepared include a solution of Depok starfruit extract and a sunscreen formulation containing Depok starfruit extract with extract concentrations of 2%, 4%, and 6%. These samples are prepared using distilled water as a diluent solution and a blank sample. For comparison, positive and negative controls are also prepared to test their SPF values.

Table 2. Activity Test Samples

Sample	Composition
Depok starfruit extract	"Depok starfruit extract with concentrations of 2%, 4%, and 6%"
Control (+) with SPF 50	Hyaluronic acid, vitamin C, vitamin E, collagen
Control (-)	A spray formulation without extract
A spray formulation with Depok starfruit extract.	A spray formulation with Depok starfruit extract at concentrations of 2%, 4%, and 6%.

2. Calculating the SPF Value

The effectiveness of sunscreen is determined by determining the SPF value using the UV-Vis spectrophotometry method. A test absorption curve was made with a wavelength between 290 to 320 nm. To calculate the value of SPF analyzed using the method of Mansur (1986). that is :

EE : Spectrum of Erythema Effects

I : Solar intensity spectrum

Abs : Spectrophotometric absorbance values at wavelength.

CF : Correction factor (10)

The value of EE × I is shown in the following table :

Table 3. The SPF value

Wavelength (nm)	EE × I
290	0,0150
295	0,0817
300	0,2874
305	0,3278
310	0,1864
315	0,0839
320	0,0180

The absorption value obtained is multiplied by the EE x I value for each wavelength, then the absorption multiplication and EE × I are added up and multiplied by the correction factor to get the SPF value.

The next step in this research was to prepare a spray formula with varying concentrations of depok starfruit extract (Averrhoa Carambola L) 2%, 4%, and 6% (w/v). The design formula for making spray preparations from the depok starfruit extract is as follows:

The samples made were a solution of depok starfruit extract and a sunscreen preparation of depok starfruit extract with an extract concentration of 2%, 4%, and 6% using distilled water as a diluent and blank solution. As a comparison, a positive control and a negative control were also made to test the SPF value.

Table 4. Activity Test Sample

Sample	Ingredients
Depok startfruit extract	Depok starfruit extract with a concentration of 2%, 4% and 6%
Control (+) with packaging labeled SPF 50	Hyaluronic acid, vitamin C, vitamin E, collagen
Control (-)	Spray preparation without extract
Preparation of depok starfruit extract spray	Spray preparation with depok starfruit extract concentrations of 2%, 4% , 6%

After getting the SPF value, the level of sunscreen ability is categorized. Divisioan of Sunscreen ability levels.

Table 5. Distribution of Levels of Sunscreen Ability

Protection power	SPF value
Minimum protection	2 - < 4
Moderate protection	4 - < 6
Extract protection	6 - < 8
Maximum protection	8 - < 15
Ultra protection	>15

RESULT AND DISCUSSION

The Results Of The Examination Of Simplisia Characteristics

1. Plant Determination

Determining the plant's identity is an initial step in research to ensure the accuracy of the plant's identity used in the study and avoid errors in sampling for phytochemical analysis. The depok starfruit used for the research comes from a plantation in the Depok area. The sampled fruits are seedless, nearly ripe, and in good condition. A determination test is conducted on the fruit samples to ensure that the starfruit to be used for extraction is indeed depok starfruit. Depok starfruit belongs to the Kingdom Plantae, Class Magnoliopsida, and Family Oxalidaceae. The depok starfruit plant (Averrhoa Carambola L.) has been identified at the Laboratory of the National Research and Innovation Agency (BRIN), Cibinong, Jl. Raya Bogor KM. 46 Cibinong - Bogor, West Java, from the plantation in the Depok area, West Java. The determination results confirm that the plant is indeed Depok starfruit with the Latin name Averrhoa Carambola L, belonging to the Oxalidaceae family.

2. Macroscopic Observation

Macroscopic testing aims to examine the physical characteristics of the plant part, with a particular focus on morphology, size, and the color of the simplisia being studied (Fajriyah et al., 2018). The results of the observations indicate that depok starfruit has an elongated shape resembling a star with 5 shiny ribs. The length of Depok starfruit varies from 7 to 15 cm, and it is greenish-yellow in color, has the distinctive aroma of Depok starfruit, and possesses a sweet taste. Based on previous research conducted by Swandono et al. (2021), their macroscopic examination of depok starfruit yielded similar results, with the fruit being elongated, star-shaped, and having 5 shiny ribs, a length of 5-12 cm, a diameter of 30-70 mm, initially greenish-dark when young, and gradually turning yellow as it matures.

Figure 1. Depok Starfruit

Depok Starfruit Extraction

Depok starfruit samples were weighed at 2 kg. The depok starfruit was thoroughly washed, drained, homogenized using a juicer, filtered using filter paper, and then concentrated using a rotary evaporator at a temperature of 50°C. This process aimed to separate the solvent from the obtained extract (Astiti et al., 2019). The resulting concentrated extract amounted to 204.25 grams. Separating the solvent from the extract at 50°C was done to prevent damage to active compounds due to excessively high evaporation temperatures (Lindawati et al., 2020). The percentage yield obtained was 10.21%, as seen in Appendix 10. Yield is the ratio of the obtained extract to the initial crude drug. Yield is expressed as a percentage (%), and a higher yield indicates a larger amount of extract produced (Senduk et al., 2020).

The requirement for the yield of a concentrated extract is that its value should not be less than 10% (Depkes RI, 2017). Therefore, the yield obtained in this research meets the requirement.

1. Organoleptic Test

Organoleptical observation aims to introduce early extracts with five senses including shape, color, smell and taste (Ministry of Health RI, 2017). The organoleptic observations of the depok starfruit extract reveal that it is a thick and viscous extract with a brownish-yellow color and a distinctive aroma of depok starfruit.

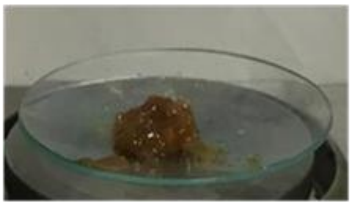

Figure 2. Organoleptic Test Depok Starfruit Extract

2. Simplicia Quality Standards Examination Results

The standard examination of simplisia includes drying loss, total ash content, and acid-insoluble ash content to ensure the uniform quality of simplisia to meet the standards for both simplisia and extracts. The results of the standard examination of simplisia can be seen in the table.

Table 6. Results Simplicia Quality Standards Inspection

Simplicia Standard Parameters	Result (%)	Standar (%)
Shrinkage drying	1,46 ± 0,11	≤10
Total ash content	5,64 ± 1,21	≤ 6
Ash content is not acid soluble	1,36 ± 0,13	≤1,7

The drying loss test aims to determine the amount of volatile substances lost under specific drying conditions (Depkes RI, 2000). The test results show that the percentage of drying loss is 1.46%. This indicates that the drying loss in depok starfruit meets the standard set by Depkes RI in 2017, which states that the percentage should be less than 10%. Furthermore, ash content is measured to determine the amount of inorganic or mineral substances remaining after the ashing process (Sudarmadji, 1989). The determination of the total ash content in this test is 5.64%, indicating that the total ash content meets the standard requirements, which should be at most 6%, according to (Depkes RI, 2017).

Determining the acid-insoluble ash content aims to determine the amount of ash originating from external factors, such as sand or soil (Depkes RI, 2000). The test results indicate an average percentage of 1.36% for Depok starfruit extract. This result meets the standard for acid-insoluble ash content, which should be less than 1.7%. Determining acid-insoluble ash content is important to assess the possibility of contamination by soil or sand in the extract. Overall, the test results show that depok starfruit meets the standards for drying loss, total ash content, and acid-insoluble ash content. This indicates that the depok starfruit samples used in the research did not undergo significant loss during the drying process and were not contaminated by external materials such as soil or sand.

Phytochemical Screening Test

The secondary metabolite content in depok starfruit extract (Averrhoa Carambola L.) is identified through phytochemical screening. The tested compounds include alkaloids, flavonoids, saponins, tannins, and triterpenoids. The results of the phytochemical screening conducted on depok starfruit extract (Averrhoa Carambola L.) can be seen in the table.

Table 7. Phytochemical Screening Results

Compound Classes	Results
Alkaloid	+

Flavonoid	+
Saponin	-
Tannin	+
Triterpenoid	-

The results of this study's phytochemical screening on depok starfruit extract indicate that the extract contains alkaloids, flavonoids, and tannins. The alkaloid test involves the addition of Mayer's reagent, Wagner's reagent, and Dragendorff's reagent to confirm the presence of alkaloid compounds. A positive result with Mayer's reagent is confirmed by forming a yellow precipitate. In the formation of Mayer's reagent, a solution of Mercuric (II) chloride is added to Potassium iodide, resulting in a red precipitate of Mercuric (II) iodide. Alkaloid identification with Mayer's reagent involves the prediction that nitrogen in alkaloids reacts with the potassium ion (K+) from Potassium tetraiodomercurate (II), forming a potassium-alkaloid precipitate (Parbuntari et al., 2019). The results of this study show the presence of a yellow precipitate.

The flavonoid test involves the addition of magnesium (Mg) powder and hydrochloric acid (HCl), which can reduce existing flavonoid compounds. A positive flavonoid test is indicated by the formation of red, yellow, or orange colors (Parbuntari et al., 2019).

The tannin test, using the addition of FeCl3, forms a green or black color. A positive tannin test indicates the presence of tannins (Ratnasari et al., 2022). The results of this test show a greenish-black color, confirming the presence of tannins.

Thin Layer Chromatography

The results of the TLC test for the separation of flavonoid compounds in the extract of Depok starfruit using the eluent n-Butanol: acetic acid: water (4:1:5). The spot produced in the quercetin reference has an Rf value of 0.93. The Depok starfruit extract has an Rf value of 0.9. The spots on the plate are observed using UV lamps at 254 nm and 365 nm. These results closely match the reference solution, indicating that the extract contains flavonoid compounds. The TLC results table shows that quercetin is the flavonoid compound in starfruit. Quercetin is used as a reference in the TLC test. The use of quercetin as a reference belongs to the flavonol group (Sari et al., 2020).

Characteristics of Sunscreen Preparations

The initial characteristics of observed sunscreen spray preparations include organoleptic evaluation, homogeneity, pH, spray pattern, and adhesion spreadability. Evaluation of the dosage form's appearance is necessary to determine the differences in the preparation condition when it is freshly made and after storage at different temperatures. In the research, physical changes that occur in each dosage form are observed and assessed.

Table 8. Characteristics of Sunscreen Preparations

No	Characteristics	Formulation Contcentration			
		0%	2%	4%	6%
1	Organoleptis				
	• Color	Pure white	Pure yellow	Deep pale yellow	Deep dark pale yellow
	• Smell	Bubble gum	Bubble gum	Bubble gum	Bubble gum
	• Texture	Soft	Soft	Soft	Soft
2	Homogenity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
3	pH	6,51 ± 0,01	6,57± 0,021	6,58 ± 0,015	6,61 ± 0,01
4	Spray pattern	Spread	Spread	Spread	Spread
	• Diameter				
	✓ Distance 5cm	4,2 ± 0,4	4,6 ± 0,31	4,1 ± 0,1	2,7 ± 0,12
	✓ Distance 10cm	4,7 ± 0,2	5,2 ± 0,15	4,2 ± 0,35	3 ± 0,06
	✓ Distance 15cm	4,8 ± 0,7	5,2 ± 0,06	5,2 ± 0,12	3,7 ± 0,06
	✓ Distance 20cm	5,2 ± 0,1	6,2 ± 0,17	5,1 ± 0,7	4,1 ± 0,55
	Drip weights (g)	0,18±0,021	0,2±0,038	0,186 ±0,039	0,198±0,023
5	Sticky Dispersion	5,4±0,26	5,2±0,038	5,4±0,039	5,2±0,023

Figure 3.

1. Organoleptic Observation

The organoleptic observations were conducted to determine the preparation's color, odor, and texture. The organoleptic observations found that the 0% concentration preparation was white and thick, the 2% concentration was pale yellow, the 4% concentration was pale yellow and thick, and the 6% concentration was a darker pale yellow and thick. Since the extract in the preparation had a yellowish-brown color, the higher the extract concentration, the darker and thicker the preparation color became. The organoleptic observations also revealed a bubble gum scent and a smooth texture, which aligned with the desired results.

2. Homogeneity Observation

The results of the observations on the spray base and the three formulations of the spray preparations containing depok starfruit extract showed that all the spray preparations exhibited excellent characteristics, each being homogeneous. Therefore, these spray preparations meet the expected requirements for homogeneity. Homogeneity is influenced by the selection of ingredients and their percentage in the preparation formulation. Good homogeneity is physically evident in the absence of particles and dissolved preparation components (Ariyani et al., 2022).

3. pH Measurement

The pH levels of the base formulation and the three formulations with different concentrations vary, ranging from 6.51 to 6.61. However, these preparations still fall within the acceptable pH range and meet the pH requirement between 4.5 and 7 (Wardani et al., 2022).

4. Observation of Spraying Patterns

The spray pattern is an important factor in evaluating whether there is a relationship between the stability of the preparation and the weight dispensed, as well as assessing the quality of the spraying device used. The spray patterns in all formulations show similar results, indicating that the applicator effectively delivers the same amount of spray with each spray. The spraying distance also influences the diameter of the spray pattern. The farther the spraying distance, the wider the diameter of the spray pattern (Pratama et al., 2020). Based on the spray pattern test results, it can be concluded that all formulation preparations meet the standard criteria for a good spray pattern, meaning that the preparations can be sprayed effectively and the particles are evenly distributed. The diameter of the spray pattern ranges from 4.2 cm to 6.2 cm at different distances, namely 5 cm, 10 cm, 15 cm, and 20 cm.

5. Observation of Sticky Spreadability

The spray pattern is an important factor in evaluating whether there is a relationship between the stability of the preparation and the weight dispensed, as well as assessing the quality of the spraying device used. The spray patterns in all formulations show similar results, indicating that the applicator effectively delivers the same amount of spray with each spray. The spraying distance also influences the diameter of the spray pattern. The farther the spraying distance, the wider the diameter of the spray pattern (Pratama et al., 2020). Based on the spray pattern test results, it can be concluded that all formulation preparations meet the standard criteria for a good spray pattern, meaning that the preparations can be sprayed effectively and the particles are evenly distributed. The diameter of the spray pattern ranges from 4.2 cm to 6.2 cm at different distances, namely 5 cm, 10 cm, 15 cm, and 20 cm.

Stability test

The results of stability testing for the sunscreen formulation containing depok starfruit extract, which includes organoleptic observation, homogeneity observation, pH measurement, spray pattern observation, and spreadability observation, were conducted over two cycles.

1. The Results of Organoleptic Observation

The Results of Organoleptic Observation for the Sunscreen Spray Formulation in 2 Cycles can be seen in the Table.

Table 9. The Results of Organoleptic Stability Test Observation

Cycles	Concentration	Color	Smell	Texture
0	0%	White	Bubble gum	Soft
	2%	Pale yellow	Bubble gum	Soft
	4%	Deep pale yellow	Bubble gum	Soft
	6%	Deep dark pale yellow	Bubble gum	Soft
1	0%	White	Bubble gum	Soft
	2%	Pale yellow	Bubble gum	Soft
	4%	Deep pale yellow	Bubble gum	Soft
	6%	Deep dark pale yellow	Bubble gum	Soft
2	0%	White	Bubble gum	Soft
	2%	Pale yellow	Bubble gum	Soft
	4%	Deep pale yellow	Bubble gum	Soft

6%	Deep dark pale yellow	Bubble gum	Soft

Observing the organoleptic stability of this formulation aims to determine whether there are any changes in the color, odor, and texture. This observation is carried out to assess a formulation's ability to maintain its quality during the period of use and storage under two cycles: at 4°C and 40°C. The results indicate that all spray formulations exhibit no significant changes and are considered stable.

2. The Results of Homogeneity Observation

The results of the homogeneity stability test for the spray formulations indicate excellent characteristics, with all formulations proving homogeneous. Thus, these spray formulations meet the expected requirements for homogeneity. The observations on the base spray and the three formulations of the depok starfruit extract spray show that they are physically homogeneous both before and after storage in two cycles. This indicates that the ingredients used in the formulation are thoroughly mixed, and good homogeneity means that no visible particles or undissolved components are present (Ariyani et al., 2022).

3. pH Measurement Results

The observations of the pH stability test for the spray formulations before and after consecutive cycling tests resulted in varying pH values for each measurement. However, all formulations remained within the standard pH range of 4.5-7, meeting the requirements (Wardani et al., 2022). A study on pH stability conducted by Hidayat et al. (2020) showed a pH of 6, which remained stable without significant changes during storage at low and high temperatures.

4. The Stability Test of Spray Pattern

The results of the spray stability test indicate satisfactory outcomes. Testing at high temperatures showed stable spray patterns. This stability may be attributed to the storage conditions. The spraying distance also influences spray results. The spray pattern test results suggest that all formulation sprays at different storage temperatures meet the criteria for good spray patterns, where the formulation can be sprayed effectively and particles are evenly distributed. The diameter of the spray pattern ranged from 2.8 cm to 6 cm at different spraying distances of 5 cm, 10 cm, 15 cm, and 20 cm. This shows that the wider the spraying distance, the larger the diameter of the spray pattern. In a study conducted by Anindhita et al. (2020), they observed the diameter of the spray pattern, and similar to your findings, the spray pattern's diameter increased as the spraying distance became greater.

5. The Average Results of the Stability Test for Adhesive Spreadability

The adhesion test was conducted to ensure the even distribution of the extract when applied to the skin. The results of the adhesion test indicate that the adherence time of the formulation on the skin is more than 10 seconds, and the adhesion falls within the standard range of 5-6 cm. Good adhesion ranges from 5-7 cm, indicating that the active ingredients in the formulation can adhere well to the skin's surface (Helmi et al., 2018). A longer adhesion time suggests a strong interaction between the active ingredients and the skin, potentially enhancing the effectiveness of topical application. After conducting stability testing for 2 cycles, the results remained stable. While some adhesion values fluctuated at different temperatures and cycles, they still fell within the 5-7 cm range. Therefore, it can be concluded that the active ingredients in the formulation can adhere well to the skin, demonstrating the expected quality, stability, and application potential (Helmi et al., 2018).

Activity Test

Based on the test results on sunscreen spray preparations with concentrations of 2%, 4%, and 6%, it can be seen that the higher the extract concentration in the preparation, the higher the protection against sunlight achieved. You can see the results of the SPF value on the sunscreen spray preparation.

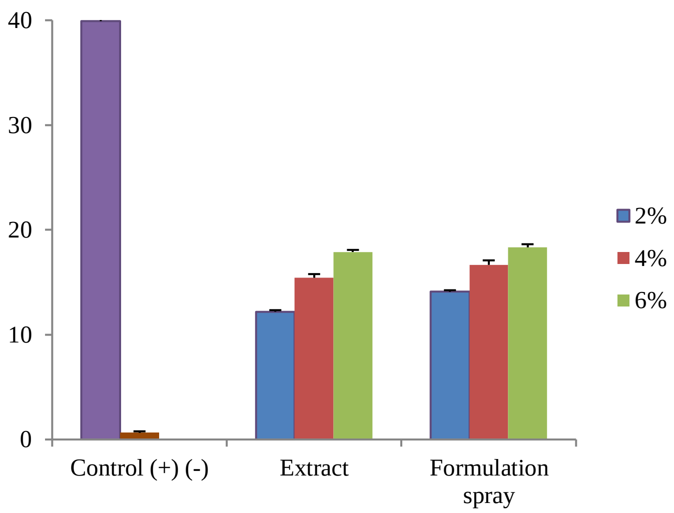

Figure 4. Results of The SPF Value on The Sunscreen Spray Preparation

Based on the results of measuring the SPF value using the Mansur equation, an SPF value of 12.19 was obtained for the 2% extract, 15.43 for the 4% extract, and 17.89 for the 6% extract. The SPF value of the spray formulation was 14.09 at 2%, 16.66 at 4% and 18.33 at 6%. It can be seen that the higher the concentration of extracts and preparations, the higher the level of sun protection achieved. The results of the SPF value of the extract compared to the spray preparation showed a higher SPF value of the sunscreen spray preparation. The increase in the SPF value of the sunscreen spray preparation can also be seen in the negative control preparation, which shows an SPF value of 1, where the preparation without extract also provides activity as a sunscreen, even though the value is small. This is because the preparation contains stearic acid, which is a stable material for antioxidants (Shah et al., 2021).

As for previous research conducted by (Rifki Pratama et al., 2020), The sunscreen activity of soybean seed extract produced by 2% extract has an SPF value of 13.82, 4% extract has an SPF value of 13.96, and 6% extract has an SPF value of 14.54. This shows that the SPF value of the starfruit depok extract produces a higher SPF value.

CONCLUSION

From the results of the research that has been done, it can be concluded that the spray preparation from the starfruit depok extract (Averrhoa carmbola L.) can be used as a sunscreen preparation. The results showed that the starfruit depok extract has the ability to absorb ultraviolet radiation and has the potential to be an active ingredient in spray preparations with the best SPF value shown by the extract concentration of 6% of 17.90, which has ultra protection against sun exposure.

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