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THE EFFECTIVENESS OF SPF(SUN PROTECTOR FACTOR*)* VALUE INEMULGEL PREPARATIONS BASED ON BALINESE MANGOSTEEN PEEL *(Garcinia mangostana L.)*

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ABSTRACT

Indonesia is a country located on the equator, so it has a fairly high exposure to solar intensity. Exposure to UV rays can cause skin damage, premature aging, skin pigmentation, and wrinkles due to prolonged exposure. The use of *sunscreen* is one of the solutions to reduce exposure to UV rays. Balinese mangosteen peel *(Garcinia mangostana L.)* has the potential to be developed as a sunscreen. The purpose of this study was to examine the effectiveness of SPF *(Sun Protector Factor)* value in emulgel preparations based on the peel of Balinese mangosteen*fruit (Garcinia mangostana L.)* The research method was designed using *a true experimental design* method with *a posttest-only control design.* Data analysis uses a descriptive statistical approach. The results of the phytochemical test showed that the mangosteen peel was positive for containing secondary metabolite compounds. The physical stability test showed a pH of 7 or normal, homogeneous, and a dispersion of 5 - 7 met SNI requirements. The SPF value performed in vitro using UV-Vis spectrophotometry showed a variation of 200 ppm, 400 ppm, and 800 ppm; the SPF value was 68.7, 70.23, and 70.72. These SPF values indicate the potential of the mangosteen peel as a sunscreen, with the 200 ppm formulation showing the highest SPF value. The organoleptic results conducted by 35 respondents show that the color category is very fond, with a percentage of 51.40%. The texture category has a percentage of 51.40%. The scent category really likes 45.70%. So it can be concluded that only using a variation of the 200 ppm formulation is able to provide ultra SPF potential.

Keywords : Balinese Mangosteen Peel; Sunscreen; Emulgel; SPF

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Introduction

Indonesia as one of the tropical countries located on the equator. This condition causes Indonesia to have a higher intensity of sun exposure. Sunlight is needed by living things in carrying out daily activities such as being useful in the formation of vitamin D in increasing the body's resistance and wound healing against viral infections. However, on the other hand, sunlight can be detrimental if exposed to the surface of the skin such as (Amalina et al., 2024) ultravioletrays or known as UV Exposure to high intensity sunlight can cause skin damage or (Serena et al., 2018). *Sunburn* (Parasiddha et al., 2016) . UV rays have a wavelength of 100-400 nm which are divided into three types namely; UV A (315-400 nm), UV B (280-315 nm), and UV C (100-280 nm). The existence of (Mumtazah et al., 2020) *ultraviolet* rays is very detrimental to the continuity of human activities. According to Pratiwi, ultraviolet radiation will cause damage to the epidermis or known as sunburn, premature aging, skin pigmentation, wrinkles due to prolonged exposure with high intensity. Exposure to UV rays can cause changes in the connective tissue in the stratum corneum layer. (Pratiwi et al., 2017)

With the many dangers posed by exposure to UV radiation, the skin needs a strong defense in overcoming these problems. There are two ways of skin defense mechanisms in overcoming exposure to UV radiation, namely; physical and chemical defenses. Physical defense: the use of clothing and hats to cover body parts so as to avoid exposure to UV rays. Meanwhile, chemical defense by using sunscreen or *sunscreen.*

Exposure to sunlight will cause protein denaturation so that it causes an inflammatory reaction in the skin so that it can cause the release of histamine and swelling of blood vessels. Sunscreen contains compounds that function in protecting the function and structure of the skin. The sunscreen mechanism (Dewi, 2024) in dealing with exposure to UV radiation works by absorbing erytmogenic rays at a wavelength of 290 – 320 nm. Sunscreen will compete with compounds damaged by sunlight and repair those damaged compounds (Fathona, 2024)

The use of *sunscreen* is a practical defense in protecting the skin from UV exposure because it is easy to use and does not take a long time. But with the existence of many *sunscreens* on the market that contain chemicals, it poses a danger to sensitive skin and other side effects. So there is a need for a product innovation from natural ingredients that is able to replace *sunscreen* products from chemicals.

One of the potential natural ingredients that can be used as sunscreen products because it is rich in benefits provided but has not been widely researched is Balinese mangosteen*fruit (Garcinia mangostana L.)* which earned the nickname *Queen of Topical Fruit.* Balinese mangosteen fruit is a plant that lives in the tropics. Based on data from the Indonesian Central Statistics Agency (2023), the number of mangosteen production in Bali is 24. 820 tons ranks first among other provinces. The large production of mangosteen fruit causes the production of excess waste to be higher. Most people consume mangosteen fruit and just throw away the peel even though the mangosteen peel has a very high use value and is nutritious. Balinese mangosteen peel can be developed into a sunscreen product because (Indonesian Central Statistics Agency, 2023) of

its content. Content of mangosteen peel *(Garcinia mangostana L.)* contain phenolic compounds that have high antioxidant activity with an IC50 of 44.49 µg/mL. The peel of the mangosteen is able to be a cell protector in the oxidation process, aging, or the consequences of free radical damage (Nasti et al., 2023). The antioxidant properties of Balinese mangosteen peel exceed vitamin C and vitamin E This is evidenced by research that shows that mangosteen peel is able to produce antioxidant activity 2,710 µg/mL higher when compared to ICof vitamin C as a comparison of 2,468 µg/mL(Desnera Putri et al., 2019).

The content of secondary metabolites of flavonoids, alkaloids, phenols, tannins, quinones, and saponies (Desnera Putri et al., 2019) . The absorption of phytoconstituents of this herb is good for use as a natural sunscreenbecause it can protect the surface of the skin from exposure to UV radiation (Rahmawati et al., 2023). The effectiveness of mangosteen fruit in the form of emulgel preparations can be a potential to be used as a sunscreen through SPF value test.

Based on the background of the above problems and the potential of natural ingredients of Balinese mangosteen peel, researchers are interested in researching the effectiveness of SPF (Sun Protector Factor)value in emulgel preparations based on Balinese mangosteen*peel (Garcinia mangostana, L.)* as a potential natural *sunscreen* that is superior to sunscreens on the market.

Method

A. Time and Place of Research

This research was carried out from April to May 2024 at the Applied Chemistry Laboratory of the Ministry of Health Poltekkes, Denpasar, Jl. Sanitasi No.1 Sidakarya, South Denpasar for the phytochemical testing process, in vitro test of SPF value with UV-Vis spectrophotometry, stability test (pH, homogeneity, dispersibility), and product acceptance test (organoleptic).

B. Research Methods

This study uses a quantitative research approach with the type of experimental research using *a True Experimental Design* design in the form of *a Posttest-Only Control Design.* This study uses a control group and an experimental group which is divided into several test variations(Sugiyono, 2013).

C. Population and Research Sample

The population in this study is mangosteen fruits taken from the same area in order to obtain valid data from a study. The research sample used was mangosteen peel that had become waste and was no longer used.

D. Data Collection Techniques

The data collection technique is procedurally systematic using literature study techniques, observation (observation), laboratory examination, and questionnaire. The data collected is in the form of primary data and secondary data. Primary data was obtained from laboratory test results in the form of SPF *(sun protector factor)* values from emulgel preparations based on Balinese mangosteen peel. Secondary data collected is sourced from previous research, journals, or other literature (Panudju*et al.,* 2024).

Data collection instruments used to support research include; 1). Test and observer result sheets, 2). CPU and Computer to support in vitro SPF testing, 3). *Mobile* phones for documentation. Meanwhile, the supporting instruments for laboratory examinations include; 1). UV-Vis spectrophotometry *(Analytic Jena Specord 210-Plus).*

E. Data Analysis

Data analysis uses a quantitative data analysis approach with descriptive statistics to analyze data by describing or describing analytically.

F. Tools and Materials

The tools used in this study were: oven, blender, analytical balance, hot plate, rotary evaporator, UV-Visspectrophotometry (Analytic Jena Specord 210-Plus),cuvette, mortar, bekerglas, erlenmeyer, measuring cup, test tube, measuring pipette test tube rack, spatula, and tube clamp.

The ingredients used in this study are: Balinese mangosteen peel powder *(Garcinia mangostana L.)*, carbopol, triethanolamine (TEA), Sodium Carboxy Methyl Cellulose (Na. CMC), glycerine, methyl paraben, essence, aquades, ethanol.

G. Procedure

1) Extract Manufacturing

Drying the mangosteen peel using an oven at 80oC for 4 hours every 4 days. The smoothing process is carried out using a blender at a speed of 80 mesh until smooth. The dried mangosteen peel powder is weighed with an analytical balance of 600 grams then dissolved with 96% ethanol as much as 2 liters in a black bottle and soaked for 5 days. Simplisia that was soaked for 5 days was then filtered and extracted with *a rotary evaporator.*

2) Preparation of Emulgel

The manufacture of emulgelsunscreen preparationsbased on the peel of balinesemangosteen fruit uses the following formulations and variations:

Table 1. Emulgel Preparation Formulation

No.	Material	Formulation (gr/mL)				Function
		F0	F1	F2	F3	
1	Balinese mangosteen peel powder *(Garcinia mangostana L.)*	0	2	4	8	SPF
2	Karbopol	0,5	0,5	0,5	0,5	*Gelling agent*
3	*Triethanolamine* (TEA)	1	1	1	1	*Alkalizing agent*
4	*Sodium Carboxy Methyl Cellulose* (Na. CMC)	2	2	2		Increases Viscosity
5	*Spritz*	5	5	5	5	As a humectant and emollient
	Methyl Paraben	0,1	0,1	0,1	0,1	Preservatives
	Essence	2	2	2	2	Deodorizers
	Aquades add	50	50	50	50	Solvent

Information:

F0 : Negative control
F1 :Emulgel concentration 2 %
F2 :Emulgel concentration 4 %
F3 :Emulgel concentration 8 %

3) Phytochemical Screening Test

Phytochemical screening tests were carried out to determine the content of bioactive compounds contained in the skin of Balinese mangosteen.

a. Flavonoids

The flavonoid test was carried out using the alkaline reagent test method. A sample of 1 mL of extract is added with 2 mL of 2% NaOH reagent then homogenized and added little by little HCl reagent until color change occurs. The formation of red to orange color is given by flavone compounds, dark red color is given by flavonols or flavonones, green to blue color is given by aglikon or glycosides.

b. Alkaloids

The alkaloid test was carried out using the meyer test method. A total of 1 mL of extract is added 2 drops of mayer reagent. If a precipitate is formed and a color change to brown occurs when the mayer reagent is added, the identification indicates the presence of alkaloids.

c. Phenol

The phenol test was carried out using the iodine test method. An additional 1 ml of extract was added with Ferric Chloride Test ($FeCl_2$). The formation of a

bluish-green color indicates the presence of phenols.

d. Tannins
Tannin tests are carried out using the braymer's test method. A total of 1 mL of extract is added, 3 mL of heated aquades is added then followed by the addition of 3 drops of FeCl3 reagent. The formation of a brownish-green color indicates the presence of tannin compounds.

e. Kuinon
The quinone test was carried out using the HCl test method. As much as 1 mL of extract is added a few drops of HCl reagent.

f. Saponins
The saponin test is carried out using the foam test method. A total of 1 mL of extract is added 2 mL of aquades that have been heated and shaken until foam is formed. The formation of foam was identified as positive for the presence of saponin compounds.

4) Physical Stability Test

Physical stability tests include pH tests, homogeneity, and dispersion tests. The pH test was carried out to determine the safety of emulgel preparations as topical preparations should ideally approach the pH range of 4.5-7 (SNI 16-4380-1196). The pH test was carried out by weighing 1 gram of emulgel preparation dissolved in 9 mL of sterile aquades and then measured using a pH stick.

The homogeneity test was carried out by diluting each variation by taking as much as 500 uL placed on a glass object and then observed with a 40x field of view microscope.

The dispersion test was carried out by placing 0.5 grams of preparation on a glass object with a load of 200 grams added for 5 minutes. The spread of the emulgel preparation is measured using a measuring device and the diameter is calculated. The spreadability test requirements for topical preparations are about 5-7cm.

5) In Vitro SPF Test

The SPF value is calculated using the Mansur equation. The absorbance of the sample was obtained using UV-Vis spectrophotometry with a wavelength of 290 – 320 nm which was determined three times at intervals of 5 nm to determine the highest SPF value. The absorption value obtained is multiplied by EE X I to determine each interval. The amount of EE x I obtained is multiplied by the correction factor or CF which is 10 to obtain the SPF value. The calculation of the SPF value is as follows:

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

Information:

E = Spectrum of erythemal effects
I = Intensity of the beam spectrum
Abs = Absorbance as tightly as the product *sunscreen*
CF = Correction factor

Table 2. EE x I value

Wavelength (nm)	EE x I
290	0,015
295	0,0817
300	0,2874
305	0,3278
310	0,1864
315	0,0839
320	0,018

The effectiveness of *sunscreen* based on SPF value can be seen in the Table 3 below :

Table 3. Categories Sunscreen Protection

SPF	Categories Sunscreen Protection
2 – 4	Minimal Protection
4 – 6	Medium Protection
6 – 8	Extra Protection
8 – 15	Maximum Protection
≥ 15	Ultra Protection

Very strong positive result = (++++)

6) Product Acceptance Test (Organoleptic)

The product acceptance test is tested on respondents who have met the set inclusion and exclusion criteria. Mangosteen peel-based emulgel preparations were tested on 35 respondents. Organoleptic observation analysis includes the level of color preference, texture, and aroma.

Result

A. Extraction

The skin of the Balinese mangosteen fruit has secondary metabolite compounds. This compound can be obtained from the extraction results using *a rotary evaporator.* In this study, a pure extract was obtained from 600 grams of mangosteen peel powder dissolved in 96% ethanol with the result of evaporation of 50 ml of simpliciamangosteen peel extract.

B. Phytochemical Screening

In this study, phytochemical screening tests were carried out on Balinese mangosteen peel extract qualitatively using reagents that were in accordance with the tests carried out. The results of the inspection are shown in the table 4 below:

Table 4. Phytochemical Screening Test Results

It	Phytochemical Test	Result
1	Flavonoids	++++
2	Alkaloids	++++
3	Phenol	++++
4	Tannins	++
5	Kuinon	+++
6	Saponins	+

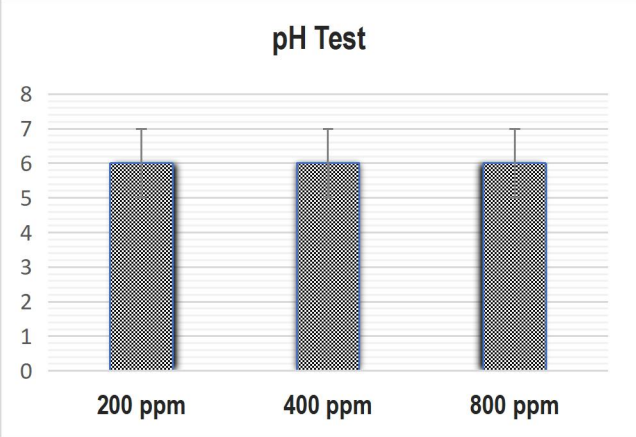
Interpretation Results (Hudaya, et al., 2013):

Negative result = (-)
Weak positive result = (+)
Strong positive result = (++)
Very strong positive result = (+++)

C. Physical Stability Test of Mangosteen Peel-Based Emulgel Preparations

1) pH

The pH test aims to determine the safety of a preparation, especially topical preparations. Ideally, topical preparations have the same value as the skin pH in the range of 4.5 – 7. Based on the results of the study, it shows that the average result is pH 7 as shown in the following graph 1:



Graph 1. pH Test Results

2) Homogeneity

The homogeneity test was carried out to determine the homogeneity of the variations of the treatment used. In this study, the results of the homogeneity test are shown in the following figure 1:

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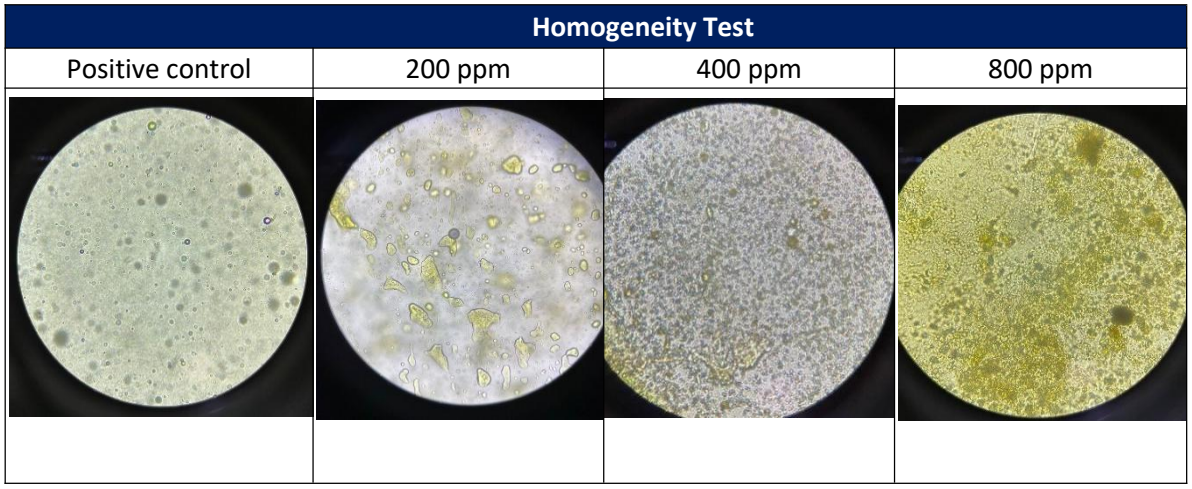
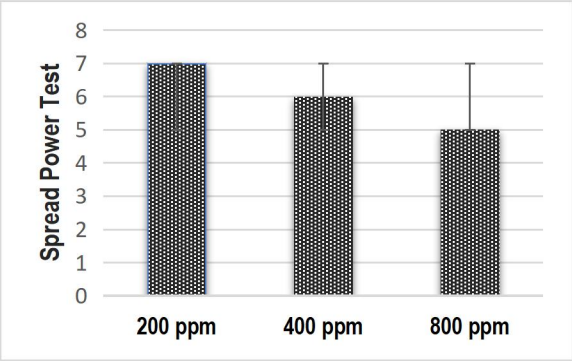


Figure1. Homogeneity Test Results

3) Spread Power

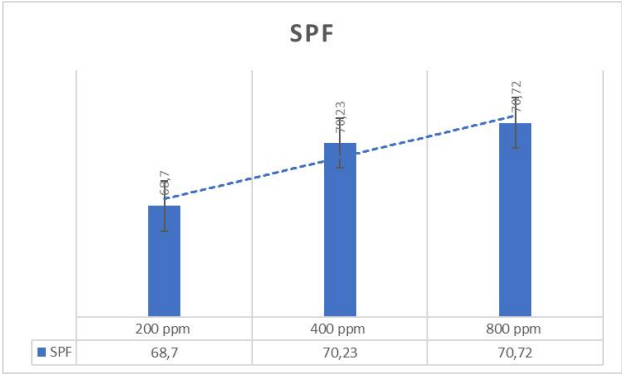
The dispersibility test was carried out to determine the ability of the sample in the form of an emulgel preparation to spread on the surface of the skin when applied. The spreadability test requirements for topical preparations are about 5 – 7 cm. The results of the spread power test are presented in the following graph 2:



Graph 2. Spread Power Test Results

D. In Vitro SPF Value Determination Test

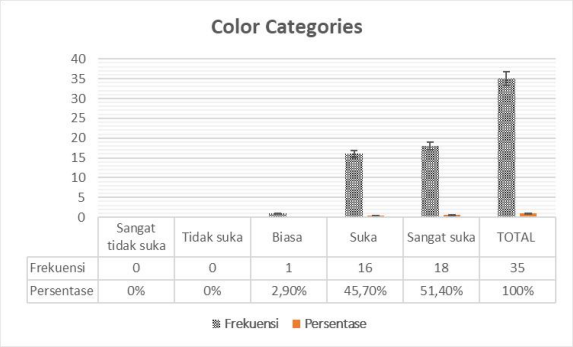
The determination of the SPF (Sun Protection Factor) value of the emulgel preparation based on the peel of balinesemangosteen obtained is presented in the following Graph 3:



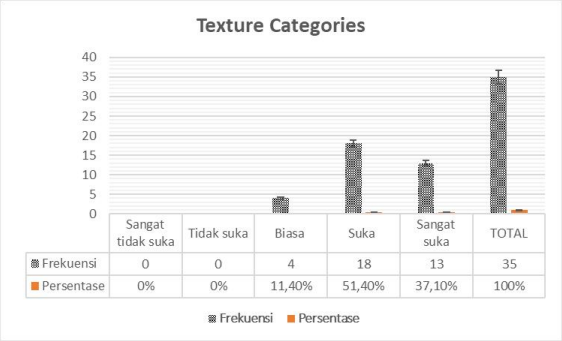
Graph 3. SPF Value of Emulgel Preparations

E. Product Reception (Organoleptic)

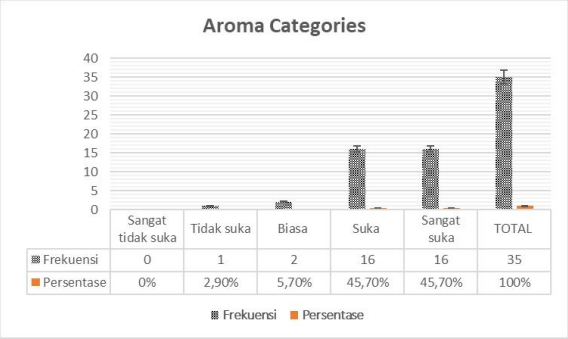
The results of the organoleptic test on 35 respondents were obtained as shown in Graphs 4, 5, and 6 below:



Graph 4. Color Categories



Graph 5. Texture Categories



Graph 6. Aroma Categories

Discussion

The determination was made at the Applied Chemistry Laboratory of the Ministry of Health of Denpasar to find out the identity of the plant from an ingredient used by seeing that the correct ingredient was the type *Garcinia mangostana L.* and belongs to the *Clusiaceae family.* Balinese mangosteen peel has been specifically determined so that it is feasible to carry out the next stage of testing. The drying process of Balinese mangosteen peel aims to reduce moisture content, prevent microbial growth, degradation of bioactive compounds. Drying of mangosteen peel is able to increase the stability and concentration of compounds such as flavonoids, alkaloids, phenols, tannins, quinones, and saponins. Sample drying also aims to simplify the smoothing process so that it will increase extraction efficiency. (Mavika Sari, 2024)

Phytochemical screening was carried out to qualitatively analyze the secondary metabolite groups contained in the bark extract of Balinese mangosteen. The results of phytochemical screening showed that the skin of the Balinese mangosteen was positive for containing flavonoid compounds, alkaloids, phenols, tannins, quinones, and saponins. Flavonoid analysis uses the alkaline reagent test method which shows a result of 4+, characterized by a color change to dark red which indicates the presence of flavonone compounds. This change occurs because the flavonoid has a hydroxyl group in the ortho position reacting with boric acid. Analysis of alkaloid compounds using the meyer test method showed a result of 4+, characterized by a change in color to brown after the addition of a reactant. This color change occurs due to the presence of hydrogen atoms that have free electron pairs in the alkaloid replacing the ions in the Mayer reagent. The analysis of phenol compounds was carried out using the iodine test method showing a result of 4+, characterized by the formation of a bluish-green color. This happens because phenolic compounds condense as a result of the reagent being added, causing a color change. The analysis of tannin compounds was carried out using the Braymer's Test method showing a result of +2, characterized by the occurrence of a brownish-green color change due to the

reaction of hydroxyl groups in tannin compounds. Quinon analysis was carried out using the HCl test method showing a result of 3+, characterized by a change in color to green. The analysis of saponin compounds by the foam test method showed a result of 1+, which was characterized by the formation of foam.

With the potential of Balinese mangosteen peel which contains bioactive compounds and has the potential to be a *sunscreen* , a formulation is carried out to make an emulgel preparation based on Balinese mangosteen peel. The addition of carbopol 940 as a *gelling agent* functions in making the consistency of the preparation have good viscosity and maintaining the stability of gel preparations containing natural ingredients in storage, as well as evaporation to make it more effective. Triethanolamine is chosen as alkalizing making the preparation more homogeneous and stable. Na. CMC functions in maintaining the consistency of the preparation. The addition of glycerin functions as a humectant because it can increase dispersion. Methyl paraben functions to increase the shelf life of the preparation so that it is well maintained. Essence works as a scent enhancer. (Wulandari&Ernawati, 2024)

Evaluation of the physical stability of emulgel preparations based on the peel of Balinese mangosteen fruit is carried out by checking the quality of feasibility as a *sunscreen* by conducting tests on the variations that have been made. Tests include pH, homogeneity, and dispersibility tests.

pH testing is done to find out whether the emulgel preparation is safe to use and does not irritate the skin. pH testing is carried out using a pH stick. Based on the results of the pH test of each variation of 200 ppm, 400 ppm, and 800 ppm, a pH of 7 or normal was obtained. So that this balsam mangosteen peel-based emulgel preparation is safe to use because it is not harmful and does not irritate the skin.

The homogeneity test was carried out by taking as much as 500 uL of diluted gel preparation placed on top of a glass object and then observed with a 40x magnification. This test is carried out to find out whether the preparation is homogeneous or not so that it does not give any side effects produced and is good to use when applied to the surface of the skin. Based on the test results on each variation of 200 ppm, 400 ppm, and 800 ppm, it shows that the higher the concentration will be proportional to the homogeneity of the preparation obtained. This is marked by a variation of 200 ppm with a slight white grain and is quite homogeneous. The variation of 400 ppm indicates that the particles of the preparation are homogeneous well. Meanwhile, the variation of 800 ppm shows that the particles of the preparation are very homogeneous between the extract and the composition of other gel ingredients.

The spreadability test was carried out by taking an emulgel preparation placed on a loaded glass cover and then measuring the diameter of the spread. A variation of 200 ppm indicates a spread of 7 cm, a variation of 400 ppm indicates a spread of 6 cm, and a variation of 800 ppm indicates a spread of 5 cm. Based on SNI requirements, a good preparation must have a dispersion power ranging from 5 to 7 cm. So based on the variations of 200, 400, and 800 ppm, it shows that all variations have good spreadability.

The determination of SPF *(Sun Protection Factor)* value in vitro was carried out using UV-Vis spectrophotometry. SPF is an indicator that explains the effectiveness of a substance with UV protection properties. The higher the SPF value, the more effective it is to protect the skin surface from the effects of UV rays. (Rahmayani 2021). This effectiveness is expressed as the SPF value which is the skin's protective factor. SPF is defined as the calculation of the energy of UV rays required to induce 1 minimum dose in the skin.

Determination of SPF value in vitro by measuring absorbance at a wavelength of 290 – 320 nm. This SPF value test consists of negative control (blank), 200 ppm variation, 400 ppm variation, and 800 ppm variation. Absorption absorption is measured every 5 nm internally with wavelengths of 290 nm, 295 nm, 300 nm, 305 nm, 315 nm, and 320 nm respectively. Based on the results of the study, the 200 ppm variation has an SPF value of 68.7, the 400 ppm variation has an SPF value of 70.23, and the 800 ppm variation has an SPF value of 70.72. So that from the three variations, it shows that the variations of 200 ppm, 400 ppm, and 800 ppm provide ultra protection. Emulgel preparations based on Balinese mangosteen peel in higher concentrations or are more effective because they contain more active ingredient compounds. However, if you look at the results of the SPF value from the smallest concentration of 200 ppm, it is able to provide ultra protection with less material composition. The compounds contained in emulgel preparations work as antioxidants and ward off free radicals. Based on previous research with different concentrations using salak bark extract at a variation of 2%. 4%, and 6% concentrations of 2% give SPF values of 19,366, 4% concentrations of 19,906, and 6% concentrations of 26,440 indicate the potential *of sunscreens* with ultra potential. This indicates that the higher the concentration, the better the potential for SPF.

A good SPF value for each variation is tested using the smallest variation of 200 ppm because it can provide an ultra SPF potential. From the organoleptic results conducted by 35 respondents, it shows that from the color category, most of them like it very much with a percentage of 51.40%. The texture category mostly likes with a percentage of 51.40%. The scent category really likes 45.70%. The results show that respondents are interested in emulgel-based sunscreen products from Balinese mangosteen peel. Based on the results of the survey, it is also proven that the product does not provide side effects and does not cause irritation to the skin so it is safe to use.

Conclusion

This study has several conclusions, including:

1. Balinese mangosteen *peel (Garcinia mangostana L.)* It can be formulated in the form of emulgel preparations and has the potential to be used as a *sunscreen*.
2. Formulation variations of 200 ppm, 400 ppm, and 800 ppm indicate that the resulting SPF potential is ultra.
3. A variation of 200 ppm produces an SPF of 68.7 capable of providing ultra potential. So that from this variety, it can be developed and has the potential to become a *natural sunscreen* by using only a few ingredients.
4. The acceptance of the product to the respondents showed that there were no side effects and irritation for the skin and the results of the questionnaire showed that many respondents liked the emulgel preparation product from both the color, texture, and aroma categories.

Conflict Of Interest

In this study, there is no conflict of interest.

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