Pharmacy Education (2024) 24(6) 134 - 143
https://doi.org/10.46542/pe.2024.246.134143

ICOPMAP SPECIAL EDITION

RESEARCH ARTICLE

The photoprotective effectiveness of microemulsion gel made from an ethanol extract of kelakai root (*Stenochlaena palustris* (Brum. f) bedd.)

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Keywords
Antioxidant
Kelakai root
Microemulsion gel
Photoprotection
SPF

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Abstract

Background: Free radicals from sunlight have detrimental effects on the skin, such as black and dull colouration and dry- and easy-to-age skin. Prevention can be done by using antioxidants derived from plants as photoprotective. Kelakai root extract has a potent antioxidant activity of 19.06 ppm. Using typical preparations in the form of microemulsion gels protects the skin from free radicals. **Objective:** This study aimed to determine the photoprotective effectiveness of the microemulsion gel preparation of kelakai root extract. **Method:** The extraction method adopted maceration with 70% ethanol solvent. The microemulsion was incorporated into a gel dosage form with a concentration of 5%. The effectiveness of the photoprotective gel was measured using UV-Vis spectrophotometry, which included determining the value of the Sun Protector Factor (SPF), erythema transmission percentage (%Te), and pigmentation transmission percentage (%Tp). **Result:** The results showed that the microemulsion gel of kelakai root extract with a concentration of 80 ppm had an SPF value of 9.816 with a %Te value of 9.591% and a %Tp value of 16.779%. **Conclusion:** The microemulsion gel of the kelakai root extract has photoprotective effectiveness as a sunscreen in the sunblock category.

Introduction

Exposure to UV rays can accelerate facial skin ageing, such as a rough facial appearance, wrinkles, red spots, uneven facial skin pigmentation, and age spots on the face skin (Eastabrook *et al*., 2018). One way to avoid exposure to UV rays on the face is to use cosmetic sunscreen agents. Unfortunately, synthetic sunscreen agents can cause skin irritation and allergic, phototoxic, or photoallergic reactions. Natural sunscreen agents from plants can be used to minimise these side effects. Plants are rich in endogenous bioactive metabolites, which have potential applications in cosmetics, such as polyphenols and phenolic acids. One of the plants that can be used as a sunscreen agent is kelakai (Georgiev *et al*., 2018; Ali *et al*., 2022).

Kelakai can grow freely in peat and sandy soil on the island of Kalimantan. All parts of the kelakai plant are efficacious as antioxidants because they contain flavonoids and phenols (Adawiyah, 2019). The kelakai root parts have potent antioxidant activity with an IC_{50} of 19.06 ppm (Adawiyah & Muhammad, 2018). This activity is related to high levels of total phenolics and flavonoids from the 70% ethanol extract of kelakai roots, namely 625.35 µg GAE/mg extract and 735.24 µg QE/mg extract (Forestryana *et al*., 2021). The phenolic and flavonoid compounds in kelakai plants have the potential to act as photoprotective agents and are effective as sunscreen. Based on research by Adawiyah (2019), 70% ethanol extract of kelakai roots with concentrations of 100 ppm, 150 ppm, and 200 ppm has SPF values of three, five, and seven, which were included in the "*minimum*" to "*extra*" protection level range. Meanwhile, kelakai root ethanol extract with concentrations of 250 ppm, 300 ppm, and 350 ppm has SPF values of nine, eleven and fourteen, which are included in the range of maximum protection (Adawiyah, 2019).

The sunscreen effectiveness of the 70% ethanol extract of kelakai roots can be maximised by the formulation of preparations for typical delivery. However, delivery through the skin has problems with penetration due to the skin barrier (stratum corneum), which prevents the active substance from entering the skin (Siampa *et al*., 2021). To overcome this problem, the delivery of active substances using a microemulsion system can maximise penetration into the skin. Microemulsions have droplet sizes of 10-100 nm, making it possible for active substances to penetrate better (Wenas, 2021). But, the microemulsion system has a very low viscosity (liquid), so it is difficult to apply to the skin. Incorporating microemulsion into a gel dosage form will make the application on the skin easier. The advantages of gel preparations are good drug release and distribution, easy washing with water, and a cool sensation on the skin (Sugihartini *et al*., 2020).

Previous research had obtained the optimum formula for microemulsion of 70% ethanol extract of kelakai roots with concentrations of surfactant Tween 80 and co-surfactant PEG 400 of 35% and 15%. Meanwhile, the optimum formula for a microemulsion gel was obtained using the gelling agent Na-CMC. Based on the background above, this research aimed to determine the photoprotective effectiveness of a microemulsion gel preparation from 70% ethanol extract of kelakai roots.

Methods

Materials

The materials used in this research include Kelakai root extract, Tween 80 (Eralika-Indonesia), polyethylene glycol (PEG) 400 (Eralika-Indonesia), propylene glycol, methylparaben (Eralika-Indonesia), propylparaben (Eralika-Indonesia), Natrium carboxyl methylcellulose (Na-CMC) (Eralika-Indonesia), and virgin coconut oil (VCO) (Eralika-Indonesia). All reagents and solvents used were of analytical grade.

Design

Kelakai root extraction (Stenochalena palustris (Burm.F) Bedd)

Kelakai roots were extracted using the maceration method with 70% ethanol solvent (Forestryana *et al*. 2020). Exactly 50 g of root powder was poured into a beaker, 500 ml of 70% ethanol was added and then stirred using a stir bar for ten minutes. The glass beaker was covered with aluminium foil and stored for 72 hours. Re-maceration was carried out twice. The liquid extract was then concentrated using a rotary evaporator at a temperature of 60℃ until a thick extract was obtained (Paramawidhita *et al*., 2021).

Phytochemical screening of extracts

Phytochemical screening was conducted for flavonoids, alkaloids, saponins, tannins and phenols.

Preparation of 70% ethanol extract microemulsion of kelakai roots (Stenochalena palustris (Burm. F) Bedd)

The microemulsion system was made by mixing the water and oil phases using the spontaneous microemulsion formation method. The water phase consists of surfactants and co-surfactants, namely Tween 80 and PEG 400, which dissolved in water and 70% ethanol using a magnetic stirrer at 60℃-70℃. The ratio of surfactant and co-surfactant used was 35:15 (Table I).

Table I: Optimum formula for the microemulsion gel made from 70% ethanol extract of Kelakai Root

Composition	Concentration (% b/v)
70% ethanol extract from kelakai root	0.1
VCO	3.0
Tween 80	35.0
PEG 400	15.0
Methylparaben	0.18
Prophylparaben	0.02
Ethanol	15.0
Aquadest ad	100 ml

The VCO and kelakai root ethanol extract were mixed in the oil phase using a magnetic stirrer at 60℃-70℃. The oil phase was mixed and homogenised into the water phase using a magnetic stirrer at 300 rpm and a temperature of 60℃-70℃ for seven minutes until a thermodynamically stable microemulsion was formed (Sulistiana & Sasanti, 2022). Microemulsion characterisation was carried out using particle size, polydispersity index, per cent transmittance, and zeta potential.

Preparation of kelakai root microemulsion gel (Stenochalena palustris (Burm. F) Bedd)

The optimum formula for kelakai root extract microemulsion gel was obtained through optimisation using Design Expert 12.0 (2020) by Simplex Lattice Design (SLD) with Na-CMC as a gelling agent at a concentration of 3.25% w/w. The Na-CMC was used as a gel matrix to construct the microemulsion-based gel to improve the viscosity of the microemulsion for topical administration. The Gel microemulsion was made by dispersing Na-CMC with 20 mL of hot water until the gel matrix was formed. Methylparaben, which had been initially dissolved in water, was added. After that, propylene glycol was added to the gel and stirred until it became homogeneous. A microemulsion of kelakai root ethanol extract with a concentration of 5% w/w into the gel matrix was added and stirred until the microemulsion-based gel became homogeneous. Details of the formulation composition are given in Table II. Evaluation of microemulsion base-gel of kelakai root ethanol extract, including organoleptic test, homogeneity, pH, adhesive power, spreadability, and viscosity, was carried out.

Table II: Optimum formula for the microemulsion-based gel of 70% ethanol extract kelakai root

Composition	Concentration (% b/v)
Microemulsion of 70% ethanol kelakai root extract	5.00
Na-CMC	3.25
Propylene glycol	5.75
Methylparaben	0.10
Aquadest ad	100

Determination of sunscreen effectiveness

Determination of SPF value

The SPF value was obtained from the results of absorbance measurements at wavelengths between 290 – 320 nm using a UV-Vis spectrophotometer. Meanwhile, to find out the SPF value, the following formula was used:

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

Where;

CF = correlation factor (10);

EE = erythema efficiency;

I = simulated spectrum of solar rays;

Abs = read absorption value (Wiraningtyas *et al*., 2019).

The SPF value of each sample, namely 70% ethanol extract of kelakai roots, microemulsion of ethanol extract of kelakai roots, and microemulsion-base gel of ethanol extract of kelakai roots, was measured using UV-VIS spectrophotometer by measuring the absorbance of each concentration at a wavelength between ±290-320 nm. Three replications were used for the measurement (Wiraningtyas *et al*., 2019).

Determination of Erythema Transmission percentage (%Te) and Pigmentation Transmission percentage (%Tp)

Each sample was put into a cuvette, and the transmittance value was measured at the wavelength (λ) of 290-320 for the percentage erythema value range and the wavelength (320-375 nm) for the percentage pigmentation value range. Three replications were carried out using internal methanol p.a. as a blank every 5 nm. After obtaining the absorption value (A), the transmission (T) value was calculated using the formula:

Assessment

Preparation of standard solution

The standard solution was made using kelakai root ethanol extract, microemulsion of kelakai root extract, and microemulsion-base gel of kelakai root extract at a concentration of 1000 ppm. Each standard solution was made into a series of five dilution concentrations: 100 ppm, 150 ppm, 200 ppm, 250 ppm, and 300 ppm.

Data analysis

The EE x I value is a constant determination from a wavelength of 290-320 nm with an interval of 5 nm. The EE x I value can be seen in Table III (Aji & Rani, 2022).

Tabel III: EE x I constant

Wavelengths (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
Total	**1.00**

Determination of %Te values

Erythema transmission (Te) was calculated by the equation:

$$\text{Te} = \text{T} \times \text{Fe}$$

Where Fe is the erythema flux whose value was at a specific wavelength. The amount of erythema flux transmitted by sunscreen (Ee) was calculated using the formula:

$$Ee = \sum Te .$$

Meanwhile, the percentage of erythema transmission was calculated using the equation:

$$\%\ \text{erythema transmission} = \frac{Ee}{\sum Fe} = \frac{\sum Te}{\sum Fe}$$

Determination of %Tp values

The pigmentation transmission (Tp) was calculated using the following equation:

$$\mathbf{Tp} = T \times Fp$$

Where Fp is the pigmentation flux whose value was at a specific wavelength, pigmentation flux was calculated by the sunscreen (Ep) using the following formula:

$$\mathbf{E}p = Tp$$

Meanwhile, the % pigmentation transmission was determined using the following equation:

$$\%\ \text{pigmentation transmission} = \frac{Ep}{\sum Fp} = \frac{\sum Tp}{\sum Fp}$$

Statistical analysis

The sunscreen effectiveness for each group was analysed with ANOVA using SPSS 18.0 (2020) with a confidence level of 95% to identify differences in sunscreen effectiveness between sample groups.

Results

Kelakai root extraction (Stenochalena palustris (Burm. F) Bedd)

In the extraction of kelakai roots using maceration, the yield was 1.408% of the total 50 g of kelakai root simplicia powder.

Table IV: Results of the ethanol extract of kelakai roots (*Stenochlaena palustris* (Burm. F) bedd)

Weigh of simplicia (g)	Weigh of extract (g)	Extract yield (%)
50	0.7043	1.408

Phytochemical screening of the extract

The results of the phytochemical screening of the ethanol extract of kelakai roots contained compounds with antioxidant activity (Table V).

Table V: Results of compound identification in Kelakai root extract

Compounds	Result
Flavonoid	+
Alkaloid	+
Saponin	+
Fenol	-
Tanin	-

Microemulsion formulation of kelakai root ethanol extract

Kelakai root ethanol extract microemulsion has a yellow translucent appearance and can transmit laser light (Figure 1).

Figure 1: Microemulsion of kelakai root ethanol extract

The results of a microemulsion of kelakai root ethanol extract are shown in Table VI.

Table VI: Parameters of a microemulsion of kelakai root ethanol extract

Parameters	Results	Standard
Particles size	14.6 nm ±1.3	10-200 nm
Polydispersity index	0.410 ±0.0	< 0.5
% transmittance	94.9%	>90%
Zeta Potential	-42.5 mV	< -30 mV or > +30 mV

Microemulsion-base gel formulation of Kelakai Root Ethanol Extract

Based on previous research results, the optimum formula of microemulsion base gel obtained with the gelling agent Na-CMC (3.25%) and propylene glycol (5.75%) had the best desirability value compared to other formulas. The resulting microemulsion base gel of ethanol extract kelakai root had a clear appearance, as shown in Figure 2 below.

Figure 2: Microemulsion base-gel of Kelakai root ethanol extract

Table VII presents the evaluation of the microemulsion base gel.

Table VII: Evaluation of microemulsion-base gel

Parameters	Results
Organoleptic	Transparent appearance
Homogeneity	Homogenous
pH	5.6
Adhesive power	1.9 s
Spreadability	6.2 cm
Viscosity	3980 Cps

Determination of sunscreen effectiveness SPF values

The SPF value of the microemulsion of kelakai root ethanol extract had the best effectiveness as a sunscreen at concentrations of 40, 50, 60, 70, and 80 ppm, which were 29.24, 29.41, 29.54, 29.55, and 29.66, respectively. These SPF values were categorised as ultra-protection. Meanwhile, for the kelakai root microemulsion gel, the SPF values with the same concentrations were 3.85, 4.64, 8.49, 8.89, and 9.8, respectively, where 60-80 ppm concentrations had the maximum protection category. A comparison of the SPF values for each test sample can be seen in Figure 3.

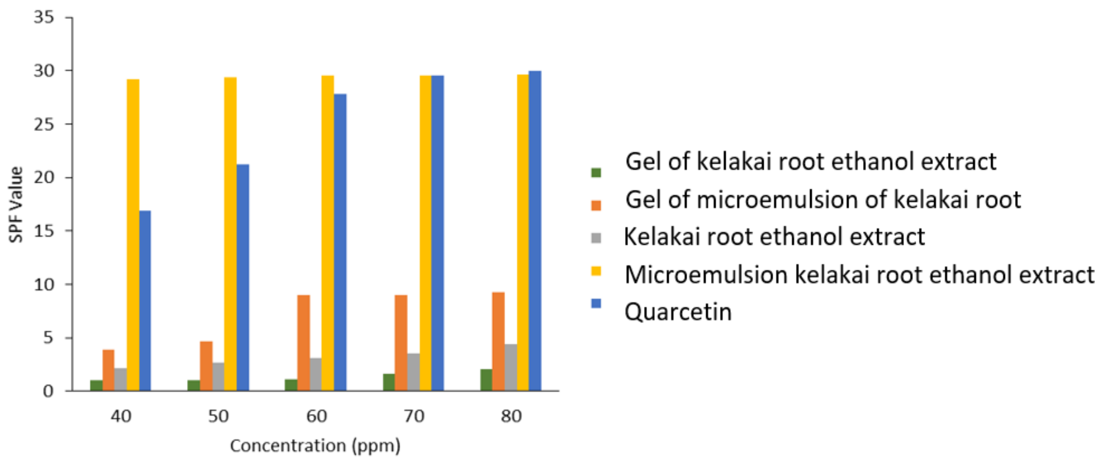

Figure 3: Graph of SPF value

Erythema Transmission percentage(%Te)

The %Te was measured at a wavelength of 292.5-320 nm. In the microemulsion of kelakai root ethanol extract with concentrations of 40, 50, 60, 70, and 80 ppm, respectively, %Te values were obtained, namely 7.80%, 5.25%, 4.26%, 3.66%, and 2.52%, with the "*extra protection*" category at concentrations 50-80 ppm. In the microemulsion base-gel of kelakai root ethanol extract with the same concentrations, the %Te values obtained were 36.60%, 27.03%, 23.14%, 17.83%, and 9.641%, respectively, with the "*fast tanning*" category at concentrations 80 ppm. The %Te value graph for each sample can be seen in Figure 4.

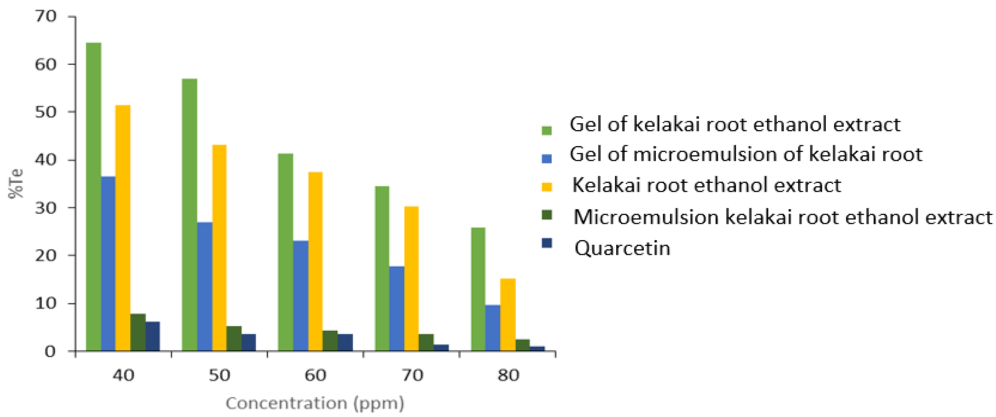

Figure 4: Graph of %Te

Pigmentation transmission percentage

Percentage TP microemulsion of kelakai root ethanol extract at concentrations of 40, 50, 60, 70, and 80 ppm obtained %Tp values of 9.35%, 6.62%, 5.90%, 5.73%, and 3.879%, respectively, with the category being "*total block*". In the microemulsion base-gel of kelakai root ethanol extract at the same concentration, obtained %Tp values of 44.76%, 35.86%, 29.53%, 25.09%, and 16.79%, respectively, with the category being "*total block*" at a concentration of 50-80 ppm. The %Tp graph for each sample can be seen in Figure 5.

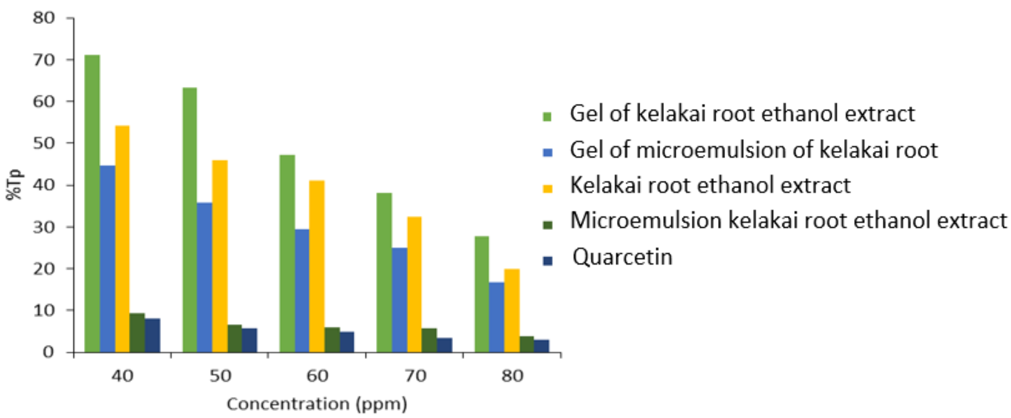

Figure 5: Graph of %Tp

Statistical analysis

Table VIII below shows the statistical analysis results using ANOVA to test each sample's SPF, %Te, and %Tp values. The variables compared are extract, extract gel, extract microemulsion gel, kelakai root extract microemulsion, and quercetin.

Table VIII: ANOVA analysis data

Test	Significance	Information
SPF	0.001 < 0.05	There are differences in SPF values between extract, extract gel, extract microemulsion gel, kelakai root extract microemulsion, and quercetin.
%Te	0.004 < 0.05	There are differences in %Te values between extract, extract gel, extract microemulsion gel, kelakai root extract microemulsion, and quercetin.
%Tp	0.007 < 0.05	There are differences in %Tp values between extract, extract gel, extract microemulsion gel, kelakai root extract microemulsion and quercetin.

Discussion

Kelakai roots have characteristics resembling fibrous roots. This type affects the amount of dried simplicia obtained for the extraction process. As observed in this study, the extract yield obtained from 50 g of Simplicia powder was 1.41% or equivalent to the weight of 0.704 g of the total Simplicia extract. Kelakai root extract contains flavonoids, alkaloids, and saponins. These compounds play vital roles in the production of antioxidant activity. Flavonoids are one of the natural compounds that can potentially be photoprotective agents because they can absorb UV rays (Saewan *et al*., 2013; Sampaio *et al.,* 2017). Tannin is a compound belonging to the class of phenolic compounds, which has two aromatic rings bonded by three carbon atoms. These compounds act as antioxidants because they have phenol groups or OH groups attached to the carbon of the aromatic ring (Charlton *et al.,* 2023). The antioxidant activity in the ethanol extract of kelakai roots can be used as an active ingredient in topical preparation formulations to protect the skin from sun exposure (Petruk *et al.,* 2018).

On formula optimisation studies, the optimum formula of kelakai root ethanol extract microemulsion was obtained using Tween 80 (surfactant) and PEG 400 (co-surfactant) with a concentration ratio of 35:15. Microemulsions are nanometer-sized droplets of liquid that do not dissolve in other liquids. The microemulsion interface becomes stable by providing the right surfactant and co-surfactant. The mixture of oil, surfactant and water allows the formation of a flexible surfactant layer. Meanwhile, the microemulsion system has tiny globule sizes (10-100 nm) and can penetrate well up to the epidermis (Ait-Touchente *et al*., 2023; Yadav *et al*., 2023). Microemulsions are thermodynamically stable and have low viscosity compared to emulsions in general (Iskandar *et al*., 2021). A combination of surfactant and cosurfactant with the right concentration is required to form a stable microemulsion—tween 80 and PEG 400 act as emulsifiers to produce stable microemulsions. Combining surfactants and co-surfactants can produce clear microemulsion results (Shabrina *et al*., 2021). The droplet size of the resulting kelakai root ethanol extract microemulsion was 14.6 nm with a zeta potential of -42.5 mV (Table VI). It is possible to increase its bioavailability for topical administration (Ait-Touchente *et al.,* 2023).

The microemulsion of kelakai root ethanol extract was then incorporated into a gel form to make it easier to use. Microemulsion has a low viscosity, so the developed gel form increases the preparation's viscosity and, thus, its contact time with the skin. The gel is easier to apply to the skin and has an attractive physical appearance compared to other topical preparations (Forestryana *et al*., 2020).

Based on the SLD analysis results, an optimum formula was obtained with Na-CMC 3.26% and propylene glycol 5.73%, with a desirable value of 0.833. Based on the evaluation of the characteristics of microemulsion-base gel ethanol kelakai root extract, the preparation was clear and homogeneous, had a pH of 5.6, was suitable for the skin range, had an adhesion of less than four seconds, and had good spreading power, making it possible to apply it to facial skin.

Based on the evaluation of the characteristics of microemulsion-base gel ethanol kelakai root extract, the preparation was clear, homogeneous, had a pH value of 5.6, was suitable for the skin range, and had an adhesion of less than four seconds, and an excellent spreading power, making it possible also to apply it to the facial skin. Based on the results of the SPF values of the positive control (quercetin) at concentrations of 40, 50, 60, 70, and 80 ppm, respectively, the SPF values were 16.90, 21.21, 27.80, 29.51, and 30.00. Activity measurements of all concentration series fell within the "*ultra-protection*" category.

Based on these results, it can be seen that quercetin had relatively high SPF capabilities. Quercetin has a ring structure and an aglycone configuration of hydroxyl groups, making it one of the most potent flavonoids in antioxidant capacity (Arifin & Sanusi, 2018). Quercetin is a flavonoid compound in the flavonol group, which has a keto group at C-4 and a hydroxyl group at the C-3 or C-5 atom, which is neighbouring flavones and flavonols (Aminah *et al*., 2017). It reacts directly with free radicals by capturing unpaired electrons without producing other free radicals, where ultraviolet radiation can cause an increase in the formation of Reactive Oxygen Species (ROS), and flavonoids can reduce their activity triggered by ultraviolet radiation (Sulastri *et al*., 2015).

Based on the data of the SPF values of kelakai root ethanol extract using concentrations of 40, 50, 60, 70, and 80 ppm, the results were 2.15, 2.68, 3.14, 3.56, and 4.42. The highest SPF value was at a concentration of 80 ppm, a medium protection category. In contrast, the SPF value was obtained at 40 ppm, the ultra-protection category in the positive control quercetin. The difference in the SPF value of the extract and the comparison of quercetin can be caused by several things, such as the fact that the extract content is very diverse, so many secondary metabolites are contained in the extract. Solvents in the kelakai root extraction process will also impact the phenolic and flavonoid content. Besides that, ethanol concentration also affects the extraction process (Faizin *et al.,* 2024)

The SPF values of kelakai root ethanol extract microemulsion with concentrations of 40, 50, 60, 70, and 80 ppm were 29.24, 29.41, 29.53, 29.55, and 29.66, respectively. The resulting SPF value was included in the "*ultra-protection*" category, where the higher the concentration of the extract and system, the higher the SPF produced. The difference in SPF values obtained between the extract and microemulsion system is caused by the microemulsion droplets, which can increase the solubility of the active antioxidant compounds in kelakai roots. SPF value within the ultra category can inhibit UV radiation by 96.0-97.4% (Suryadi *et al*., 2021).

The SPF values of kelakai root ethanol extract gel at concentrations of 40, 50, 60, 70, and 80 ppm showed SPF values of 1.08, 1.05, 1.11, 1.64, and 2.01, where only a concentration of 80 ppm depicted a minimal protection ability. Meanwhile, kelakai root extract microemulsion-base gel with the same concentration had SPF values of 3.84, 4.64, 8.98, 8.98, and 9.22, where 60-80 ppm concentrations indicate the "*maximum protection*" category. The SPF values in the "*maximum protection*" category mean it can protect against UV rays by inhibiting UV radiation, amounting to 93.3-95.9% (Suryadi *et al*., 2021). The SPF values of the microemulsion gel were higher than those of the extracted gel because microemulsion gel uses microemulsion, which has a small particle size, thereby increasing the solubility of the extract in the gel matrix. The statistical analysis showed significant differences in the SPF values between the sample groups of the extract, extract gel, microemulsion of kelakai root extract, and microemulsion-base gel of kelakai root extract. Based on the SPSS analysis results, it can be seen that microemulsion had a significant influence on the SPF value.

The erythema transmission percentage describes the amount of sunlight that is transmitted after hitting the sunscreen, causing skin erythema (skin becomes reddish) (Rijar *et al*., 2022). The results of the erythema transmission percentage (%Te) on the positive control (quercetin) at concentrations of 40, 50, 60, 70, and 80 ppm were 6.17%, 3.65%, 3.54%, 1.45%, and 1.02% respectively where these values categorised into the "*extra protection*" category (Suharsanti *et al.,* 2019). Microemulsion of kelakai root extract at concentrations of 40, 50, 60, 70, and 80 ppm obtained a %Te value of 7.8%, 5.25%, 4.26%, 3.66%, and 2.52%. In microemulsion base-gel preparations with the same concentrations, the %Te values were 36.60%, 27.02%, 23.14%, 17.83%, and 9.64%. Based on Figure 4, the %Te value for kelakai root ethanol extract microemulsion at a concentration of 50-80 ppm is in the "*extra protection*" category, which means that the kelakai root ethanol extract microemulsion can protect both standard and sensitive skins because its absorption capacity was less than 95% of UV rays, enough to prevent erythema and pigmentation.

Meanwhile, in the microemulsion base-gel of kelakai root ethanol extract, the "*standard suntan*" category was obtained at a concentration of 80 ppm. Standard suntan is the ability of a chemical molecule to protect normal or non-sensitive skin to absorb most of the UV B rays and a small amount of UV A rays (Suharsanti *et al.,* 2019; Rijar *et al.,* 2022). Standard suntan contains ingredients that absorb sunscreen at least 85% UV radiation on the wavelength of 290-320 mn. Still, it transmits UV light over a long period of waves greater than 320 nm and produces light brown skin, which is temporary (Hasanah *et al.,* 2015).

In the ethanol extract of kelakai roots with the transmission of pigmentation is an abundance of energy ultraviolet light transmitted over long distances ultraviolet waves (UV A) 320-375 nm, different from measurements of transmission erythema. The pigmentation transmission percentage value (%Tp) describes the compound's ability to protect the skin from ultraviolet rays (UV A) 320-375 nm, which can cause the skin to darken (Hasanah *et al*., 2015). The %Tp values on the positive control were 8.00%, 5.73%, 4.90%, 3.46%, and 3.09%, which translates to the "*sunblock*" category in protecting against tanning. Quercetin has an antioxidant ability to inhibit photooxidation (Wang *et al*., 2017). Photooxidation is an oxidation reaction caused by light, and this reaction triggers the emergence of reactive oxygen species, which leads to the formation of brown or black melanin (Nahhas *et al*., 2019).

The results of the %Tp value category in the difference in erythema and pigmentation values in the preparation was due to its ability to absorb UV rays, and the erythema value was smaller than the pigmentation value because it was weak against the UV-B rays. The %Te value showed the effectiveness of sunscreen against UV-B rays, while the %Tp showed the effectiveness against UV-A rays. The UV-B radiation can cause sunburn and skin cancer, while UV-A causes skin blackening (tanning) and photosensitivity (Tang *et al.,* 2024). UV-A and UV-B can cause skin cancer even though UV-B is 1000-10,000 times more carcinogenic than UV-A, so it is 1000 times stronger than UV-A in forming erythema on the skin (DeBuys *et al*., 2000). UV-A radiation is at a wavelength of 320-400 nm and is responsible for skin tanning due to the excess melanin production from the epidermis. UV-B radiation is known as light that can cause skin burns 1000 times more than UV-A light (Juliadi *et al*., 2020).

Based on the analysed data, the %Te value and the %Tp value showed that compounds can absorb ultraviolet light (UV A) and (UV B), and little light is transmitted to the skin, thus preventing skin damage from sunlight (Amrillah *et al*., 2015). Based on the values %Te and %Tp, as well as the SPF values, the greater the concentration of the extract, the better the protection against UV rays. The sunscreen potential obtained provides good protection because flavonoid compounds in the extract absorb UV rays so that UV rays can be less transmitted to the skin surface. Theoretically, ethanol extract from kelakai root can provide benefits and protection against UV radiation on the skin.

The microemulsion of kelakai root ethanol extract has better effectiveness as a sunscreen, both in terms of SPF, %Te, and %Tp values compared to the other test sample groups, because the microemulsion has a small droplet size, making it possible to dissolve better than the extract. Meanwhile, in extract gel preparations and microemulsion base gels of kelakai root ethanol extract, the effectiveness of sunscreen is much different compared to the microemulsion system because the gel matrix prevents the active ingredients in the preparation from diffusing out and dissolving and produces effective sunscreen so that the formulation requires an appropriate concentration to create better effectiveness.

Conclusion

The microemulsion base gel of kelakai root ethanol extract was effective as a sunscreen at a concentration of 80 ppm. The SPF values of the microemulsion base gel of kelakai root ethanol extract were in the "*maximum protection*" category, and those of the per cent transmission of erythema and per cent transmission of pigmentation were in the "*sunblock*" category.

Acknowledgement

The authors hereby appreciate the University of Borneo Lestari for facilitating this research, which enhanced its timely completion.

Conflict of interest

The authors declare no conflict of interest in the study.

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