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Research Article

Potential for Herbal Oil from Virgin Coconut Oil with Turmeric Rhizome Addition as a Natural Ingredient in Skin Care for Tropical People

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ABSTRACT

The tropical climate results in high exposure to sunlight and humidity, which can lead to skin damage due to increased oxidative stress and pathogenic bacterial infections. Indonesians often utilize VCO and turmeric in skin care separately, as both have potential as antioxidants, antibacterials, and sunscreens. This study aims to produce herbal oil from VCO and turmeric (CHO) to maintain skin health in terms of antioxidant, antibacterial, and sunscreen activities. CHO was created by varying the maceration time to 1, 6, 12, 18, and 24 hours. The resulting CHO was analyzed for phytochemicals and physicochemical quality and tested for antioxidant, antibacterial, and sunscreen activities. The results showed that all CHO oils contained secondary metabolites: flavonoids, alkaloids, terpenoids, saponins, and phenolics. Physicochemical tests on CHO oil showed that the oil with a maceration time of 24 hours had the best physicochemical characteristics with a moisture content of 0.0051%, peroxide number 0.0081 meq/kg, and free fatty acids 0.0041%. The test results of antioxidant activity, antibacterial, and sunscreen activity indicate that all CHO oils are antioxidant, antibacterial, and able to protect from UV exposure. CHO-24 oil is the oil with the best bioactivity, with antioxidant activity of IC_{50} 177.352 ppm, antibacterial inhibition against *Staphylococcus aureus* of 8.42 mm, and SPF value of 40.798. From the results of the study, it can be concluded that CHO oil as a whole has the potential to maintain coolie health through its activity as an antioxidant, antibacterial, and sunscreen, with the best product being CHO-24.

Keywords: (Curcuma herbal oil, sun protection factor, antioxidant, antibacterial)

1. Introduction

Indonesia has a tropical climate with high heat and humidity in many areas. This tropical climate results in high exposure to direct sunlight on the skin. Excessive sun exposure can damage skin cells due to ultraviolet (UV) radiation [1]. Skin that is continuously exposed to UV light will experience an increase in oxidative stress, which can trigger DNA damage [2]. This can lead to aging and genetic mutations in the skin, resulting in skin damage and even skin cancer [3], [4]. Some efforts to overcome this problem often use substances that are antioxidants that can reduce oxidative stress on the skin. Antioxidants found in the skin can neutralize or prevent damage caused by free radicals to reduce oxidative stress in the skin [5].

The tropical climate with high humidity can make it easy for pathogenic bacteria to infect the skin, thus disturbing health [6]. *Staphylococcus aureus* (*S. aureus*) is one of the pathogenic bacteria that can cause skin health problems such as impetigo itching, cellulitis, boils, crusts, and skin wounds. Infections on the skin that are injured from body parts can lead to infections in other organs [7], [8].

Virgin Coconut Oil (VCO) is widely used as an ingredient for skin care and has been proven safe for human use. VCO is used as a skin care ingredient due to its antimicrobial and antioxidant properties [9]. VCO can provide moisture to the skin so that it can regenerate damaged skin cells [10]. Although it has the ability to maintain skin health, its activity as an anti-microbial and anti-oxidant is low. To increase its activity, some researchers manipulate it by adding secondary metabolites from herbal plants that improve the function of VCO in skin care [11], [12].

Turmeric is one of the herbal plants that has potential in maintaining skin health [13]. Its potential is because this plant has activity as an antioxidant, anti-inflammatory, and anti-microbial [14]. The content of secondary metabolite compounds in turmeric, such as curcumin, saponins, phenols, alkaloids, tannins, flavonoids, and terpenoids, is thought to be responsible for the bioactivity of turmeric [15]. The addition of turmeric rhizomes into VCO (CHO) is believed to improve the quality and bioactivity of the resulting herbal oil products, such as anti-oxidant and anti-bacterial activities [16]. The potential for improving the quality of CHO oil is because it will increase the levels of curcumin, alkaloids, steroids, flavonoids, and phenols in CHO [14]. Increased levels of secondary metabolites from CHO due to the addition of turmeric will increase the bioactivity of the resulting CHO oil, such as antioxidant activity, antibacterial activity, and sunscreen activity [11]. The concoction of VCO and turmeric can also provide various benefits for the skin due to the content of lauric acid, curcumin, and secondary metabolites that can moisturize the skin, regenerate skin cells, and prevent oxidative stress on the skin [13].

This study will synthesize VCO-turmeric herbal oil (CHO) by varying the maceration time, performing phytochemical and physicochemical tests, and evaluating its potential for maintaining skin health. The ability to maintain skin health is done by testing its bioactivity as an antioxidant and antibacterial, and its ability to protect from UV exposure.

2. Materials and Method

2.1 Materials

The materials: turmeric, virgin coconut oil (VCO), distilled water (H_2O), agar, 70% alcohol, hydrochloric acid (HCl), iron (III) chloride ($FeCl_3$), DPPH, 96% ethanol (C_2H_6O), chloramphenicol ($C_{11}H_{12}Cl_2N_2O_5$), chloroform ($CHCl_3$), magnesium powder (Mg), nutrient broth, sodium thiosulfate ($Na_2S_2O_3$), phenolphthalein indicator ($C_{20}H_{14}O_4$), potassium hydroxide (KOH), potassium iodide (KI), Dragendorff reagent, Liebermann-Burchard reagent, Mayer reagent, Wagner reagent.

2.2 Oil preparation

Preparation of virgin coconut oil (VCO) based oil preparations based on research methods Wahyuzan and modified without heating in this study [17]. Turmeric that has been air-dried is pulverized using a milling machine. The turmeric is finely sieved so that a finer turmeric powder is obtained. Turmeric powder with a mass of 17.5 g is put into virgin coconut oil as much as 300 mL and soaked with a time variation of 1, 6, 12, 18, and 24 hours at room temperature.

2.3 Phytochemicals test

2.3.1 Flavonoids

1 mL of oil is added with Mg powder and 5 drops of concentrated HCl. Positive test results are indicated by orange, pink, or red color [12].

2.3.2 Saponins

1 mL of oil was added to 5 mL of hot distilled water and shaken. The presence of saponin content is characterized by the formation of stable foam [11].

2.3.3 Terpenoids

As much as 1 mL of oil is added with 5 drops of Liebermann-Burchard reagent, and the color change that occurs is observed. Positive results of the terpenoid test are indicated by the formation of red or purple color [18].

2.3.4 Phenols

1 mL of oil is added with 5 drops of $FeCl_3$, and the color changes that occur are observed. Positive test results are indicated by the onset of a blue-black color [19].

2.3.5 Alkaloids

Into three test tubes, 1 mL of herbal oil was added each, and sequentially reacted with 5 drops of Mayer, Dragendorff, and Wagner reagents, and the formation of precipitate from the mixture was observed [19].

2.4 UV-Vis Characterization

Herbal oils with various immersion variations were scanned with a UV-Vis device at a wavelength of 200–700 nm to see their absorption patterns [20].

2.5 Physicochemistry

2.5.1 Moisture content

Oil weighing 1 gram was baked for 1 hour at 105 ^{o}C and then cooled in a desiccator. Weighing and heating were carried out until a constant weight was obtained [21].

2.5.2 Density

The pycnometer was filled with distilled water until it was full and no bubbles formed and then weighed. The distilled water was removed, and the pycnometer was baked again at 105 ℃ for 30 minutes. The pycnometer was filled with herbal oils until it was full and then weighed [22].

2.5.3 Free fatty acid content

Herbal oils as much as 5 mL are put into an Erlenmeyer flask, 96% ethanol is added as much as 50 mL, and 3 drops of PP indicator (phenoftalein). The mixture was titrated using 0.1 N KOH solution until it changed color to pink [16].

2.5.4 Peroxide number

The oil was weighed as much as 3 grams and put into an Erlenmeyer. Glacial acetic acid and chloroform were mixed in a ratio of 3:2. The mixture of glacial acetic acid and chloroform was added to the herbal oils sample as much as 15 mL and shaken until dissolved. KI 10% solution was added as much as 0.5 mL, then allowed to stand for 30 minutes in a dark place. Distilled water was added as much as 15 mL and 1% amylum as much as 0.5 mL. The sample was titrated with 0.02 N sodium thiosulfate solution until the blue color disappeared [21].

2.6. Antioxidant activity

The oil was dissolved using chloroform with concentration variations of 200, 250, 300, 350, and 400 ppm. Oil samples of as much as 2 mL of each concentration were added with 2 mL of 0.1 mM DPPH solution and incubated for 30 minutes. The solution was measured for absorbance at 528 nm wavelength using a UV-Vis spectrometer. Antioxidant activity was determined by the value of percent inhibition versus time made a regression equation graph to obtain a regression equation that will be used to obtain the IC_{50} value [23].

2.7 Antibacterial activity

A total of 20 µL samples were dripped onto the disc paper and allowed to stand until the sample was absorbed on the disc paper. The disc paper containing the sample was then placed on a Petri dish containing NA media. The petri dish was then incubated for 24 hours, and the diameter of the inhibition zone formed was measured. The samples used in this study were made with concentration variations of 20, 40, 60, 80, and 100% with VCO solvent. In this study, chloramphenicol was used as a positive control and VCO as a negative control [24].

2.8 Sun Protection Factor (SPF) test

SPF measurement of herbal oil using spectrophotometric method. Herbal oils with various immersion variations were scanned with a wavelength of 290-320 nm to see the absorption peak at the wavelength [18].

3. Result and Discussion

3.1 Result

3.1.2 Herbal oil products

In this study, maceration of turmeric rhizomes with Virgin Coconut Oil (VCO) solvent produced herbal oil products with orange color characteristics (**Figure 1**). The change in color of the product from colorless (pure VCO) to orange (herbal oil product) indicates the extraction of secondary metabolites from turmeric rhizomes into VCO [25]. The color of the herbal oil produced did not show any significant difference between CHO-1, CHO-6, CHO-12, CHO-18, and CHO-24, where the orange color density of all variations was visually the same.

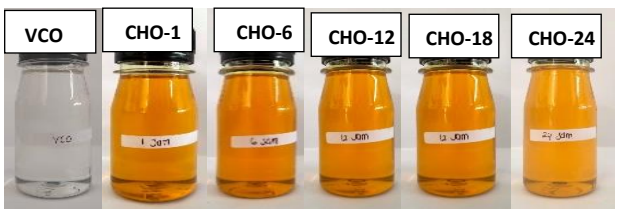


Figure 1. Herbal oil with maceration variations

3.1.2 Phytochemicals Tests

Phytochemical tests on the synthesized herbal oils are shown in **Table 1**. The results of phytochemical tests in this study showed that all herbal oils contained secondary metabolites of flavonoids, alkaloids, terpenoids, saponins, and phenolics. Meanwhile, VCO oil in this study only contains alkaloids, terpenoids, and saponins in small amounts when compared to the secondary metabolites contained in herbal oils. This is because the main content of VCO is lipid compounds, which are primary metabolites [19]. The increased content of secondary metabolites in herbal oil is due to the dissolution of phenolic compounds, flavonoids, terpenoids, saponins, and alkaloids derived from turmeric rhizomes. These results are in accordance with the research of Wibowo, which states that the maceration of plants using VCO oil will enrich the content of secondary metabolite compounds from the resulting herbal oil [11].

Table 1. Phytochemical test results

Test type	VCO	Maceration Variation CHO(Hour)				
		1	6	12	18	24
Flavonoids	-	+++	+++	+++	+++	+++
phenols	-	+++	+++	+++	+++	+++
Terpenoids	+	+++	+++	+++	+++	+++
Alkaloids						
a.Dragendorf	-	-	-	-	-	-
b.Mayer	-	-	-	-	-	-
c.wagner	+	++	++	++	++	++
Saponins	+	++	++	++	++	++

Remarks: (+) contained; (-) not contained

3.1.3 UV-Vis Characterization

Characterization of herbal oil using UV-Vis spectrophotometry showed absorption at wavelengths of 200-470 nm (**Figure 2**). Compared with VCO, the herbal oil showed increased absorption at wavelengths of 254-462 nm (**Figure 2**, **Table 2**). The increase in absorption in herbal oil is due to the presence of chromophore groups and aromatic rings in the sample due to the increased content of secondary metabolites derived from turmeric rhizomes. According to Patel et al. (2020), the presence of terpenoid class compounds was indicated by UV-Vis absorption at a wavelength of 400-462 nm. The presence of flavonoid compounds was indicated by UV-vis absorption in the wavelength range of 300-356 nm, while phenol in the wavelength of 254-298 nm [26]. Alkaloid absorption peaks occur at a wavelength of 254-470 nm [27]. The absorption that occurs indicates the presence of π-π^* and n-π^* transitions from the chromophore group present in secondary metabolite compounds [26].

Table 2. Absorbance of herbal oil

Sampel	absorbance at wavelength λ(nm)			
	254	298	356	462
VCO	3.661	0.774	0.095	0.052
CHO-1	4.159	3.891	3.581	3.245
CHO-6	4.214	4.025	3.865	3.280
CHO-12	4.100	3.888	3.545	3.211
CHO-18	4.506	3.954	3.684	3.250
CHO-24	5.000	4.640	3.988	3.344

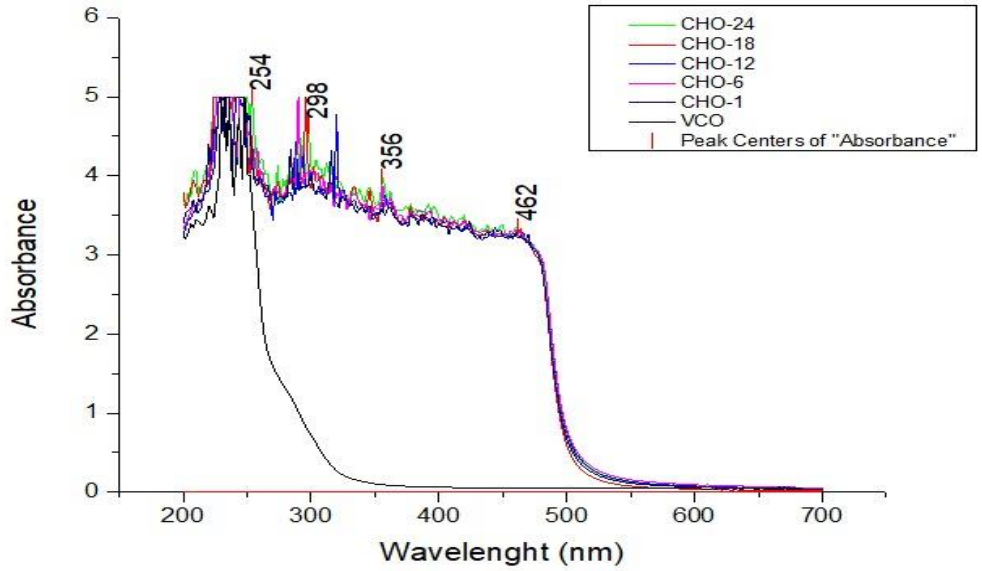


Figure 2. Wavelength of secondary metabolites herbal oils

This data reinforces the results of the phytochemical test, which states the content of secondary metabolite compounds, such as flavonoids, terpenoids, alkaloids, and phenols in the herbal oil produced. Research data in **Figure 2** and **Table 2** show that the absorbance of CHO-24 oil has a higher absorbance value when compared to CHO-18, CHO-12, CHO-6, and CHO-1, which indicates the content of more secondary metabolite compounds.

3.1.4 Physicochemistry

Physicochemical tests carried out by measuring the water content, density, peroxide number, and free fatty acids of herbal oils made by varying the maceration time are given in **Table 3**. The measurement of water content showed that the longer the maceration time, the lower the water content of herbal oil. The occurrence of a decrease in water content is due to the absorption of water from VCO oil into turmeric powder. This happens because turmeric powder is hygroscopic [28]. The results showed that the length of maceration time will increase the density of herbal oil (**Table 3**). The increase in density is caused by the dissolution of secondary metabolites into VCO [12]. The solubility of secondary metabolites in VCO is reinforced by phytochemical analysis and UV-vis characterization of the herbal oil produced.

Table 3. Physicochemical properties of herbal oil

Samples	Moisture content (%)	Density (g/mL)	Free fatty acid (%)	Peroxide number (meq/kg)
VCO	0.0318	0.9129	0.0131	0.0115
CHO-1	0.0085	0.9208	0.0057	0.0095
CHO-6	0.0073	0.9215	0.0050	0.0089
CHO-12	0.0057	0.9205	0.0049	0.0084
CHO-18	0.0056	0.9221	0.0046	0.0083
CHO-24	0.0051	0.9222	0.0041	0.0081

The determination of free fatty acid content was carried out to determine the effect of maceration time on free fatty acid content. The research data (**Table 3**) showed that a longer maceration time will reduce the free fatty acid content of herbal oil. The decrease in free fatty acid levels is caused by the decrease in water content

in the oil (**Table 3**). The low water content in the oil will result in low hydrolysis reactions of triglyceride compounds by water, which produces free fatty acids [16].

A peroxide number test on herbal oil was conducted to see the effect of maceration time on peroxide number. The test results show that the longer the maceration time, the greater the reduction of the peroxide number of herbal oil (**Table 3**). The occurrence of a decrease in peroxide number is due to the increase in secondary metabolite compounds in VCO. The decrease of secondary metabolites in herbal oil will reduce the occurrence of oxidation reactions of fatty acids, this is because secondary metabolites are antioxidants [12].

Overall, the results of the physicochemical tests showed that the addition of turmeric rhizomes into VCO can improve the quality of herbal oil by reducing water content, peroxide number, and free fatty acid content. The quality of herbal oil produced meets SNI standards (moisture content ≤0.2%, free fatty acids ≤ 02%, peroxide number ≤ 0.2 meq/kg), with the best herbal oil result being CHO-24 [29].

3.1.5 Antioxidant activity

The results of the antioxidant activity test (**Table 4**) showed a decrease in the IC_{50} value of the herbal oil as the maceration time increased. This indicates that the maceration process significantly affects the potential antioxidant activity of herbal oils. Herbal oil with 24 hours maceration time (CHO-24) gave the lowest IC_{50} value (177.3529 ppm), which indicates that its antioxidant activity is stronger than VCO (IC_{50} 461.8684 ppm). This phenomenon can be explained by the fact that increasing the maceration time increases the amount of secondary metabolites dissolved into herbal oils, such as alkaloids, flavonoids, terpenoids, phenolics, and saponins, which are known to have antioxidant properties [14]. Phytochemical analysis data (**Table 1**) and UV-vis (**Figure 2**) reinforce these findings, where the content of secondary metabolites increases with increasing maceration time. This indicates that the addition of turmeric rhizome to the herbal oil will increase the antioxidant activity of the resulting herbal oil.

Table 4. Antioxidant activity of herbal oil

Samples	Maceration Variation (hours)	IC_{50} (ppm)
α-tokoferol	-	6.7612
VCO	-	461.8684
CHO-1	1	307.1953
CHO-6	6	276.1897
CHO-12	12	202.3540
CHO-18	18	181.1434
CHO-24	24	177.3529

3.1.6. Antibacterial activity

The research data showed an increase in antibacterial activity in herbal oils. The results showed that the positive control (chloramphenicol) provided inhibition that was classified as strong, while the negative control, and in the form of VCO did not provide inhibition. All maceration time variations performed on herbal oils produced different inhibition zones (**Table 5**). CHO-1, CHO-6, CHO-12, and CHO-18 have bacterial activity classified as weak, while CHO-24 produces antibacterial activity classified as moderate. This increase in antibacterial activity occurs due to the extraction of active secondary metabolite compounds from turmeric rhizomes, such as curcuminoids and essential oils, which are known to have antibacterial properties [30]. The results of phytochemical and UV-vis analysis (**Table 1** and **Figure 2**) also support these findings, showing that there is an increase in the content of bioactive compounds such as alkaloids, flavonoids, terpenoids, steroids, phenolics, and saponins, along with the length of maceration time which contributes to its antibacterial activity [31]. This finding indicates that the synthesized herbal oil has potential as a natural antibacterial against *S. aureus*, with the best inhibitory activity being CHO-24, which is classified as moderate. The minimum inhibitory concentration determination of the best herbal oil (CHO-24) is given in **Table 6**. The KHM test results provide that the minimum inhibitory concentration of CHO-24 oil is 60%, with an inhibition zone of 1.38 mm.

Table 5. Antibacterial activity of herbal oil

Samples	Inhibition zone diameter (mm)
Chloramphenicol (+)	16.3 ± 0.1803[a]
VCO (-)	0
CHO-1	4.32 ± 0.9674[b]
CHO-6	4.35 ± 0.4770[b]
CHO-12	4.51± 1.1951[b]
CHO-18	5.53 ± 0.4782[b]
CHO-24	8.42 ± 0.8180[c]

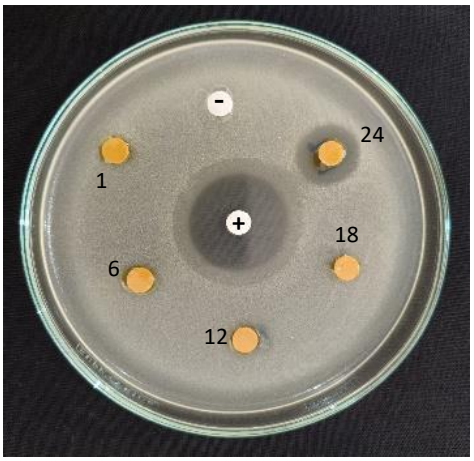


Figure 4. The antibacterial activity of CHO

Table 6. Determination of the minimum inhibitory concentration of the CHO-24 herbal oil

Concentration Variation	Inhibition zone diameter (mm)
Chloramphenicol (+)	16.7 ± 0.1527[a]
VCO (-)	0
20 %	0[b]
40 %	0[b]
60 %	1.38 ± 0.3686[bc]
80 %	2.45 ± 0.5074[c]
100 %	6.75 ± 1.3402[d]

Statistical analysis of the antibacterial test results was carried out using the one-way ANOVA test followed by a post hoc test. The test results showed that CHO-1, CHO-6, CHO-12, and CHO-18 did not have significant differences (P>0.05), while CHO-24 was significantly different from all treatments (P<0.05).

3.1.7 Sun Protection Factor (SPF) Herbal Oil

The results showed that the SPF value of herbal oil made from a mixture of VCO and turmeric increased when compared to VCO (**Table 8**). The research data showed that the SPF value of VCO oil was 5.538, while all herbal oils had an increased SPF value, as seen in **Table 8**. The increase in the SPF value of herbal oils was caused by the addition of secondary metabolite compounds from turmeric rhizomes that have chromophore groups that can absorb UV-A and UV-B rays [32]. The measurement results show that all synthesized herbal oils have the potential to be sunscreens that are classified as ultra-protection.

Table 7. Absorbance of herbal oil

λ(nm)	Abs Samples					
	VCO	CHO-1	CHO-6	CHO-12	CHO-18	CHO-24
290	1.019	4.045	5.000	3.803	3.974	4.025
295	0.592	3.862	3.964	4.058	4.000	4.048
300	0.722	3.999	4.069	4.073	3.833	4.107
305	0.856	3.797	4.026	3.810	3.935	4.137
310	0.463	3.749	3.954	3.841	3.930	3.973
315	3.887	4.095	3.822	3.912	3.860	4.076
320	0.274	3.667	3.795	4.780	3.993	3.874

Table 8. The sun protection factor value of the herbal oil

Variation	SPF	Group
VCO	5.538	Currently
CHO-1	38.786	Ultra
CHO-6	40.140	Ultra
CHO-12	39.383	Ultra
CHO-18	39.062	Ultra
CHO-24	40.798	Ultra

3.2 Discussion

High sun exposure in tropical climates is one of the main factors affecting skin health due to exposure to UV rays [1]. Excessive exposure to ultraviolet (UV) light from sunlight will induce an increase in the production of free radicals or reactive oxygen species (ROS) in the skin, which will cause DNA damage that leads to genetic mutations and skin cell death [2]. This event will result in damage to skin cells that can trigger skin disorders such as premature aging, the formation of dark spots, sunburn, and even skin cancer [3], [4]. These effects worsen skin conditions, which can cause long-term damage that can affect quality of life. Therefore, for individuals living in the tropics, materials that can protect the skin from the effects of UV exposure and oxidative stress are needed [5], [33].

In addition to sun exposure, high humidity in tropical climates also has the potential to increase the risk of skin infection by *S. aureus* bacteria. This infection can trigger various skin disorders, ranging from rashes, boils, and impetigo to more severe conditions such as cellulitis and peeling skin syndrome due to staphylococcal bacteria [34]. High humidity can facilitate bacterial growth on the skin surface and create ideal conditions for the development of skin infections [6]. For the above phenomenon, it is very important to find natural ingredients that can protect against UV radiation, have antioxidant activity, have antibacterial activity, and are safe for the skin to prevent skin damage.

CHO oil can be a solution to protect the skin from damage due to sun exposure and microbial infections. The results showed that all variants of synthesized turmeric herbal oil are classified as ultra sunscreen and antioxidant (**Table 4** and **Table 7**). Its nature as an ultra-sunscreen results in this oil being able to provide a high level of protection against UV exposure and free radicals [35]. The ability of CHO oil to protect the skin from UV exposure is due to the presence of secondary metabolite compounds contained therein, such as alkaloids, terpenoids, saponins, flavonoids, and phenolic compounds (**Table 1**) [36]. The increase in secondary metabolite content is supported by UV-Vis analysis data, which shows the presence of absorption in the wavelength range of 254-462 nm (**Figure 2**). This uptake is due to the secondary metabolite compounds contained in CHO oil, containing chromophore groups that can absorb UV rays [32]. In addition to being a sunscreen, CHO oil is also an antioxidant (**Table 4**). Its activity as an antioxidant makes it able to prevent oxidative stress on the skin both by UV exposure and other environmental factors. This ability to prevent oxidative stress makes it a natural ingredient that has the potential to protect and treat the skin from damage due to UV exposure and oxidative stress [33]. Skin disorders due to microbial infection by *S. aureus* in tropical

areas can be prevented by CHO oil. This antibacterial activity is indicated by its ability to inhibit the growth of *S. aureus* (**Table 5**). This antimicrobial ability is due to the presence of bioactive compounds in turmeric oil that have antibacterial properties, such as alkaloids, terpenoids, saponins, flavonoids, and phenols [37]. The Mechanism of CHO oil in preventing skin disorders due to UV exposure and bacterial infections was illustrated by **Figure 4.**

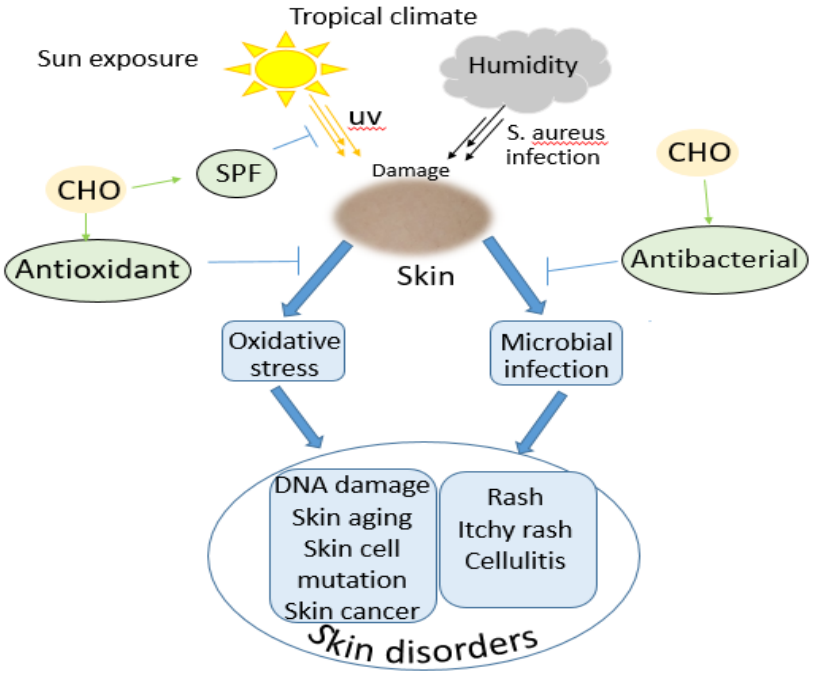


Figure 4. The Mechanism of CHO oil in preventing skin disorders due to UV exposure and bacterial infections in tropical populations.

In addition to their ability to protect against UV exposure, oxidative stress, and *S. aureus* bacterial infection, CHO oils are also safe for the skin. The physicochemical analysis data in this study showed that CHO oils have a free fatty acid value and peroxide number lower than the maximum value allowed by the SNI standard (**Table 2**). The quality of CHO oils that meets this standard can be an effective and safe choice in skin care in tropical areas that are prone to various skin problems due to UV exposure, oxidative stress, and microbial infections [16], [29].

4. Conclusion

Based on the research that has been done, it can be concluded that CHO oil can be useful as a skin care ingredient for tropical people because of its potential as an antioxidant, antibacterial, and sunscreen. CHO-24 oil is the best herbal oil product with antioxidant and antibacterial activities that are classified as moderate, as well as a sunscreen with ultra protection.

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