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RESEARCH ARTICLE

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# Sunscreen lip balm stick formulation contains a combination of virgin voconut oil and crude palm oil

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**Abstract:** Virgin coconut oil (VCO) and crude palm oil (CPO) are products of Indonesia's natural wealth with significant antioxidant activity and potential as lip balm sticks to treat dry lips caused by sun exposure. This study aims to determine the formulation of lip balm stick preparations containing VCO and CPO that have sunscreen activity and acceptable physical characteristics. This study included the phases of testing, formulation of lip balm stick, sunscreen activity test, and evaluation of physical properties. The compositions were melted using a water bath, and the sunscreen's efficacy was evaluated using UV-Vis spectrophotometry. VCO and CPO concentrations varied between 5%, 7.5%, 10%, 12.5%, and 15% (w/w). The F1 formula containing 5% VCO and 15% CPO (w/w) had the highest sun protection factor (SPF) value of 15.438. The evaluation of the formula activity test revealed that the higher the CPO content, the greater the sunscreen activity. Formula F1 has stable physical properties while stored at room temperature for 28 days. Formula F1 has a yellow color, chocolate scent, semi-solid consistency, homogeneous, 3.35 cm dispersion, 56°C melting point, and 64 gram hardness. Formula F1 provides excellent sun protection and physical properties. It may be further evaluated as a lip balm stick sunscreen formulation for chapped lips.

**Keywords:** crude palm oil, dry lips, lip balm stick, sunscreen, virgin coconut oil

## Introduction

The lips are one of the most important face features on an individual's self. The lips have a thin layer of corneum, a limited quantity of melanin, and no protective barrier such as sweat glands, making them more susceptible to damage [1]. Dry lips are among the most common forms of damage. Poor exposure to UV rays, which damage the surface layer of the lips' outermost keratin cells and create dry lips, necessitates protection and care for the lips [2].

Lip balms are cosmetics that are used to the lips to maintain their health. Lip balm protects the lips from environmental factors such as UV radiation, temperature fluctuations, and dehydration [3]. Lip balms are composed of wax, which works as a physical shaper. Oil in lip balm often contains both saturated fatty acids and unsaturated fatty acids, as well as fat as a film-forming layer [4]. In this study, stick lip balm was chosen due to its convenience to use.

Sunscreen activity may be present in lip balm preparations; it is one of the ingredients that protects the skin from UV radiation from the sun by absorbing or reflecting UV rays [5]. Sun Protection Factor (SPF) refers to the ability of sunscreen products to protect against sun exposure. The SPF value indicates the level of protection provided: minimum (2-4), moderate (4-6), extra (6-8), maximum (8-15), and ultra (above 15) [6].

Currently, cosmetics exploit the benefits of natural ingredients, particularly in Indonesia, where natural products are abundant. Coconut (*Cocos nucifera L.*) is a plant from which virgin coconut oil (VCO) is extracted. VCO contains vitamin E and high levels of antioxidants that can be utilized as emollients to maintain skin elasticity [7]. VCO contains an abundance of medium-chain fatty acids and is readily absorbed by the skin [8]. In a previous study, the $IC_{50}$ value for VCO's antioxidants ranged from 1.16 to 12.54 mg gallic acid equivalents (GAE) per gram [9]. VCO can protect against UV radiation because to its SPF value of 7.119 [10].

Oil palm (*Elaeis guinennsis*) is another type of coconut plant that produces oil, which is then refined into crude palm oil (CPO). This oil has a distinctive reddish-orange color due to the presence of carotenoids

**Table 1.** Formula for lip balm stick sunscreen preparations with variations of VCO and CPO

| Ingredient | Function | Concentration (% b/b) | | | | |
|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 |
| VCO | Active substance (Oil phase) | 5 | 7.5 | 10 | 12.5 | 15 |
| CPO | | 15 | 12.5 | 10 | 7.5 | 5 |
| Cera alba | Base, texturers | 13 | 13 | 13 | 13 | 13 |
| Candelilla wax | Hardener | 10 | 10 | 10 | 10 | 10 |
| Lanolin | Softener | 6 | 6 | 6 | 6 | 6 |
| Glycerine | Humectants | 5 | 5 | 5 | 5 | 5 |
| BHT | Antioxidant | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Oleum cacao ad | Fastener | 100 | 100 | 100 | 100 | 100 |

and vitamin E [11]. It contains antioxidants that can neutralize free radicals and prevent oxidative cell damage by inhibiting lipid peroxidation in the plasma membrane. CPO has strong antioxidant activity with $IC_{50}$ value of 15.6 µg/mL [11,12].

VCO and CPO have the potential to be used as sunscreens in cosmetic preparations for dry lips. However, it has not yet been developed, thus a formulation is required to enable the use of the two oils in lip balm stick formulations comfortable. This study aims to determine the optimal formulation for stick lip balm sunscreen preparations employing a combination of VCO and CPO as the sunscreen. The formulations of lip balm stick sunscreens with the highest sun protection activity were evaluated for their physical properties to determine whether or not they meet the standards.

## Method

Variations in the concentrations of VCO and CPO were used to determine the potential activity of five formulas of lip balm sticks containing sunscreens. Lip balm stick formula contains VCO, CPO, beeswax (cera alba), candelilla wax, lanolin, glycerine, butylated hydroxytoluene (BHT), and cacao oleum (Table 1). This study was divided into several stages: formulation of a sunscreen lip balm stick, *in vitro* sunscreen activity testing using UV-Vis spectrophotometry, and evaluation of physical properties.

### Sunscreen lip balm stick formulation

The lip balm stick was prepared by melting the ingredients in a water bath. The total concentration of oil phase (VCO and CPO) was 20% [13]. The concentrations of VCO and CPO varied as follows: VCO 5% and CPO 15% (Formula F1), VCO 7.5% and CPO 12.5% (Formula F2), VCO 10% and CPO 10% (Formula F3),VCO 12.5% and CPO 7.5% (Formula F4), VCO 5% and CPO 15% (Formula F5) (Table 1).

First, cera alba and candelilla wax base were melted at 62-64°C and 56-79°C, respectively. The cacao oleum fat base was melted at a temperature of 31-34°C. After melting the first three ingredients, lanolin and glycerine were added while stirring. Finally, the oil phases VCO, CPO, and BHT were added. Homogeneous ingredients were then put into the lip balm stick container.

### SPF value measurement

The activity test of the preparation was observed using UV-Vis spectrophotometry (GENESYSTM). The sample weighed 1.25 grams on a digital balance. The sample was then transferred to a 25 mL volumetric flask, dissolved in N-hexane, and filtered using filter paper. The absorbance was measured using a UV-Vis Spectrophotometer, and as a control, N-hexane was prepared without adding the sample preparation [13,14].

The SPF value of the preparation was determined by using UV-Vis spectrophotometry. The Mansyur equation was then calculated, where CF (correction factor/10), EE (Erythema spectrum of effect), I (sun intensity spectrum), and Abs (absorbance value) were scanned in the wavelength range of 290-320 nm. The absorbance value (λ) obtained then was multiplied by EE (λ) and I (λ) for each of the wavelengths (Table 2) (7).

Mansyur's equation to calculate the SPF value of

**Table 2.** Values of EE × I at a wavelength of 290-320 nm

| Wavelength (λ nm) | EE × I |
|---|---|
| 290 | 0.0150 |
| 295 | 0.0817 |
| 300 | 0.2874 |
| 305 | 0.3278 |
| 310 | 0.1864 |
| 315 | 0.0839 |
| 320 | 0.0180 |
| Total | 1 |

lip balm stick preparations *in vitro* can be seen in the following equation [6].

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

### Evaluation of physical characteristics of sunscreen lip balm stick preparations

Based on the results of the activity screening that provided the greatest SPF value, the physical properties of lip balm stick sunscreen formulations were evaluated. The 28-day evaluation included organoleptic qualities, homogeneity, spreadability, hardness, and melting point.

The organoleptic evaluation comprised scent, shape, and color. The homogeneity test was performed by smearing 0.1 grams of the sample onto a microscope slide and observing it with another slide. The spreadability test was conducted by placing a 0.5-gram sample on a glass lined with scale paper, and then covering the top of the glass with two glasses. After putting 50 gram and 100 gram loads for one minute, the diameter of the resulting spread was measured [15].

The hardness of the preparation was determined by hanging a weight of 10 grams from the lip balm at a distance of 0.5 inch, starting with 10 grams and adding 10 grams every 30 seconds. This procedure was repeated until the lip balm stick broke. The melting point was determined by placing the sample in a 50°C oven, gradually increasing the temperature by 1°C every 15 minutes, and terminating when the substance melted [16].

## Data analysis

Graph and statistical test (one-way Anova) was carried out by using Prism GraphPad 9.0 (San Diego, USA). Data were shown as mean ± SEM. $p < 0.05$ was considered significant.

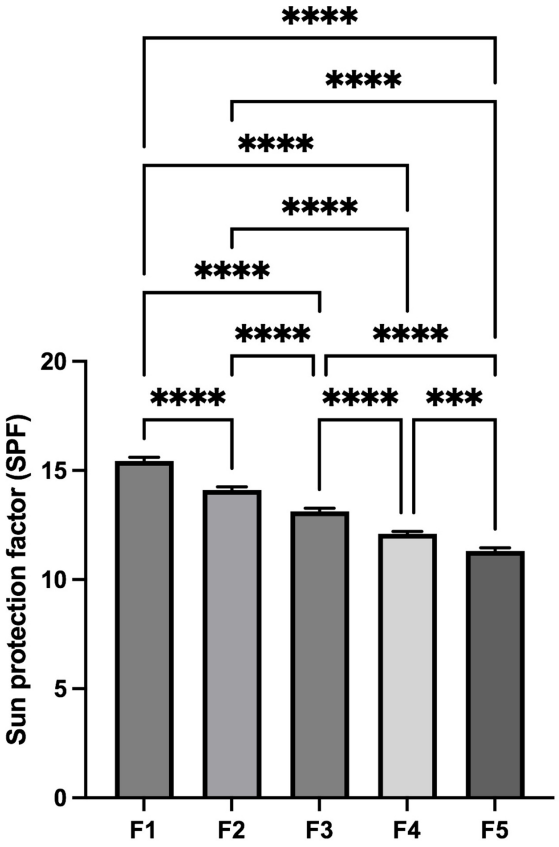


**Figure 1.** SPF value results for lip balm stick sunscreen preparation. **** $p < 0.0001$, *** $p < 0.0005$

## Results

### Sunscreen lip balm stick formulation

Five different concentrations of VCO and CPO-containing lip balm stick were formulated. The SPF value was used to determine the potential of the preparation to protect the skin of the lips from UV-induced damage, as evaluated by the sunscreen activity test. Mansyur's equation was used to derive the SPF value from the absorbance of the five scanning formulas in the wavelength range of 290-320 nm.

The statistical tests used to determine the SPF value yielded a significant result of $p < 0.05$, showing that there is a significant difference among the formula. The F1 formula yielded the highest SPF value in the ultra category, which was 15.438 ± 0.16. While formulas F2, F3, F4, and F5 provide the maximum SPF category value, with values of 14.096 ± 0.14; 13.128 ± 0.15; 12.102 ± 0.11 and 11.309 ± 0.15 (Figure 1).

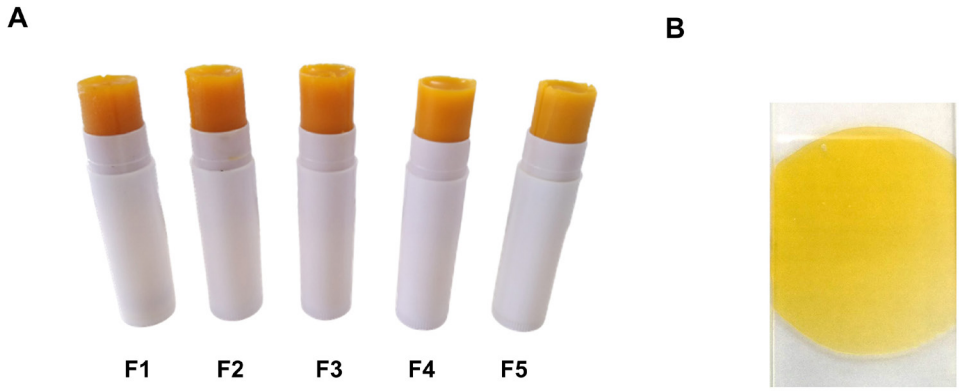


**Figure 2.** Lip balm stick sunscreen preparation contain a combination of VCO and CPO. (A) Physical appearance, (B) Homogeneity test

### Physical evaluation of lip balm stick sunscreen preparations

Figure 2A depicts the physical results of the lip balm stick formulation produced from the fifth formulation. The physical characteristics of preparations were evaluated for the F1 formula, a formula that produced the highest SPF value. Based on the organoleptic testing, the formulation was slightly dark yellow, had a chocolate scent, and was in the form of a solid stick. After examining the sample's storage at room temperature for 28 days, no organoleptic changes were detected.

The homogeneity test findings demonstrated that the preparation met the requirements, marked by the absence of coarse grains during observations (Figure 2B). After 28 days of storage at room temperature, no changes in sample homogeneity were observed.

In the evaluation of the spreadability test, the preparation had a distribution of 3.35 ± 0.02 cm. The observed findings of the spreadability test conducted for 28 days at room temperature indicate that the formulations already meet the standards for ease of application (Figure 3A). Statistical tests were carried out to obtain the results of a significant value $p > 0.05$ or no significant change.

In the evaluation of the spreadability test, the preparation had a distribution of 3.35 ± 0.02 cm. The preparations made already meet the requirements that are expected to be easy to spread when used. The results of the observation of the speadability test for 28 days at room temperature (Figure 3A). Statistical tests were carried out to obtain the results of a significance value $p > 0.05$ or there was no significant change.

The formula's hardness was 64.67 ± 6.91 grams, which met the requirements because the value was virtually same as the commercial products. The results of the observation of the hardness test for 28 days at room temperature (Figure 3B). Statistical tests results showed that a significance value $p > 0.05$ or no significant change.

The preparation has a melting temperature of 56 ± 0.53°C, which meet the requirements. The results of the observation of the hardness test for 28 days at room temperature (Figure 3C). Statistical tests results showed that a significance value $p > 0.05$ or no significant change.

## Discussion

VCO is reported to have sunscreen activity with an SPF value of 7.119, which can protect against UV rays [17]. CPO contains carotene and vitamin E, which help in skin care and protection [12]. The formulation of lip balm stick sunscreens with various concentrations of VCO and CPO is designed to obtain the highest SPF value. Based on the analysis of the sunscreen activity of lip balm sticks, the higher the CPO content, the higher the SPF value produced. F1 with a concentration of 5% VCO and 15% CPO with an SPF of 15.438 is the best formula for producing the highest SPF. The evaluation of the physical properties of lip balm stick sunscreen formulations yielded results that met the requirements. They were stable for 28 days and had the following physical characteristics: yellow color, chocolate scent and semi-solid shape, homogeneity, 3.35 cm dispersion, a melting point of 56 degrees Celsius, and a hardness of 64 grams.

Figure 1 depicts the result of varying the concentrations of VCO and CPO in a lip balm stick sunscreen formulation comprising varying SPF values. It demonstrates that when the concentration of CPO

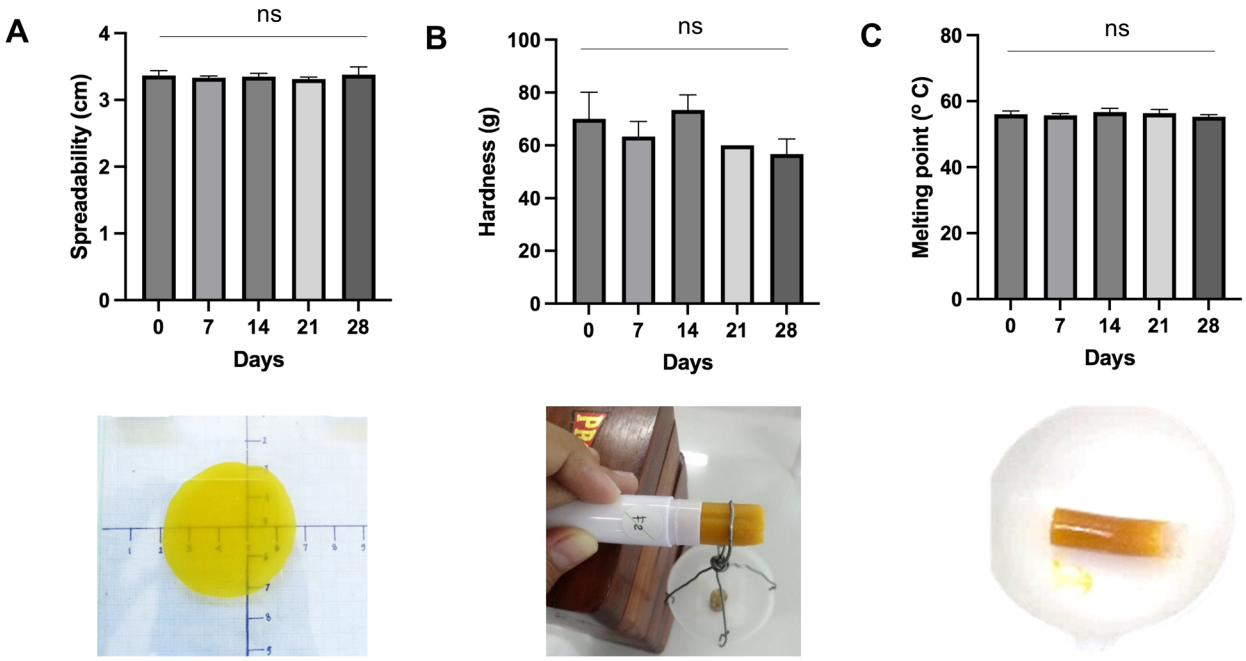


**Figure 3.** Physical test of lip balm stick. (A) Spreadability test, (B) Hardness test, (C) Melting point test. ns = not significant

increases, the SPF value increases, however the SPF value did not increase as the concentration of VCO increases.

Sunscreen preparations were anticipated to provide approximately 85% protection against UV B ray absorption and prevent melanin pigment accumulation. The skin can naturally withstand 10 minutes of exposure to UV rays before turning red and experiencing a burning sensation. The SPF value is the duration of sunscreen protection from UV rays [18]. In the current study, the higher the concentration of CPO used, the higher the SPF value, implying that more active compounds capable of absorbing UV radiation were present. The formula F1 lip balm stick with 5% VCO and 15% CPO produced the highest SPF value.

The organoleptic test found that the product's main color is reddish-yellow, which derives from the carotenoid, the main active content of CPO. The preparation has a distinctive chocolate scent derived from oleum cacao. Due to the highest concentration oleum cacao in the F1 formula, the aroma of cacao oleum is more prominent. The product formed a stick solid, because the use of cera alba as a texture former and a base with a high melting point [15]. Using cera alba as a hardener reduce the total concentration of cacao oleum. It provides a high-density level due to a higher melting point than the cocoa oleum base.

The homogeneity test was conducted to ensure that the active ingredient was consistent provided each time it is applied. Test was conducted by observing the subject glass directly. The preparation must be homogeneous, with no visible coarse granules. The products were homogeneous, indicating that all of the ingredients used were well combined. The use of a cera alba basis in the formulation has advantages since it has excellent binding characteristics, allowing for the perfect mixing of all lip balm stick ingredients [15].

The dispersion test aims to determine whether the lip balm stick can be spread in diameter between 3 and 5 cm, carried out by observing the glass on a scaled paper. Lip balm stick formulation with a thick and hard texture are difficult to spread, whereas formulations with a too-soft consistency produce an oily effect and leave residue when applied.

A hardness test was performed to assess the lip balm's resistance to pressure or impact [16], conducted by applying pressure to the sample. The load is gradually increased until the lip balm stick breaks. There is no definite requirements for the breaking point %. In this study, a commercial lip balm stick of brand V was compared to the results of a hardness test conducted on a broken lip balm stick under a 60-gram force. As a hardener, the addition of cera alba wax base affects the hardness of the lip balm stick. Cera alba is a texture-enhancing and stiffening component in the formulation. It contains myristic and palmitate, which make it solid at room temperature, and saturated fatty acids with a high melting point, which impact its hardness [19].

The optimal melting point for lip balm stick formulations is between 50-70°C [16]. In this study, the preparation has a melting temperature of 56°C, which meet the requirements. The melting point of a quality lip balm stick is between 36°C and 38°C Celsius, but it can also tolerate the temperature of its environment [20].

## Conclusion

Based on the results, it can be concluded that the lip balm stick sunscreen preparations combination of VCO and CPO has sunscreen activity and stable physical properties so that it can be tested further as a lip balm stick sunscreen preparation for dry lips.

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## Declaration of conflict interest

None.

## Author contributions

Formulation, ON; conceptualization, ES; data analysis and supervision, TLN. All authors contributed to the article and approved the submitted version.

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