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Research Article

Formulation and Optimization of Avocado Oil (*Persea americana* oil) Emulsion as a Carrier for Vitamin E (α -Tocopherol) with Sun Protection Factor Analysis in Lotion Preparation

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Abstract

This study aims to formulate and optimize an emulsion based on avocado oil (*Persea americana* oil) as a delivery system for vitamin E (α -tocopherol) in cream lotion preparations using the Response Surface Methodology (RSM). Avocado oil was chosen due to its high α -tocopherol content and skin benefits. Optimization was carried out by varying the stirring time, homogenization speed, and avocado oil-Tween 80 ratio. The resulting emulsion was evaluated for vitamin E content, Sun Protection Factor (SPF), viscosity, pH, density, and physical stability. The optimal formulation was achieved at 11.9 min of stirring, 1000 rpm speed, and a ratio of 0.4798, resulting in a vitamin E content of 0.0913% and an SPF value of 14.02. The results showed that the oil-Tween 80 ratio had a significant effect on SPF value, while stirring speed had a low effect on vitamin E content. This emulsion shows potential as an effective topical antioxidant and UV protection formulation.

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1. Introduction

Vitamin E is a group of compounds consisting of tocopherols and tocotrienols, which were first discovered by Bishop and Evans in 1922. These compounds are the primary fat-soluble antioxidants and play a crucial role in protecting the body from damage caused by free radicals. Among the eight naturally occurring forms of vitamin E—namely four tocopherols (α , β , γ , δ) and four tocotrienols— α -tocopherol is the most biologically active and the most widely distributed form (Devitasari & Basuki, 2022). Vitamin E has been extensively applied in the fields of healthcare and dermatology due to its ability to maintain skin moisture, enhance skin elasticity, delay the signs of aging, and support the repair of damaged skin structures (Tirmiara et al., 2018).

However, the effectiveness of vitamin E in topical

formulations still faces several challenges. The stability of vitamin E can be compromised by environmental factors such as light, temperature, and pH. In addition, its lipophilic nature limits its solubility in aqueous systems, resulting in reduced skin absorption. Conventional formulations that rely on organic solvents do not always provide optimal outcomes and may cause skin irritation (Rinaldi et al., 2022). Therefore, an active ingredient delivery system is required to enhance the stability, penetration, and bioavailability of vitamin E in cosmetic formulations.

One promising approach is the use of emulsion-based delivery systems. Emulsions are colloidal systems composed of two immiscible liquid phases, stabilized by surfactants, with droplet sizes typically ranging from 20 to 200 nm. Oil-in-Water (O/W) emulsions are particularly suitable as carriers for lipophilic compounds such as vitamin E, as they can enhance solubility and stability, improve the rheological properties of the formulation, and increase

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skin penetration and absorption. The oil phase in emulsions typically employs vegetable oils rich in bioactive compounds, such as antioxidants and essential fatty acids.

Avocado oil (*Persea americana* oil) is a vegetable oil rich in α -tocopherol and has significant benefits in skin care. This oil not only acts as a moisturizing agent but also functions as a regenerative and anti-aging agent (Manaf et al., 2018). Several studies have shown that avocado oil derived from Indonesian cultivars contains high levels of α -tocopherol, ranging from 40 to 45 mg/kg, making it an ideal candidate for use as the oil phase in emulsion formulations. In addition, avocado oil contains vitamins A and D, as well as unsaturated fatty acids that support overall skin health (Lin & Li, 2024; Flores et al., 2019).

Based on the aforementioned background, this study aims to formulate and optimize avocado oil-based emulsions as a delivery system for vitamin E (α -tocopherol) in cream lotion preparations using a Response Surface Methodology (RSM) approach. The variables investigated in this study include the avocado oil-Tween 80 ratio, stirring time, and homogenization speed. Optimization was conducted to obtain a formulation with good physical stability, as well as optimal vitamin E content and Sun Protection Factor (SPF) value.

2. Materials and Methods

The materials used in this study were avocado oil, polysorbate 80 (Tween 80), cetyl alcohol, distilled water, chloroform, and ethanol.

The equipment used in this study included beakers, measuring cylinders, homogenizers, an oven, a pH meter, a thermometer, an Ostwald viscometer, a pycnometer, a digital balance, a desiccator, a centrifuge, a glass funnel, a UV-Vis spectrophotometer, a microscope, and a magnetic stirrer.

This study employed Response Surface Methodology (RSM) using Minitab software. The emulsion preparation process involved the preparation of the oil phase, the preparation of the aqueous phase, and the mixing of the oil and aqueous phases through homogenization using a homogenizer. The emulsion formulation is presented in Table 1.

2.1 Research Procedure

The preparation of the nanoemulsion began with the preparation of the oil and aqueous phases. The oil

phase was prepared by mixing avocado oil and cetyl alcohol, while the aqueous phase was prepared by mixing distilled water and Tween 80. Both phases were stirred using a magnetic stirrer for 10 min at 200 rpm and 70°C. Subsequently, the oil phase was added to the aqueous phase and homogenized using a homogenizer for a specific time and speed according to the F1-F16 variables (Arancibia et al., 2017).

2.2 Research Testing

2.2.1 Determination of Vitamin E Content

Ten milligrams of the obtained emulsion sample were weighed and then diluted with 9 mL of chloroform. Subsequently, 1 mL of 0.1% iodide was added, and the mixture was shaken until homogeneous. The sample was then transferred into a cuvette, and its absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 570 nm (Andulaai et al., 2017). The vitamin E content can then be calculated using Equation (1).

$$\text{Vitamin E content (\%)} = \frac{C \times V \times F}{m} \times 100\% \quad (1)$$

where C represents vitamin E concentration ($\mu\text{g}/\text{mg}$), V is the total sample volume (ml), F is the dilution factor, and m stands for the sample mass (g).

2.2.2 Determination of SPF Value

The sunscreen activity was evaluated by determining the Sun Protection Factor (SPF) in vitro using a UV-Vis spectrophotometer. The sample solution was prepared by weighing 0.1 g of the sample and dissolving it in 100 mL of ethanol in a volumetric flask to obtain a stock solution with a concentration of 1000 ppm. The solution was then diluted to concentrations of 200 ppm, 400 ppm, 600 ppm, and 800 ppm. Subsequently, the absorbance was measured at wavelengths ranging from 290 to 320 nm with 5 nm intervals (Yani et al., 2023). The SPF value was determined using Equation (2).

$$\text{SPF} = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda) \quad (2)$$

where CF is the correction factor (10), I represents the light intensity spectrum, EE is the erythral effect spectrum, and Abs is the absorbance of the sunscreen sample (Yani et al., 2023).

Table 1. Emulsion preparation formulation.

| No | Materials | Per 100 mL | | |
|----|----------------|------------|------|------|
| | | F1 | F2 | F3 |
| 1 | Avocado Oil | 7.3 | 5.5 | 4.4 |
| 2 | Aquadest | 80 | 80 | 80 |
| 3 | Tween 80 | 14.67 | 16.5 | 17.6 |
| 4 | Cethyl Alcohol | 3 | 3 | 3 |

2.2.3 Determination of Density

The density was measured using a 10 mL pycnometer at room temperature (Saputra et al., 2018). The empty pycnometer was weighed, then the sample was added and weighed again to determine the density using Equation (3).

$$\rho = \frac{w_2 - w_1}{V_p} \quad (3)$$

where ρ is the density (g/mL), w_1 is the weight of the empty pycnometer (g), w_2 is the weight of the pycnometer with the sample (g), and V_p is the volume of the pycnometer (mL).

2.2.4 Viscosity Determination

Viscosity measurements were carried out using an Ostwald viscometer, where the viscosity of a liquid is determined by measuring the flow time of the substance between two marks as it passes through a capillary tube under the force exerted by the liquid (Dara et al., 2021). Once the flow time is obtained, the viscosity can be calculated using the following formula (Equation (4)).

$$\eta = \eta_0 \frac{t \times \rho}{t_0 \times \rho_0} \quad (4)$$

where η is the viscosity of the sample liquid, η_0 is the viscosity of the reference liquid, t is the flow time of the sample liquid, ρ is the density of the sample liquid, t_0 is the flow time of the reference liquid, and ρ_0 is the density of the reference liquid.

2.2.5 pH Determination

The pH test was performed using a pH meter at room temperature. First, the electrode was calibrated with pH 4.0 and 7.0 standard solutions. Next, the

electrode was rinsed with distilled water and then immersed in the formulation until the pH value on the meter display stabilized. The pH range of formulations that is tolerable for the skin is 4.2–7.0 (Helsawati et al., 2023).

3. Results and Discussion

3.1 Analysis of SPF Value

Based on the surface plot and contour plot of the avocado oil ratio and stirring time versus SPF value, it can be observed that the SPF value increases with higher avocado oil ratios and longer stirring durations. The surface plot indicates a tendency for higher SPF values at combinations of high avocado oil ratios (0.45–0.50) and extended stirring times (11–12 min), with the highest SPF exceeding 13. The contour plot reinforces this observation through color gradation, where dark green zones represent high SPF values corresponding to these parameter combinations. Conversely, lower SPF values (approximately 6–8) are represented by blue areas at combinations of low oil ratios and short stirring times. These results indicate that the avocado oil ratio has a significant effect on the emulsion's ability to provide UV protection, while stirring time also contributes to optimal homogenization within the emulsion system.

Based on the Pareto chart in Figure 2, the factor that most significantly affects the SPF value is the avocado oil ratio (C), with the largest standardized effect exceeding the significance line (2.45) at a 95% confidence level ($\alpha = 0.05$). This indicates that increasing the avocado oil ratio has a significant impact on enhancing the SPF value in the emulsion formulation. The interaction factor AC (stirring time and oil ratio) and factor A (stirring time) also showed an effect, although they did not exceed the significance threshold, but were relatively substantial compared to the other factors. Meanwhile, the stirring speed (B) and

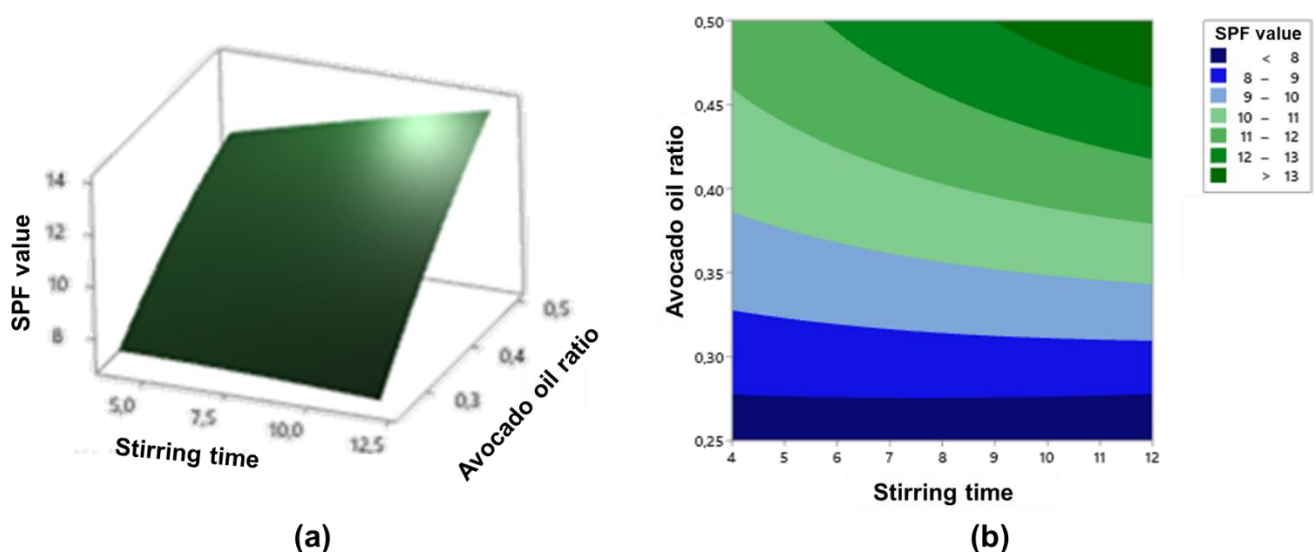


Figure 1. Surface plot (a) and contour plot (b) showing the effect of stirring time and tween-avocado oil ratio on SPF value.

other interactions such as BC, AB, AA, BB, and CC exhibited smaller and non-significant effects on the SPF value. These results support previous findings that the avocado oil ratio is the primary factor determining UV protection efficacy, while stirring time and speed mainly act as supporting factors in homogenizing the emulsion system (Khoirunnisa et al., 2023).

3.2 Analysis of the Optimum Point

The optimal point analysis yielded the predicted values of vitamin E content and SPF value, as shown in Table 2. The results indicate that the most optimal parameters were achieved with the independent variables at an avocado oil-Tween ratio of 0.4798, a stirring speed of 1000 rpm, and a stirring time of 11.912 min, resulting in a predicted vitamin E content of 0.0949% and an SPF value of 14.0169. Upon testing, the emulsion exhibited a vitamin E content of 0.0813% and an SPF value of 14.0169. Based on the predicted optimal conditions, the error values were 3.79% for vitamin E and 0.36% for SPF. These results are consistent with the predicted optimal conditions, as the experimental values closely approached the target optimization.

4. Conclusion

Based on the results of this study, the formulation and optimization of avocado oil-based emulsions as a delivery system for vitamin E (α -tocopherol) in lotion preparations were carried out using the Response Surface Methodology (RSM) approach. The optimal

formulation was obtained at an avocado oil-Tween 80 ratio of 0.4798, a homogenization speed of 1000 rpm, and a stirring time of 11.9 min. The predicted results showed a vitamin E content of 0.0949% and an SPF value of 14.0673. Laboratory testing yielded a vitamin E content of 0.0913% and an SPF value of 14.0169. The percentage error between the predicted values and the experimental results indicates good model accuracy, with errors of 3.79% for vitamin E content and 0.36% for SPF value.

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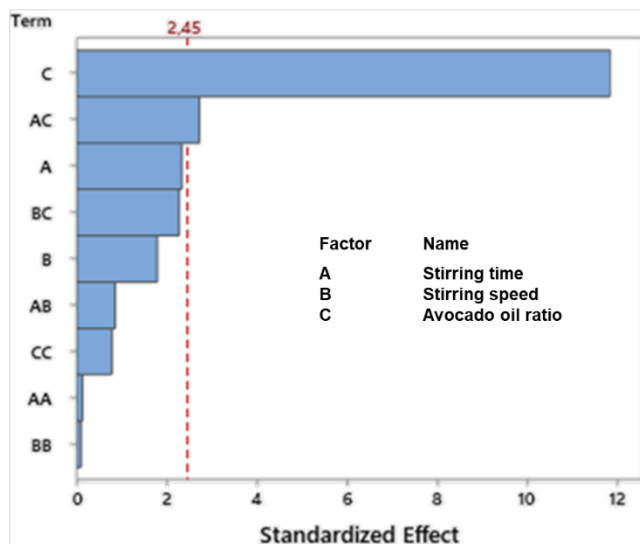


Figure 2. Pareto diagram of SPF content at $\alpha = 0.05$.

Table 2. Predicted target values of Vitamin E content and SPF.

| Data | Tween-Avocado Oil Ratio | Speed (rpm) | Time (min) | Vitamin E Content (%) | SPF Value | Composite Desirability |
|--------------|-------------------------|-------------|------------|-----------------------|-----------|------------------------|
| Predicted | 0.4798 | 1000.0 | 11.9192 | 0.0949 | 14.0673 | 0.9126 |
| Experimental | 0.4798 | 1000.0 | 11.9192 | 0.0913 | 14.0169 | - |

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