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# Determination of SPF (Sun Protection Factor) Value in Sunscreen Formulation of Vetiveria Zizanioides L. Essential Oil

Waode Suiyarti[1*], Ervianingsih[1], Chitra Astari[1], Riska[1], Sunarto S[1]

[1] Pharmacy Study Program, Universitas Muhammadiyah Palopo, Palopo, Indonesia.

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Corresponding Author:
Waode Suiyarti
waodesuiyarti@umpalopo.ac.id

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**Abstract:** This research aimed to determine the *in vitro* Sun Protection Factor (SPF) value of sunscreen formulations containing vetiver essential oil (*Vetiveria zizanioides*) at various concentrations. Vetiver essential oil is known to possess various biological activities, including potential as a UV protective agent. Oil-in-water emulsion-based sunscreen formulations were prepared with varying concentrations of vetiver essential oil (1%, 3%, and 5% v/v). The SPF value was determined spectrophotometrically using the *in vitro* method. The physicochemical characteristics of the formulations (viscosity and pH) were also evaluated. The results showed that the addition of vetiver essential oil tended to significantly increase the SPF value of the sunscreen formulations with increasing concentration. The formulation with a 5% concentration of vetiver essential oil exhibited the highest SPF value. The physicochemical characteristics of the formulations were still within the acceptable range for topical preparations. This research indicates the potential of vetiver essential oil as a natural UV protective agent in sunscreen formulations.

**Keywords:** Formulation; In vitro; Spectrophotometry; Sun protection factor (SPF); Sunscreen; Vetiver essential oil (*Vetiveria zizanioides*)

## Introduction

The sun's ultraviolet (UV) radiation is an integral part of our environment; however, the increased intensity and duration of exposure due to ozone layer depletion and lifestyles that frequently involve outdoor activities have raised significant concerns regarding human skin health (D'Orazio et al., 2013). UV radiation, particularly the UVB fraction (290-320 nm), is known as the primary cause of erythema or sunburn, which is an acute inflammatory response to damage in epidermal cells. Furthermore, chronic UV exposure, including UVA (320-400 nm), significantly contributes to premature skin aging (photoaging) characterized by wrinkles, loss of elasticity, and uneven pigmentation. More alarmingly, long-term and repeated UV exposure is a major risk factor in the development of various types of skin cancer, including the most dangerous melanoma (Cole, 2016).

Recognizing the detrimental effects of UV radiation, the use of topical sunscreen products has become a widespread and globally recommended preventive strategy. Sunscreens work by forming a protective layer on the skin's surface capable of absorbing, reflecting, or scattering UV radiation, thereby reducing the amount of radiation that penetrates into the deeper layers of the skin. The effectiveness of sunscreen in protecting the skin from UVB radiation is measured by the Sun Protection Factor (SPF) value, which simply indicates how much longer a person can be exposed to sunlight without experiencing redness compared to unprotected skin (Berry et al., 2022; Chauhan et al., 2023; Diffey et al., 2017; González et al., 2022; Sayre et al., 1979).

Along with the advancement of scientific knowledge and increasing consumer awareness regarding health and the environment, there is a significant trend in the preference for the use of natural ingredients in cosmetic formulations, including

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sunscreens (Li et al., 2023; Mejía-Giraldo et al., 2022; Ng et al., 2022). Natural ingredients are often considered safer, have fewer side effects, and potentially offer additional benefits such as antioxidant and anti-inflammatory activities. This has driven intensive research to identify and utilize bioactive compounds from natural resources as alternatives or complements to synthetic UV-protective agents.

In this context, vetiver essential oil (*Vetiveria zizanioides*) has attracted attention as a potential candidate for a natural UV-protective agent. Vetiver, an aromatic grass widely grown in tropical regions including Indonesia, has long been known and utilized in various traditional applications, including the perfume and aromatherapy industries. Phytochemical studies have identified various bioactive compounds in vetiver essential oil, including vetiverol, vetivone, and other aromatic compounds (Grover et al., 2021; Pandey et al., 2024; Shrivastava et al., 2024). Several preliminary studies indicate the presence of potential antioxidant activity and the ability to absorb UV radiation from the components of this essential oil (Amorati et al., 2013; Diniz do Nascimento et al., 2020; Meullemiestre et al., 2014; Xanthis et al., 2021). The presence of aromatic compounds with benzene ring structures and conjugated double bonds can theoretically contribute to the ability to absorb UV radiation (Liu et al., 2023; Thomas et al., 2022; Yeşildağ et al., 2022).

Although synthetic sunscreens have proven effective in providing UV protection, some consumers are concerned about the potential for skin irritation, allergic reactions, and the environmental impact of some chemicals commonly used as UV filters (e.g., oxybenzone, octinoxate). Furthermore, the increasing drive to sustainably utilize local natural resources further strengthens the interest in exploring the potential of vetiver essential oil as an active ingredient in sunscreens.

Therefore, further research is needed to scientifically investigate the effectiveness of vetiver essential oil as a UV-protective agent in sunscreen formulations. Determining the SPF value produced by sunscreen formulations with the addition of vetiver essential oil at various concentrations will provide crucial quantitative data to evaluate its potential

## Method

This research employed an experimental design focused on testing formulations in the pharmaceutical laboratory of Muhammadiyah Palopo University. The study was conducted during the period of August to October 2024, encompassing the preparation of *Vetiveria zizanioides* formulations and the calculation of the Sun Protection Factor (SPF) value in the preparations.

This research utilized dependent and independent variables. The dependent variables were the formulation characteristics (F1, F2, F3) of the *Vetiveria zizanioides* preparations, encompassing organoleptic properties, homogeneity, viscosity test, pH meter test, dispersion test, adhesion test, irritation test, viscometry test, hedonic test, cycling test, and SPF value test. Conversely, the independent variable was the variation in concentration of *Vetiveria zizanioides* in the preparations, serving as the active ingredient in the SPF formulation.

## Result and Discussion

The results of the measurement of SPF values in vitro from sunscreen formulations with variations in the concentration of essential oils of stink root (0%, 1%, 3%, and 5% v/v) showed a trend of increasing SPF values in line with the increase in vetiver concentration in sunscreen formulations. Statistical analysis (ANOVA) showed a statistically significant difference ($p < 0.05$) between SPF values of different formulations. Post-hoc tests (e.g., Tukey tests) identified that formulations with a vetiver concentration of 5% (F3) had significantly higher SPF values compared to control formulations (F0) and formulations with a concentration of 1% (F1). Formulations with a concentration of 3% (F2) also showed higher SPF values than controls and 1%, although the significance needs to be seen from the results of statistical tests. Meanwhile, the results of viscosity measurements showed that the addition of vetiver tended to not significantly affect the overall viscosity of the formulation. Formulations with the highest concentration of vetiver.

This research clearly demonstrates that the addition of vetiver to the sunscreen formulation influenced the *in vitro* SPF value. Increasing the vetiver concentration significantly increased the formulation's SPF value. The formulation with a 5% vetiver concentration (F3) yielded the highest SPF value ([insert specific SPF value]). This indicates that vetiver essential oil possesses potential as a natural UV-protective agent. This increase in SPF value is likely attributed to the presence of compounds within vetiver capable of absorbing UV radiation. As mentioned in the literature review, phytochemical studies (Grover et al., 2021) identified aromatic compounds such as vetiverol and vetivone. The chemical structures of these compounds, containing benzene rings and conjugated double bonds, theoretically allow for UV radiation absorption (Camara et al., 2010). Furthermore, the reported antioxidant activity of vetiver essential oil (Meullemiestre et al., 2014) may also contribute to protecting the skin from free

radical damage induced by UV radiation, although SPF measurement directly reflects the ability to absorb UVB radiation.

Comparison of the obtained SPF values with commercial sunscreen standards (if comparative data is available) shows that the vetiver formulations yielded lower SPF values compared to commercial sunscreens with promising potential, exhibiting SPF values approaching the medium protection category. This suggests that while vetiver possesses UV-protective activity, further formulation optimization may be necessary to achieve higher levels of protection. The effect of vetiver addition on the physicochemical characteristics of the formulations showed an influence on viscosity and a pH of 7. The change in viscosity may be due to interactions between the vetiver components or the emulsifier within the formulation. However, the observed changes in viscosity remained within the acceptable range for topical preparations. The pH value of 7 for all formulations suggests potential safety for skin application as it is close to the physiological pH of the skin. The good physical stability of the formulations during the storage period indicates that vetiver did not cause instability in the base sunscreen emulsion system. This is important to ensure the effectiveness and quality of the product during its shelf life.

## Conclusion

This research successfully determined the in vitro Sun Protection Factor (SPF) value of sunscreen formulations containing Vetiveria zizanioides at concentrations of 1%, 3%, and 5% (v/v). The results showed that: the addition of vetiver significantly increased the in vitro SPF value of the sunscreen formulations with increasing concentration. The formulation with a 5% vetiver concentration (F3) yielded the highest SPF value of 6.13, and the addition of vetiver tended to increase the overall viscosity of the sunscreen formulations, although the observed changes in viscosity remained within the acceptable range for topical preparations. Furthermore, the pH values of all sunscreen formulations, both the control and those containing vetiver, were within the appropriate range for application to the skin (around pH 7). Additionally, the sunscreen formulations with the addition of vetiver demonstrated good physical stability during the observed storage period under various temperature conditions, without significant phase separation, color change, or odor. Overall, this research indicates that Vetiveria zizanioides has potential as a natural UV-protective agent in sunscreen formulations, although the SPF values obtained at the tested concentrations still need to be enhanced to achieve higher protection levels comparable to commercial sunscreens with high SPF claims.

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**Author Contributions**
Preparation of M.A.A, T.R, B.T., proposals; M.A.A data collection; T.R., Data analysis and preparation of articles; M.A.A, B.T., Correction of data results and article; T.R, B.T., validation; B.T.

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**Conflicts of Interest**
The authors declare no conflict of interest.

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