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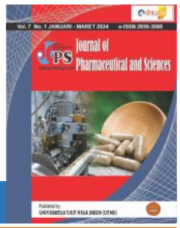

Sunscreen Innovation: Development of a Long-Adhering Pressed Powder Formula Based on Titanium Dioxide for Optimal UV Protection

Inovasi Tabir Surya: Pengembangan Formula Bedak Padat Tahan Lama Berbasis Titanium Dioksida untuk Perlindungan Sinar UV yang Optimal

Rahmat Muliadi [a*], Vica Aspadiah [b], Muhammad Handoyo Sahumena [a], Nidya Aftira [a]

[a] *Bachelor of Pharmacy Study Program, Faculty of Pharmacy, Universitas Halu Oleo, Southeast Sulawesi, Indonesia.*
[b] *Pharmacist Professional Education Study Program, Faculty of Pharmacy, Universitas Halu Oleo, Southeast Sulawesi, Indonesia.*

**Corresponding Authors: rahmatmuliadi@uho.ac.id*

Abstract

Background: Ultraviolet (UV) radiation contributes to skin ageing and damage, necessitating adequate protection. Sunscreens offer a solution by absorbing, diffusing, and reflecting UV radiation, especially those containing titanium dioxide, which has strong UV-blocking properties. Innovation in the form of pressed powder sunscreen presents a practical and efficient daily protection approach due to its easy-to-apply formulation. **Objective:** This study aimed to evaluate the physical characteristics of pressed powder sunscreen formulations, including organoleptic properties, pH, homogeneity, adhesion, hardness, and the effect of titanium dioxide on the Sun Protection Factor (SPF) value. **Methods:** Formulations were prepared and evaluated through physical tests, including organoleptic assessment, pH, homogeneity, adhesion, and hardness, as well as SPF measurement using a UV-Vis spectrophotometer. **Results:** Titanium dioxide contributed to the formulations' light brown colour, smooth texture, and vanilla scent. It also enhanced the SPF value. The most optimal formulation was Formula 4, containing 25% titanium dioxide, which met the desired physical criteria and achieved an SPF value of 15.06, categorised by the FDA as ultra protection. **Conclusion:** The addition of titanium dioxide positively affected the physical characteristics and SPF value of pressed powder sunscreen. Formula 4, with 25% titanium dioxide, demonstrated the best results and the highest SPF, making it the most optimal formulation for UV protection.

***Keywords*: Pressed Powder, Water-Resistant, Sunscreen, Titanium Dioxide, SPF**

Abstrak

Latar Belakang: Radiasi ultraviolet (UV) berkontribusi terhadap penuaan dan kerusakan kulit, sehingga diperlukan perlindungan yang efektif. Tabir surya merupakan salah satu solusi yang dapat menyerap, menyebarkan, dan memantulkan radiasi UV, terutama dengan kandungan titanium dioksida yang memiliki sifat perlindungan tinggi. Inovasi tabir surya dalam bentuk bedak padat menawarkan pendekatan yang praktis dan efisien untuk perlindungan sehari-hari karena formulanya yang berupa bedak padat dan mudah diaplikasikan. **Tujuan:** Penelitian ini bertujuan untuk mengevaluasi karakteristik fisik dari formulasi tabir surya bedak padat, meliputi aspek organoleptik, pH, homogenitas, adhesi, kekerasan, serta pengaruh titanium dioksida terhadap nilai Sun Protection Factor (SPF). **Metode:** Metode penelitian dilakukan dengan formulasi sediaan dengan uji karakteristik fisik berupa organoleptik, pH, homogenitas, daya lekat, kekerasan serta pengujian nilai SPF menggunakan Spektrofotometer UV-Vis. **Hasil:** Titanium dioksida memberikan warna coklat muda, tekstur halus, dan aroma vanila pada formulasi tersebut. Hasil penelitian juga mengindikasikan bahwa titanium dioksida memberikan warna coklat muda, tekstur halus, dan wangi vanila pada sediaan, serta meningkatkan nilai Sun Protection Factor (SPF). Formulasi yang paling optimal berdasarkan evaluasi karakteristik fisik dan nilai SPF adalah Formula 4, yang mengandung 25% titanium dioksida. Formula ini menghasilkan hasil pengujian fisik yang memenuhi kriteria yang ditetapkan dan mencapai nilai SPF sebesar 15,06 (perlindungan ultra). **Kesimpulan:** Penambahan titanium dioksida berpengaruh positif terhadap karakteristik fisik dan nilai SPF bedak padat tabir surya. Formula 4, dengan kandungan 25% titanium dioksida, memberikan hasil terbaik dan nilai SPF tertinggi sebesar 15,06, sehingga dinyatakan sebagai formulasi paling optimal untuk perlindungan terhadap radiasi UV.

Kata Kunci: Bedak Padat, Tabir Surya, Titanium Dioksida, SPF.

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Introduction

Skin health plays a crucial role in human life, not only supporting aesthetic appearance but also serving as an indicator of overall health status [1]. Dermatological disorders can negatively impact an individual's self-image and are, therefore, a primary concern within the healthcare field [2]. Among the most common skin issues are those induced by excessive sun exposure, particularly from ultraviolet A (UV-A) and ultraviolet B (UV-B) radiation, which can cause sunburn, penetrate the epidermal and dermal layers, and accelerate skin ageing processes [3].

Excessive exposure to ultraviolet radiation can result in various skin conditions, including erythema, dryness, burns, wrinkles, and an increased risk of irritation and skin cancer [1]. To mitigate these harmful effects, sunscreen is widely recommended as a protective measure against UV radiation [4]. The effectiveness of a sunscreen product is commonly assessed based on its Sun Protection Factor (SPF), which quantifies its ability to protect the skin from UV radiation. One of the most widely used UV-protective agents in sunscreen formulations is titanium dioxide, an active physical blocker against UV radiation [5].

Titanium dioxide, or titanium micropigment, is an inorganic compound capable of reflecting and scattering UV and infrared radiation. Its photoreactive properties under UV exposure make it a widely utilised ingredient in cosmetic formulations [6]. The most commonly available public-use sunscreen preparations are cream, lotion, gel, and spray. Sunscreens are traditionally available in creams, lotions, gels, and sprays. However, these formulation types may be less practical for daily use due to their relatively long absorption time and the temporary alteration of skin appearance post-application. Furthermore, maintaining photoprotective efficacy requires reapplication every 2–3 hours, posing challenges for individuals wearing facial makeup, as reapplication may compromise the makeup finish. As a solution, sunscreens formulated as pressed powders offer a more practical and efficient alternative for daily application. This formulation type enables reapplication of sun protection without disrupting facial makeup, thereby enhancing user convenience and compliance [7].

Pressed powder is a pressed powder preparation typically applied with a cosmetic sponge. It must possess adequate mechanical strength to remain intact during handling while also ensuring smooth transfer onto the applicator [8]. He primary advantages of pressed powder include its oil-absorbing properties, ease of application, and good skin adhesion, making it suitable for a wide range of users [9]. Despite these benefits, pressed powders can suffer from limited durability and ease of removal. Silicones are frequently incorporated into formulations to enhance product longevity, contributing to improved wear resistance and product stability. Standard silicones in cosmetic formulations include cyclomethicone and dimethicone [10].

Silicones serve as skin-conditioning agents and act as protective barriers against environmental stressors such as UV radiation, while also contributing to smooth texture and sensory enhancement. Cyclopentasiloxane is among the most frequently used silicones in cosmetic products due to its excellent spreading ability and conditioning effects on skin and hair [11]. In sunscreen formulations, cyclopentasiloxane functions as an emollient, humectant, solvent, and viscosity modifier, thus playing a multifunctional role in enhancing product aesthetics and performance[12].

Although SPF values similar to those achieved in this study have been reported in commercial mineral sunscreens and previous research, the innovation of this formulation lies in its combination of UV protection efficacy, long-lasting, and user-friendly application in a pressed powder format. The developed formulation uses 25% titanium dioxide as the sole active UV filter and successfully achieves an SPF of 15.06, placing it in the ultra protection category [13]. In contrast, the current formulation achieves comparable SPF efficacy in a dry, compact powder base without relying on additional active ingredients, making it more straightforward, potentially safer, and more suitable for sensitive skin.

Moreover, a key aspect of this innovation is the inclusion of cyclopentasiloxane, a volatile silicone commonly used in cosmetics for its excellent spreading properties and quick-drying, non-greasy finish. Cyclopentasiloxane acts as a film-forming agent in sunscreen systems, improving skin adherence and long adhering. This property addresses a standard limitation of powder-based sunscreens, which often suffer from low wear time and poor resistance to sweat or sebum. By integrating this silicone, the formulation can maintain UV protective performance while offering longer-lasting wear and greater practicality, especially for reapplication over facial makeup throughout the day. Thus, while the SPF value alone may not appear exceptional, the overall formulation strategy—using only titanium dioxide as the active UV filter, enhancing long adhering through cyclopentasiloxane, and delivering the product in a pressed powder form—represents a novel, multifunctional approach in the realm of physical, mineral-based sunscreens [14].

Given the considerations above, formulating a water-resistant pressed powder based on titanium dioxide as a sunscreen agent represents a significant innovation. This approach aims to improve the efficacy of UV protection and the product's physical durability, making it better suited for daily application in various environmental conditions.

Experimental Section

Materials and Apparatus

The instruments used in this study were an analytical balance (Fujitsu FS-AR®), a pH meter (Jenway®), sieves, crucibles (Pyrex®), a mortar, pestle, spatulas (Pyrex®), powder godet, droppers (Pyrex®), measuring cylinders (Pyrex®), stirring rods (Pyrex®), 50 mL beakers (Pyrex®), 200 mL beakers (Pyrex®), spatulas (Pyrex®), 10 mL volumetric flasks (Pyrex®), 50 mL volumetric flasks (Pyrex®), a double-beam UV-Vis spectrophotometer (Jenway®), cuvettes, and pressed powder containers. The materials used in this study included titanium dioxide (Sunscreen Grade, *Sunsafe® T-100*), cyclopentasiloxane (*DC 345 Fluid* by Dow Corning), talcum (Cosmetic Grade, *CTC-99*), zinc stearate (Pharmaceutical Grade, *Merck*®), vanilla (*Natural Vanillin*, Sigma-Aldrich), glycerin (Pharmaceutical Grade, *Brataco*®), calcium carbonate (Cosmetic Grade, *Merck*®), polyvinyl alcohol (Analytical Grade, *Sigma-Aldrich*®), D&C Red No. 17 (*Sensient*®), D&C Yellow No. 10 (*Sensient*®), 96% ethanol (Pharmaceutical Grade, *Brataco*®), and tissues.

Methods

Pressed Powder Formulation

The pressed powder formulation was prepared using titanium dioxide and cyclopentasiloxane at concentrations of 10%, 15%, 20%, 25%, and 30%, with a total formulation weight of 20 grams (Table 1).

Titanium dioxide, cyclopentasiloxane, zinc stearate, and calcium carbonate were first mixed until homogeneous. Sieved talcum powder was added and triturated until the mixture became uniform (Mass I). A portion of sieved talcum (mesh no. 200) was triturated evenly (Mass II) in a separate container. Into this mixture, polyvinyl alcohol and glycerin were added in the required quantities. Mass I and II were combined in a single container and mixed thoroughly. D&C Red and D&C Yellow colourants were added and blended until evenly distributed. The final mixture was triturated until homogeneous, passed through a mesh no. 200 sieve, placed into a container, and manually pressed into powder form.

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Table 1. Formulation Design of Titanium Dioxide-Based Pressed Powder Sunscreen

Ingredients	Concentrations (%)				
	F1	F2	F3	F4	F5
Titanium dioxide	10	15	20	25	30
Cyclopentasiloxane	0,1	0,1	0,1	0,1	0,1
Vanila	0,01	0,01	0,01	0,01	0,01
Zinc stearate	0,5	0,5	0,5	0,5	0,5
Calcium carbonate	4	4	4	4	4
Polyvinyl alcohol	2	2	2	2	2
D & C Red	0,1	0,1	0,1	0,1	0,1
D & C Yellow	0,05	0,05	0,05	0,05	0,05
Glycerine	5	5	5	5	5
Talc	ad 100				

Physical Evaluation

Organoleptic Test

The organoleptic evaluation was carried out by observing the physical characteristics of the pressed powder, including its shape, colour, scent, and texture. [15].

pH Test

The pH was measured using a pH meter after dispersing 1 gram of powder in 10 mL of distilled water to form a suspension. Cosmetic products are expected to have a pH range suitable for skin, which lies between 4.5 and 8.0 [16].

Homogeneity Test

The homogeneity test was performed by evenly applying a thin layer of pressed powder onto a glass slide, then observing under light to ensure the absence of coarse particles [17].

Adhesion Test

The adhesion test involved applying the pressed powder onto the back of the hand. Adhesion was evaluated based on the resistance of the powder to removal using water and its ability to remain on the skin [9]. A small amount of water (approximately 5 mL) is dropped onto the area and left for five minutes without rubbing. After that, the water is gently wiped in one direction using a dry tissue, and the remaining powder adhering to the skin is observed[18].

Hardness Test

Hardness testing was conducted to assess the hardness of the final formulation. This was done by dropping the product from a height of 20–25 cm onto a flat surface and observing whether cracks or breakage occurred, which indicates the product's mechanical strength [19].

Uji Sun Protecting Factor (SPF)

In this study, the SPF value was determined in vitro using UV spectrophotometry, based on the method developed by Mansur et al. While in vitro methods offer a practical and ethical alternative to human testing, they are known to potentially overestimate SPF values compared to in vivo assessments, due to factors such as lack of skin interaction, film-forming behaviour, and real-life application variability.

An amount of 0.1 grams from each formulation was weighed and dissolved in 25 mL of 95% ethanol in a 50 mL beaker. After homogenization and sonication for 3 minutes, the solution was filtered using filter paper. From each sample, 1 mL of the filtrate was transferred into a 10 mL volumetric flask and diluted to volume with 96% ethanol. The absorbance of the samples was measured using a UV-Vis spectrophotometer in the wavelength range of 290–320 nm (AT et al., 2019). The SPF value was calculated using the following equation [20]:

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$$SPF = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda) \quad (1)$$

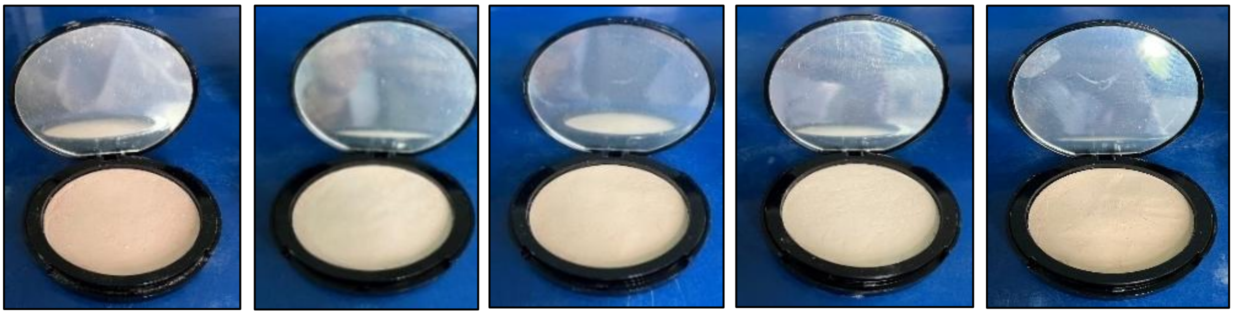
SPF: Sun Protection Factor
CF: Correction Factor (10)
EE: Erythemal Effectiveness
I: Solar Intensity Spectrum
Abs: Absorbance of the Sample
λ: Wavelength

Results and Discussion

Pressed powder is a type of powder formulated through a compression process. It is typically applied using a powder sponge. The main advantages of pressed powder are its portability and ease of application. Additionally, it helps absorb and reduce excess oil and has good adhesion to the skin. Nowadays, pressed powder products are often formulated with SPF to provide dual protection. One of the active ingredients used for sun protection is titanium dioxide.

Titanium dioxide is a sunscreen agent due to its ability to reflect sunlight, especially high-energy ultraviolet (UV) radiation. When combined with other cosmetic ingredients, titanium dioxide forms a protective surface coating on the skin. This coating helps maintain skin protection and prevents darkening caused by intense sun exposure. Therefore, the use of pressed powder containing titanium dioxide is effective in protecting the skin from the harmful effects of sunlight [12]. However, pressed powder has a common drawback—its tendency to be easily removed or smudged. Therefore, the use of silicone is crucial in pressed powder formulations. The type of silicone commonly used in pressed powder is cyclopentasiloxane.

Cyclopentasiloxane (D5) is widely used in cosmetic products due to its unique functions, including acting as an emollient, humectant, solvent, and viscosity-controlling agent. In this study, cyclopentasiloxane is a water-resistant agent, enhancing the product's ability to adhere to the skin and resist removal by sweat or moisture. The results of the formulations can be seen in Figure 1.



(a) **(b)** **(c)** **(d)** **(e)**

Figure 1. Pressed powder sunscreen formulations containing titanium dioxide at varying concentrations: (a) F1 with 10% titanium dioxide; (b) F2 with 15% titanium dioxide; (c) F3 with 20% titanium dioxide; (d) F4 with 25% titanium dioxide; (e) F5 with 30% titanium dioxide.

The pressed powder sunscreen formulations with titanium dioxide were developed in five different concentrations: 10%, 15%, 20%, 25%, and 30%. The purpose of varying the titanium dioxide concentration was to evaluate its influence on the Sun Protection Factor (SPF) value in the pressed powder sunscreen formulations.

Additional ingredients in the formulation included talc, which served as the primary filler to increase the bulk of the product, provide a smooth texture, and improve spreadability on the skin for user comfort. Zinc stearate functioned as a binder, helping to press the pigments, prevent crumbling, and enhance the texture and viscosity of the product. Vanilla was added to give a distinctive fragrance. Glycerin acted as a humectant to maintain skin moisture.

Calcium carbonate served as an absorbent to maintain the physical stability of the formulation and control moisture. Polyvinyl alcohol functioned as a stabiliser to prevent ingredient separation and improve product longevity. D&C Red No. 17 and D&C Yellow No. 10 were incorporated to provide a stable colour and enhance the product's aesthetic appeal [21].

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Physical Evaluation

Organoleptic Test

The pressed powder formulations were evaluated organoleptically based on odour, colour, and texture. [19]. Observations conducted over one week on F1, F2, F3, F4, and F5 showed that all formulations had a light brown colour, smooth texture, and a vanilla scent. These results are consistent with previous studies, which state that good organoleptic quality is indicated by the absence of changes in colour, odour, and texture during the observation period. The formulation's observed light brown colouration and vanilla scent result from the combination of added colourants and aromatic agents, rather than the intrinsic properties of titanium dioxide (TiO_2), which is white and odourless. Specifically, incorporating D&C Red and D&C Yellow dyes contributes to the overall hue through colour blending, while vanillin imparts a characteristic vanilla aroma [22]. Organoleptic stability ensures the formulation meets users' aesthetic and sensory expectations [23].

pH Test

pH is a measurement that determines the acidity or alkalinity of a solution. A pH that is too low can cause skin irritation, while a pH that is too high may lead to dryness. The ideal pH range for topical application on skin is between 4.5 and 7 [24].

Table 2. Results of pH Tests

Formula	pH
F1	5,93 ± 0,02
F2	5,98 ± 0,01
F3	6,61 ± 0,00
F4	6,84 ± 0,02
F5	7,75 ± 0,03

The results in Table 2 indicated that formulations F1–F4 exhibited pH values within the range of normal skin pH. However, F5 demonstrated a pH value of 7.75, which falls outside this physiological range. This deviation may be influenced by factors such as the decomposition of components resulting in acid formation, temperature fluctuations, improper storage conditions, and environmental factors. [25].

Titanium dioxide is an amphoteric compound, meaning it can act as either an acid or a base depending on synthesis conditions and the nature of accompanying excipients. Thus, its incorporation in formulations may influence the overall pH of the system [26]. Furthermore, the increase in pH may also be attributed to adding excipients with differing pH values, leading to interactions between the active ingredients and additives that result in pH variations among formulations.

Homogeneity Test

The homogeneity test assessed whether the particles within each formulation were uniformly dispersed or segregated. A homogeneous formulation reflects high product quality, ensuring even ingredient distribution, reducing skin irritation risk and promoting consistent application. This finding is consistent with Hastuti et al. (2020), who stated that a consistent particle distribution and the absence of coarse granules characterise optimal homogeneity. All tested pressed powder formulations were homogeneous, as evidenced by the uniform particle dispersion on glass slides and the lack of clumping in all samples.

Adhesion Test

The adhesion test results met the acceptable standard, indicating that each formulation adhered to the skin for 6 hours, as shown in Table 3.

Table 3. Adhesion test results

Formula	Adhesion	Duration (h)
F1	Adhered	6
F2	Adhered	6
F3	Adhered	6
F4	Adhered	6
F5	Adhered	6

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The adhesion test was designed to evaluate the ability of the formulation to remain on the skin after application. Greater adhesion generally enhances the potential for absorbing active ingredients due to prolonged contact time [27]. As such, extended adhesion supports sustained release and prolonged effectiveness of the formulation [28].

Hardness Test

Hardness testing of pressed powder formulations was performed to assess the tablets' mechanical strength and compression quality. Hardness is directly related to the pressure applied during compression; greater pressure results in higher hardness values [29]. If formulations that do not exhibit cracking or breaking upon handling indicate good pressedness [19]. All five formulations met the required hardness standards, as none displayed any signs of cracking or breakage [4]. The good adhesion observed is also attributed to the inclusion of water-resistant agents, which prolong skin contact [3]. Additionally, excipients such as polyvinyl alcohol (PVA) may enhance the adhesion properties of pressed powders, improving their longevity and resistance to smudging. All five formulations fulfilled the necessary hardness and adhesion criteria based on the results.

Sun Protection Factor (SPF) Evaluation

The Sun Protection Factor (SPF) indicates a product's or active ingredient's effectiveness in protecting the skin against ultraviolet (UV) radiation. A higher SPF value corresponds to greater protection from harmful UV effects [30]. SPF is a widely accepted index for evaluating sunscreen performance. UV-Visible spectrophotometry was conducted over the wavelength range of 290–320 nm to determine SPF values in titanium dioxide-containing pressed powders. Absorbance values at each sample concentration were calculated using a validated equation to derive SPF values.

Results showed that absorbance increased proportionally with sample concentration, directly influencing the resulting SPF values, as presented in Table 4.

Table 4. SPF Test Results

Formula	SPF Value	Protection Category
F1	8,41 ± 0,06	Maximum Protection
F2	8,60 ± 0,01	Maximum Protection
F3	14,57 ± 0,00	Ultra Protection
F4	15,06 ± 0,00	Ultra Protection
F5	15,57 ± 0,00	Ultra Protection

The data demonstrate that higher concentrations of titanium dioxide correlate with increased SPF values. Additional influencing factors include the type of solvent, carrier components, the inclusion of other active ingredients, and pH conditions. Titanium dioxide is typically utilised in sunscreen formulations at concentrations ranging from 2% to 15%. However, increasing its concentration to 20–30% has significantly enhanced SPF values. The SPF values obtained in this study ranged from 8.41 to 15.57, with Formulas 3, 4, and 5 falling into the ultra protection category. These findings are consistent with previous reports. For instance, Geoffrey et al. (2019) stated that mineral-based sunscreen formulations containing agents such as titanium dioxide and zinc oxide typically exhibit SPF values ranging from 2 to 20, depending on formulation factors such as particle size, dispersion, and film uniformity.

Formulations F3 to F5 achieved SPF values categorised as "Ultra Protection," providing efficacy comparable to para-aminobenzoic acid (PABA) in absorbing UV radiation [31]. These formulations prevent tanning and offer superior protection against UVA and UVB radiation, which are implicated in skin ageing, hyperpigmentation, and increased skin cancer risk. While maximum protection is adequate for daily activities, ultra protection suits environments with intense UV exposure. Although Formula 5 demonstrated a slightly higher SPF value (15.57) than Formula 4 (15.07), Formula 4 is considered superior overall due to better safety and cosmetic acceptability, particularly for daily use. Formula 5 contains a high concentration of titanium dioxide (TiO_2) at 30%, which enhances UVB protection but may lead to undesirable effects such as white cast and mild skin irritation, especially in individuals with sensitive or darker skin tones. TiO_2 is a physical UV filter known for its intense opacity and bright white colour, and at high concentrations, it can negatively impact the visual aesthetics of the product [32], [33]. Moreover, while TiO_2 is generally recognised as safe for

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topical use up to 25% by the European Scientific Committee on Consumer Safety (SCCS), formulations exceeding this threshold warrant further evaluation for potential local adverse effects such as irritation or inflammation [34]. Therefore, Formula 4, which utilises a lower TiO_2 concentration, offers a more balanced approach, delivering adequate sun protection while minimising cosmetic drawbacks and irritation risks, making it more suitable for routine application. In conclusion, pressed powder formulations containing titanium dioxide demonstrated effective photoprotective performance, as evidenced by SPF values. These findings align with previous studies supporting the potential of titanium dioxide as an active ingredient in cosmetic formulations designed for UV protection and optimal SPF efficacy.

Conclusions

Based on the study results, the pressed powder sunscreen formulation—comprising titanium dioxide, cyclopentasiloxane, zinc stearate, calcium carbonate, glycerin, polyvinyl alcohol (PVA), D&C Red and Yellow colourants, and talc—met the required standards. Organoleptic testing showed a light brown colour, distinctive aroma, and smooth texture. The pH ranged from 5.93 to 7.75, with uniform homogeneity across all formulas. Adhesion was good at all concentrations, and no cracking occurred in hardness tests. Titanium dioxide significantly influenced SPF values: F1 (8.41), F2 (8.60), F3 (14.57), F4 (15.06), and F5 (15.57), with F3–F5 classified as ultra protection. Although F5 exhibited the highest SPF, F4 was considered the most optimal UVB protection under the tested conditions, due to its favourable balance of SPF performance, physical stability, and user acceptability. Notably, F4 maintained adequate UVB protection while avoiding the white cast and irritation potential associated with the higher titanium dioxide level in F5. However, this conclusion is limited to UVB performance; further studies are recommended to evaluate UVA protection, photostability, and long-term safety.

Conflict of Interest

The authors declare no conflict of interest involving any individual or organisation in conducting this research and writing this article. The authors also affirm that all materials were prepared with full responsibility and awareness.

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References

[1] Z. R. Hakim, P. K. Isnaini, and E. Genatrika, “Formulasi, Evaluasi Sifat Fisik, dan Uji Efektivitas Tabir Surya Losion Ekstrak Buah Jamblang (Syzygium cumini (L.) Skeels),” *PHARMACY: Jurnal Farmasi Indonesia (Pharmaceutical Journal of Indonesia)*, vol. 17, no. 1, pp. 225–240, 2020.

[2] R. Nabillah, “Prevalensi dermatitis seboroik di poli kulit dan kelamin RSUD Meuraxa Kota Banda Aceh periode Tahun 2016-2019,” *Jurnal Health Sains*, vol. 2, no. 1, pp. 112–119, 2021.

[3] N. H. Amimi and L. R. Rizkuloh, “Uji Spf Dan Aktivitas Antibakteri Sediaan Sunscreen Powder Ekstrak Etanol Daun Jambu Biji (Psidium Guajava L.) Terhadap Propionibacterium Acnes,” *Pharma Xplore: Jurnal Sains dan Ilmu Farmasi*, vol. 8, no. 2, pp. 91–103, 2023.

[4] W. Widyastuti, A. E. Kusuma, N. Nurlaili, and F. Sukmawati, “Aktivitas antioksidan dan tabir surya ekstrak etanol daun stroberi (Fragaria x ananassa AN Duchesne),” *Jurnal Sains Farmasi & Klinis*, vol. 3, no. 1, pp. 19–24, 2016.

[5] K. Geoffrey, A. N. Mwangi, and S. M. Maru, “Sunscreen products: Rationale for use, formulation development and regulatory considerations,” *Saudi Pharmaceutical Journal*, vol. 27, no. 7, pp. 1009–1018, 2019.

[6] A. Rampaul, I. P. Parkin, and L. P. Cramer, “Damaging and protective properties of inorganic components of sunscreens applied to cultured human skin cells,” *J Photochem Photobiol A Chem*, vol. 191, no. 2–3, pp. 138–148, 2007.

Electronic ISSN : 2656-3088
Homepage: https://www.journal-jps.com

[7] F. Farhamzah *et al.*, "Sun protection factor activity of black glutinous rice emulgel extract (Oryza sativa var glutinosa)," *Indian Journal of Pharmaceutical Education and Research*, vol. 56, no. 1, pp. 302–310, 2022.
[8] M. Justitia, "Formulasi Sediaan Bedak Kompak Menggunakan Sari Wortel (Daucus carota L.) Sebagai Pewarna," *Universitas Sumatera Utara*, 2014.
[9] R. Izza and C. I. N. H. Safitri, "Formulasi dan Uji Mutu Fisik Ekstrak Kunyit (Curcuma domesticae Val.) Sebagai Bedak Padat," in *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)*, 2020, pp. 317–326.
[10] D. Rachmawati, H. Stevani, and E. Santi, "Uji Stabilitas Mutu Fisik Sediaan Masker Gel Wajah Dari Ekstrak Daun Belimbing Wuluh (Averrhoa bilimbi L.) Dengan Variasi Konsentrasi Carbopol," *Media Farmasi*, vol. 14, no. 1, pp. 77–84, 2018.
[11] A. Aprilia, *The Natural Beauty Solution*. Gramedia Pustaka Utama, 2019. [Online]. Available: https://books.google.co.id/books?id=jXyMDwAAQBAJ
[12] J. Lee, K. Kim, S.-M. Park, J.-S. Kwon, and E.-B. Jeung, "Effects of decamethylcyclopentasiloxane on reproductive systems in female rats," *Toxics*, vol. 11, no. 4, p. 302, 2023.
[13] K. Geoffrey, A. N. Mwangi, and S. M. Maru, "Sunscreen products: Rationale for use, formulation development and regulatory considerations," *Saudi Pharmaceutical Journal*, vol. 27, no. 7, pp. 1009–1018, 2019.
[14] M. D. Berthiaume, "Silicones in cosmetics," *Cosmetic Science and Technology Series*, pp. 275–324, 1999.
[15] H. Warnida, A. Juliannor, and Y. Sukawaty, "Formulation of Bawang Dayak (Eleutherine bulbosa (Mill.) Urb.) Extract into a Gel Toothpaste," *Jurnal Sains Farmasi dan Klinis*, vol. 3, no. 1, pp. 42–49, 2016.
[16] I. S. Karimah, R. S. Dani, H. Agustin, S. Rohmawati, L. Rahmawati, and S. Susanti, "Formulasi dan Uji SPF Sediaan Sunscreen Powder Ekstrak Daun Kelor (Moringa oleifera)," *Jurnal Sains Dan Kesehatan*, vol. 5, no. 6, pp. 893–899, 2023.
[17] R. Hastuti, S. R. N. Endah, and A. Nofriyaldi, "Formulasi Dan Uji Stabilitas Fisik Sediaan Gel Ekstrak Daun Alpukat (Persea americana. Mill)," *Pharmacoscript*, vol. 3, no. 2, pp. 150–161, 2020.
[18] J. Y. Hong *et al.*, "Increased Long adhering and Adhesion Force to Skin through the Hybrid of Fatty Acid Ester and Titanium Dioxide," *Journal of the Society of Cosmetic Scientists of Korea*, vol. 49, no. 3, pp. 247–258, 2023.
[19] R. D. D. Anggraini, E. Purwati, and C. I. N. H. Safitri, "Formulasi dan Stabilitas Mutu Fisik Ekstrak Kayu Manis (Cinnamomum burmannii) sebagai Bedak Padat Antioksida," in *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)*, 2021, pp. 603–610.
[20] J.S. Mansur, M.N. Breeder, and R.D. Azulay, "Determinação do fator de proteção solar por espectrofotometria," *An. Bras. Dermatol*, vol. 61, 1987.
[21] R. C. Rowe, P. Sheskey, and M. Quinn, *Handbook of pharmaceutical excipients*. Libros Digitales-Pharmaceutical Press, 2009.
[22] Z. D. Draelos, "Colored facial cosmetics," *Dermatol Clin*, vol. 18, no. 4, pp. 621–631, 2000.
[23] W. A. Pratama and A. K. Zulkarnain, "Uji SPF in vitro dan sifat fisik beberapa produk tabir surya yang beredar di pasaran," *Majalah Farmaseutik*, vol. 11, no. 1, pp. 275–283, 2015.
[24] D. Pratimasari, N. Sugihartini, and T. Yuwono, "Evaluasi sifat fisik dan uji iritasi sediaan salep minyak atsiri bunga cengkeh dalam basis larut air," *Jurnal Ilmiah Farmasi*, vol. 11, no. 1, pp. 9–15, 2015.
[25] M. M. Putra, I. Dewantar, and D. A. Swastini, "Pengaruh lama penyimpanan terhadap nilai pH sediaan cold cream kombinasi ekstrak kulit buah manggis (Garcinia mangostana L.), herba pegagan (Centella asiatica) dan daun gaharu (Gyrinops versteegii (gilg) Domke)," *Jurnal Farmasi Udayana*, vol. 3, no. 1, p. 279745, 2014.
[26] E. Tombácz, "pH-dependent surface charging of metal oxides," *Periodica Polytechnica Chemical Engineering*, vol. 53, no. 2, pp. 77–86, 2009.
[27] E. Kumalasari, A. Mardiah, and A. K. Sari, "Formulasi sediaan krim ekstrak daun bawang dayak (Eleutherine palmifolia (L) Merr) dengan basis krim tipe A/M dan basis krim tipe M/A," *AFAMEDIS*, vol. 1, no. 1, pp. 23–33, 2020.
[28] D. Saryanti, I. Setiawan, and R. A. Safitri, "Optimasi Asam Stearat Dan Tea Pada Formula Sediaan Krim Ekstrak Kulit Pisang Kepok (Musa paradisiaca L.)," *Jurnal Riset Kefarmasian Indonesia*, vol. 1, no. 3, pp. 225–237, 2019.
[29] S. V. Gopalan and D. Gozali, "Review Artikel: Formulasi Dan Evaluasi Sediaan Granul Effervescent Dan Sediaan Tablet Dengan Metode Granulasi Basah," *Farmaka Suplemen*, vol. 16, no. 1, pp. 117–123, 2018.

Electronic ISSN : 2656-3088
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[30] U. Syarif, "Uji Potensi Tabir Surya Ekstrak Daun Jambu Biji (Psidium guajava L). berdaging Putih secara In vitro," *Skripsi. Fakultas Kedokteran. Makasar: Universitas Islam Negeri Alauddin*, 2017.

[31] A. R. Erwiyani, R. P. Rizky Wulandini, T. D. Zakinah, and I. Sunnah, "Formulasi dan Evaluasi Bedak Tabur Daging Labu Kuning (Cucurbita maxima D.)," *Majalah Farmasetika*, vol. 7, no. 4, p. 314, May 2022, doi: 10.24198/mfarmasetika.v7i4.39149.

[32] G. J. Nohynek, J. Lademann, C. Ribaud, and M. S. Roberts, "Grey goo on the skin? Nanotechnology, cosmetic and sunscreen safety," *Crit Rev Toxicol*, vol. 37, no. 3, pp. 251–277, 2007.

[33] B. Dreno, A. Alexis, B. Chuberre, and M. Marinovich, "Safety of titanium dioxide nanoparticles in cosmetics," *Journal of the European academy of dermatology and venereology*, vol. 33, pp. 34–46, 2019.

[34] E. Gaffet *et al*., "SCCS Scientific Advice on Titanium dioxide (TiO2)(CAS/EC numbers 13463-67-7/236-675-5, 1317-70-0/215-280-1, 1317-80-2/215-282-2)-SCCS/1661/23-Final document," 2024.

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