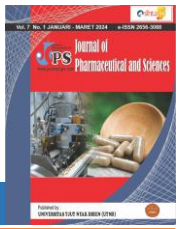
Journal of Pharmaceutical and Sciences
Electronic ISSN: 2656-3088 DOI: https://doi.org/10.36490/journal-jps.com
Homepage: https://journal-jps.com
ORIGINAL ARTICLE JPS. 2025, 8(4), 3039-3050



Optimization of BHT Concentration to Maintain the Stability of Natural Pigments in Cream Blush Preparations From *Hemigraphis Colorata* Extract

Optimasi Konsentrasi BHT untuk Menjaga Stabilitas Pigmen Alami pada Sediaan *Cream Blush* Ekstrak *Hemigraphis colorata*

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Abstract

The use of natural dyes from *Hemigraphis colorata* Hall. extract as cosmetic dyes faces stability challenges due to oxidative degradation. This study aims to test the effect of Butylated Hydroxytoluene (BHT) antioxidant concentration on the physical stability and color of cream blush formulations. *H. colorata* leaves were extracted by maceration and lyophilization, then formulated into four cream blush preparations with varying concentrations of BHT: without BHT (F0), 0.0075% (F1), 0.05% (F2), and 0.1% (F3). Physical stability of the formulations was evaluated for 28 days through organoleptic testing, homogeneity, pH, viscosity, spreadability, adhesion, and color stability using UV-Visible spectrophotometry. The results showed that all formulations met the physical standards for topical preparations. However, F2 (0.05%) and F3 (0.1%) successfully maintained color stability with minimal shifts. This study concludes that BHT can effectively maintain the physical stability of cream blush formulations based on *H. colorata* extract, with 0.05% (F2) being the optimal BHT concentration (the lowest effective concentration), based on considerations of effectiveness, safety, and cost, proven to be optimal in protecting natural pigments from degradation. These results provide important information for the development of safe, high-quality natural cosmetic products with a longer shelf life.

***Keywords*: Hemigraphis colorata, cream blush, BHT antioxidant, color stability.**

Abstrak

Pemanfaatan pewarna alami dari ekstrak *Hemigraphis colorata* Hall. sebagai pewarna kosmetik menghadapi tantangan stabilitas akibat degradasi oksidatif. Penelitian ini bertujuan menguji pengaruh konsentrasi antioksidan *Butylated Hydroxytoluene* (BHT) terhadap stabilitas fisik dan warna sediaan krim *blush on*. Daun *H. colorata* diekstraksi dengan maserasi dan liofilisasi, kemudian diformulasikan ke dalam empat sediaan *cream blush* dengan variasi konsentrasi BHT: tanpa BHT (F0), 0,0075% (F1), 0,05% (F2), dan 0,1% (F3). Evaluasi stabilitas fisik sediaan selama 28 hari melalui uji organoleptik, homogenitas, pH, viskositas, daya sebar, daya lekat serta stabilitas warna menggunakan Spektrofotometri UV-Vis. Hasil menunjukkan bahwa seluruh formula memenuhi standar fisik sediaan topikal. Namun, formula F0 dan F1 mengalami pergeseran hipokromik secara signifikan, mengindikasikan degradasi pigmen yang cepat. Sebaliknya, F2 (0,05%) dan F3 (0,1%) berhasil mempertahankan stabilitas warna dengan pergeseran minimal. Studi ini menyimpulkan bahwa BHT secara efektif dapat mempertahankan stabilitas fisik sediaan *cream blush* berbasis ekstrak *H. colorata*, dengan 0.05% (F2) adalah konsentrasi BHT yang optimal (terendah yang efektif), berdasarkan pertimbangan efektivitas, keamanan ataupun biaya, terbukti optimal dalam melindungi pigmen alami dari degradasi. Hasil ini memberikan informasi penting untuk pengembangan produk kosmetik alami yang aman, berkualitas, dan memiliki masa simpan yang lebih lama.

***Kata Kunci*: Hemigraphis colorata, cream blush, antioksidan BHT, stabilitas warna.**

Article History:
Received: 17/09/2025,
Revised: 24/11/2025,
Accepted: 24/11/2025,
Available Online: 30/12/2025.

QR access this Article

https://doi.org/10.36490/journal-jps.com.v8i4.1139

Introduction

Decorative cosmetics have become an important part of beauty procedures, with blush being one of the most sought-after products. Blush is a decorative cosmetic product that adds color to the cheeks with an aesthetic touch, making the face appear more beautiful, fresh, and dimensional in makeup [1]. There are various types of blush available on the market, based on their form and application method, namely compact powder blush, cream blush, blush on ball, gel blush, tint blush, and liquid blush [2]. However, cream blush has the advantage of being practical and its ability to provide a natural finish that blends seamlessly with the skin. One of the key considerations in the formulation of cream blush is color [3].

Rapid development continues to be experienced in the natural-based cosmetics industry, with the use of natural dyes now increasingly recognized as a safer alternative to synthetic dyes [4]. One plant that contains natural pigments is the 'remek daging' leaf *(Hemigraphis colorata)*. This plant, which is widely known ethnobotanically, has been identified as containing secondary metabolites that act as coloring agent [5]. Phytochemical analysis shows that the red color in the leaves comes from anthocyanin pigments, including flavonoid compounds that have potential applications in cosmetic preparations [6].

H. colorata plants are rich in anthocyanins, natural pigments that produce a strong purple-red color, ideal as a safer and more functional dye for cream blush compared to synthetic dyes [7]. The anthocyanins from this extract also offer topical antioxidant activity, providing dual benefits for the skin, making it a value-added ingredient in cosmetic formulations [8].The use of anthocyanins from *H. colorata* plants as natural dyes in cosmetic preparations shows that the pigment content has great potential, as found in rosella flowers, dragon fruit, and red beets [9]. However, the stability of natural pigments tends to be highly susceptible to environmental factors such as temperature, pH, light exposure, and oxygen exposure [10]. To maintain their function as pigments, the use of synthetic antioxidants such as Butylated Hydroxytoluene (BHT) is a common choice in cosmetic industry practices with the aim of preventing oxidation and product degradation [11].

BHT is known to be effective in maintaining the physical and chemical quality of cosmetic products. BHT functions as an antioxidant in preventing damage to the main ingredients and products due to air oxidation and exposure to light [12], and can delay pigment degradation at higher temperatures [13]. BHT is also used in anti-aging cream formulations containing green tea extract to prevent oxidation [14], as well as in other semisolid formulations [15]. The stability of anthocyanin color is highly susceptible to oxidative degradation triggered by free radicals (oxygen, light, etc.), which affects the structure of the flavilium cation core, causing bond breakage and color loss [16]. BHT, as a phenolic antioxidant, functions as an oxidation chain breaker; BHT donates its hydrogen atom to neutralize free radicals before they damage the pigment. This action effectively protects the anthocyanin structure, ensuring color retention and enhancing the stability of cosmetic formulations [17].

Therefore, this study aims to determine the effect of varying BHT concentrations in maintaining the physical stability and color of cream blush preparations containing *H. colorata* extract. This research developed a formulation by systematically testing the effect of varying BHT concentrations (0.0075%, 0.05%, and 0.1%) to find the most effective and efficient concentration in maintaining the color stability of the cream blush formulation. This study is expected to provide scientific information for the cosmetics industry in creating products that are safe and have a longer shelf life, ensuring better product quality and safety for consumers.

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Experimental Section

Materials and Instrumentals

The equipment and instruments used in this study included standard laboratory glassware, macerator, analytical balance, oven, furnace (Thermolyne™ Benchtop 1100°C), pH meter (Mettler Toledo, Switzerland), Lamy Rheology Viscometer (B-One Plus, France), UV-Vis spectrophotometer (Shimadzu 1800, Japan), and Lyophilizer freeze dryer (Biobase BK-FD10P, Beijing). The materials used in this study included 'daun remek daging' plants (*H. colorata*) obtained from the Baturraden Botanical Garden, Purwokerto, Central Java. The formulation ingredients included beeswax, span 80, tween 80, propylene glycol, glycerin, titanium dioxide, isopropyl myristate, triethanolamine, butyl hydroxytoluene, methyl paraben, propyl paraben, and distilled water. All ingredients were pharmaceutical grade and of analytical quality.

Determination of *H. colorata* Plant

The determination of *H. colorata* plants was carried out at the Jatinangor Herbarium, Plant Taxonomy Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Padjajaran University (Serial No.: 45/HB/02/2024).

Characteristics of *H. colorata* Crude Drug

The examination of the characteristics of *H. colorata* crude drug includes macroscopic examination (shape, color, size, smell, and taste of the crude drug), as well as the determination of total ash content and moisture content [6].

Phytochemical Screening of *H. colorata* Extract

Phytochemical screening aims to qualitatively determine the presence of secondary metabolites contained in the *H. colorata* plant, including alkaloids, flavonoids, quinones, tannins, polyphenols, saponins, steroids & triterpenoids, monoterpenoids, and sesquiterpenoids [6].

Extraction of *H. colorata* Plants

Extraction was performed using the maceration method (3 x 24 hours) using crude drug (60 mesh) with a crude drug:solvent ratio of 1:10. The solvent used was distilled water acidified with 10% w/v citric acid; this acidic pH condition was essential to stabilize the anthocyanin pigments in the form of flavilium cations and maximize extraction efficiency. The filtrate was then concentrated and lyophilized to obtain a dry extract [18].

Production of *H. colorata* Dry Extract

The *H. colorata* maserat liquid is dried using the lyophilization method. The aim is to convert the liquid phase into a solid phase to obtain a dry extract. The filtrate was collected in round-bottom flasks, and the lyophilization process was carried out using a Lyophilizer freeze dryer (Biobase BK-FD10P, Beijing), freezing the samples at -40°C for 24 hours, followed by drying for 72 hours at a pressure of 0.01 mbar [19].

Physical Color Stability Test of *H. colorata* Extract

a. Determination of the Maximum Wavelength of *H. colorata* Extract

Weigh 15 grams of dry extract and dissolve it in 250 mL of citric acid buffer solution with a pH of 6 (stock solution). Next, the stock solution was diluted to several concentrations, namely 8,000, 10,000, 12,000, 14,000, 16,000, 18,000, and 20,000 µg/mL, then the absorbance of each was measured using UV-Vis spectrophotometry (Shimadzu 1800, Japan) in the wavelength range of 400-800 nm [20].

b. Stability of Color During Storage

The dry extract was dissolved in pH 6 citrate buffer and stored at room temperature (±27°C) for 28 days. Absorbance and wavelength shifts were measured every 7 days using a UV-Vis spectrophotometer (Shimadzu 1800, Japan) in the 400–800 nm range [21].

c. Stability of Color Against Duration of Light Exposure

Color stability of *H. colorata* extract was tested using a modified accelerated photostability method with two light sources: polychromatic light (Philips 15 W) observed every 12 hours for 24 hours, and UV light (365

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nm) observed hourly for 5 hours. After exposure, wavelength shifts were analyzed using a UV-Vis spectrophotometer (Shimadzu 1800, Japan) at 400–800 nm [22].

d. Stability of Color Against pH Variations

The color stability of *H. colorata* extract was evaluated using the organoleptic pH stability test by preparing solutions with pH 1–14. Fifty milligrams of dry extract was dissolved in 10 mL of buffer at each pH level, and the resulting color was visually observed to determine the pH producing the desired color [23].

Formulation of Blush Cream based on *H. colorata* Extract

The preparation of *H. colorata* extract cream blush was formulated into four formulas with different BHT concentrations, namely F0 (0%), F1 (0.0075%), F2 (0.05%), and F3 (0.1%). Each ingredient was weighed as listed in **Table 1.** The oil phase consisted of beeswax, isopropyl myristate, propyl paraben, and span 80. Meanwhile, the water phase consists of tween 80, glycerin, propylene glycol, methyl paraben, triethanolamine, and pH 6 citric acid. Each phase was heated at a constant temperature of 60°C. The cream blush preparation was made by mixing the water phase into the oil phase using a magnetic stirrer until a cream base was formed. The 27.5% w/v concentration was selected through preliminary studies to achieve the optimal color intensity and coverage for a marketable cream blush. This necessary high pigment load justifies the study, as it increases the risk of oxidative degradation, mandating BHT optimization.

Table 1. Formulation of cream blush based on *H. colorata* extract.

Materials	Concentration (% w/v)			
	F0	**F1**	**F2**	**F3**
Extract of *H. colorata*	27.5	27.5	27.5	27.5
BHT	0	0.0075	0.05	0.1
Beeswax	20	20	20	20
Span 80	1.74	1.74	1.74	1.74
Tween 80	4.26	4.26	4.26	4.26
Propylene glycol	15	15	15	15
Glycerine	15	15	15	15
Titanium dioxide	0.5	0.5	0.5	0.5
Isopropyl myristate	5	5	5	5
Methylparaben	0.18	0.18	0.18	0.18
Propylparaben	0.02	0.02	0.02	0.02
Triethanolamine	5	5	5	5
Perfume	q.s	q.s	q.s	q.s
Citric acid solution pH 6	ad 100	ad 100	ad 100	100

Evaluation of Cream Blush Preparations

Organoleptic Test

Organoleptic testing was conducted visually, observing the shape, aroma, color, and taste. The test was conducted by placing the sample on a dish and observing changes in shape, color, aroma, and taste of the cream blush extract of *H. colorata*.

Homogeneity Test

The homogeneity of the *H. colorata* extract cream blush was tested by placing 1 g of sample between two glass slides. The formulation was considered homogeneous if it showed a uniform texture without visible coarse particles. [24].

pH Test

The pH measurement of the *H. colorata* extract cream blush preparation was carried out using a calibrated pH meter (Mettler Toledo, Switzerland). Samples were prepared in appropriate containers, then the electrode *probe* on the device was dipped into the sample, observed, and the pH value was recorded as specified [25] .

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Viscosity Test

The viscosity of the *H. colorata* extract cream blush preparation was determined using a *Lamy Rheology Viscometer* (B-One Plus, France). Samples were prepared in appropriate containers, and measurements were taken using an R3 spindle at a speed of 10 rpm. The spindle rod was then inserted into the sample. The viscosity value was observed and recorded as defined [26].

Spreadability Test

The spreadability of the *H. colorata* extract cream blush preparation was measured by weighing 0.5 grams of the preparation and placing it in the center of a round glass plate, covering it with another glass plate, and storing it in the device. Then, a 150 grams weight was placed on the glass and left for 5 minutes after which the diameter of each side of the preparation was measured and recorded [27].

Adhesion Test

The adhesive strength of the *H. colorata* extract cream blush preparation was measured using the same device as in the spreadability test, by weighing 0.5 grams of the preparation and placing it in the center of a round glass plate and covering it with another glass plate. After applying a weight, the circular glass plate holder was slowly lowered, and the time required for the circular glass plate to separate from the cover glass was observed and measured [28].

Evaluation of Physical Color Stability of Cream Blush Preparations

a. Stability of Color During Storage

Samples of *H. colorata* extract cream preparations were stored at room temperature (± 27°C), dissolved in citrate buffer pH 6, filtered, and then placed in a 10 mL measuring flask. The samples were measured for absorption and observed for maximum wavelength shifts using UV-Vis Spectrophotometry (Shimadzu 1800, Japan) in the wavelength range of 400-800 nm. Observations were made every 7 days during 28 days of storage [21].

b. Stability of Color Against Duration of Light Exposure

Color stability of *H. colorata* cream blush was evaluated using a modified accelerated photostability method with two light sources: polychromatic light (Philips 15 W) measured every 12 hours for 24 hours, and UV light (365 nm) measured hourly for 5 hours. After exposure, wavelength shifts were analyzed using a UV-Vis spectrophotometer (Shimadzu 1800, Japan) at 400–800 nm [22].

Results and Discussion

Determination, Characteristics, and Phytochemical Screening of *H. colorata* Plants

Identification of *H. colorata* was carried out at the Jatinangor Herbarium, Universitas Padjadjaran, confirming the plant as *Hemigraphis colorata Hall. F* (Acanthaceae), locally known as "daun remek daging", based on taxonomic references [29]. This identification ensured the accuracy of the plant material used and minimized sampling errors. Macroscopic observation showed that *H. colorata* has single, oval leaves with pointed tips, narrow bases, serrated margins, pinnate venation, dark green upper surfaces, and purplish-red undersides, with no distinctive odor or taste[6,30]. Evaluation of crude drug quality parameters included determination of total ash and moisture content. The results met compendial standards, with total ash content of 16.32% (<18%) and moisture content of 7.88% (<10%) [31], indicating good quality material free from metal contamination and microbial growth. Phytochemical screening revealed the presence of alkaloids, flavonoids, quinones, polyphenols, saponins, steroids–triterpenoids, and monoterpenoids-sesquiterpenoids, while tannins were absent [6]. The presence of flavonoids, polyphenols, and quinones contributes to the extract's potential as a natural pigment source with antioxidant properties, supporting its use as an active coloring agent in cosmetic formulations [32].

Physical Color Stability of *H. colorata* Extract

The color stability test of *H. colorata* extract showed a maximum absorption wavelength (λmax) of 519 nm. During 28 days of storage at room temperature, UV-Vis spectrophotometric analysis demonstrated minimal wavelength variation, shifting slightly from 519 nm to 518 nm. Such a change (<5 nm) indicates good

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color stability, as minor shifts typically do not alter visual appearance significantly [33,34]. Exposure to 365 nm UV light for 5 hours resulted in a small shift of λmax from 519 nm to 517 nm, while polychromatic light exposure (Philips 15 W) for 24 hours produced a slightly greater shift to 515 nm. This behavior aligns with the known photosensitivity of anthocyanins, which degrade more rapidly under broad-spectrum light [35]. However, these changes remained minor, suggesting that the extract retains sufficient stability during short-term storage and light exposure [36].

Organoleptic evaluation of the extract at different pH levels revealed a clear color transition—from pink in acidic conditions to greenish-yellow in alkaline environments (**Figure 1)** [37,38]. This pH-dependent shift corresponds to the structural transformation of anthocyanins, which are red in their flavylium cation form under strongly acidic conditions (pH 1–3), turning pink to purplish as they convert to quinonoidal bases near neutral pH (pH 5–7) [39]. At alkaline pH values above 8, anthocyanins predominantly form hemiketal or chalcone structures, resulting in color fading to yellow-green tones [40]. These findings are consistent with previous studies indicating that anthocyanins are highly sensitive to pH and prone to degradation in basic environments [41]. Therefore, selecting pH 6 as the formulation condition for the cream blush is appropriate, as it lies within the physiological pH range of the skin (4.5–7) and maintains optimal pigment stability [42].

Figure 1. Organoleptic color visualization of *H. colorata* extract at varying pH levels (1–14), showing color changes from pink (acidic) to pale/neutral to greenish yellow (alkaline) due to the sensitivity of anthocyanins to pH.

Formulation & Evaluation of Cream Blush Containing *H. colorata* Extract

The *H. colorata* extract cream blush was developed in four formulas containing different concentrations of BHT antioxidant to evaluate its role in maintaining anthocyanin pigment stability. The BHT concentrations were: F0 (without BHT), F1 (0.0075%), F2 (0.05%), and F3 (0.1%). The formulation used pH 6 to align with skin's physiological pH and to preserve pigment stability, aiming to produce a safe, stable, and comfortable natural-colored cosmetic product.

Organoleptic observations over 28 days at room temperature (**Figure 2**) showed that the cream retained its pink to purplish-pink color, characteristic vanilla scent, and uniform texture. Only F0 showed a decrease in consistency at the end of the storage period, while F1–F3 remained stable. These results suggest that BHT contributes to emulsion stability and prevents physical degradation during storage [11].

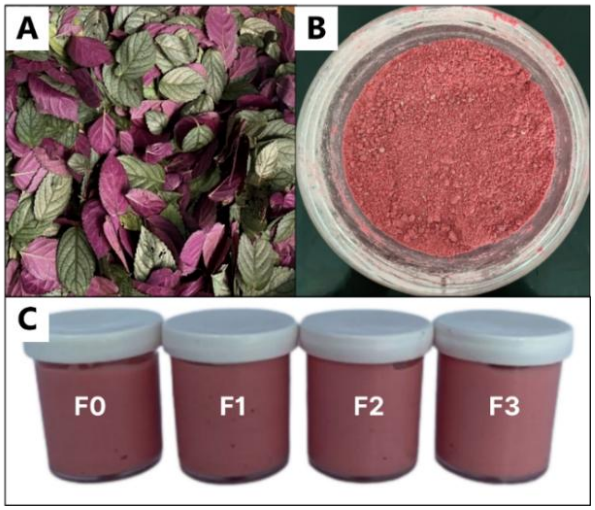

Figure 2. Physical visualization of: **(A)** *H. colorata* leaves, **(B)** *H. colorata* dry extract, and **(C)** cream blush preparations based on *H. colorata* extract in four formulas with different concentrations of BHT antioxidant.

Homogeneity testing revealed that F0 exhibited coarse particles from day 21, and F1 began losing uniformity on day 28. In contrast, F2 and F3 (0.05% and 0.1% BHT) maintained stability and homogeneity

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throughout the 28-day period. This indicates that BHT effectively enhances the physical stability of the cream blush by preventing lipid oxidation and pigment degradation caused by oxygen and light exposure. Therefore, the inclusion of BHT at appropriate concentrations helps preserve the quality and consistency of *H. colorata*-based cream blush [43].

The pH test results show that all cream blush formulas based on *H. colorata* extract have a pH within the safe range for skin, namely 4.5–7, so they can be said to meet the pH requirements for topical preparations [44]. During 28 days of storage at room temperature, pH fluctuations occurred in each formula, but the changes were relatively small and still within an acceptable range. The formula without antioxidants (F0) showed a greater tendency for pH increase than the formulas with BHT addition (F1–F3), indicating that the presence of antioxidants plays a role in suppressing pH changes due to the oxidation of active compounds. The pH changes that occurred were thought to be influenced by storage conditions, particularly exposure to oxygen, light, and the degradation of certain metabolites that can increase the acid or base content [45]. Thus, overall, the cream blush preparation can be considered stable based on the physical pH stability test of the preparation during 28 days of storage, as shown in **Table 2.**

Table 2. pH measurement of cream blush based on *H. colorata* extract

Formula	pH Value				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0	4.88±0.03	5.19±0.01	5.78±0.05	5.48±0.07	5.73±0.02
F1	4.80±0.02	4.58±0.05	5.48±0.03	5.44±0.01	5.46±0.03
F2	4.77±0.05	4.82±0.02	5.39±0.01	5.36±0.03	5.29±0.03
F3	4.83±0.02	4.84±0.04	4.94±0.03	4.84±0.04	4.84±0.02

Data represents the mean ± SD (n = 3)

Table 3. Determination of the viscosity of cream blush based on *H. colorata* extract

Formula	Viscosity value (cPs)				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0	17,600±887	17,430±163	18,313±152	18,340±255	16,790±848
F1	19126±278	19,796±983	16,916±542	15,273±133	16,160±998
F2	19,813±231	17,916±135	18,103±439	17,600±277	16,810±150
F3	18,266±480	17,200±656	17,200±147	16,883±437	17,600±277

Data represents the mean ± SD (n = 3)

The viscosity test results showed fluctuations in all cream blush formulas during 28 days of storage, but the changes were still within the standard viscosity range for cream preparations (4000–50,000 cPs) [46]. This consistency is in line with the results of the homogeneity test, in which formulas with the addition of BHT (F1–F3) remained stable until day 28, indicating that the even distribution of ingredients contributed to viscosity stability. In addition, the pH value remained within the safe range for the skin (4.5–7), indicating that there was no significant degradation that could affect the emulsion structure. The results of determining the viscosity of *H. colorata* extract cream blush are attached in **Table 3.** Thus, the viscosity stability in all formulas reinforces the previous results that the addition of BHT plays a role in maintaining the physical stability of cream blush during storage, while formulas without BHT (F0) are more susceptible to changes [14].

Table 4. Results of testing the spreading power of cream blush based on *H. colorata* extract

Formula	Spreadability (cm)				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0	5.23±0.29	5.27±0.38	5.57±0.12	6.17±0.15	6.50±0.2
F1	5.33±0.40	6.03±0.06	6.17±0.15	6.2±0.20	6.07±0.06
F2	5.30±0.26	5.93±0.12	5.83±0.29	5.53±0.06	5.90±0.10
F3	5.63±0.25	6.03±0.15	6.20±0.10	5.80±0.26	6.57±0.06

Data represents the mean ± SD (n = 3)

The spreadability test assessed the ease of cream blush distribution on the skin surface, an essential factor for topical formulations [47]. As shown in **Table 4**, all formulas (F0–F3) exhibited spreadability values

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ranging from 5.23–5.63 cm. These values remained within the acceptable range for topical preparations (5–7 cm) [48], indicating good application properties and consistent texture during storage.

Table 5. Adhesion testing of cream blush based on *H. colorata* extract

Formula	Time (seconds)				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0	9.24±0.49	9.18±0.21	8.81±0.48	7.76±0.52	7.43±0.50
F1	9.78±0.09	9.44±0.59	8.81±0.51	9.07±0.80	7.81±0.51
F2	8.31±0.59	8.86±0.42	8.55±0.47	9.71±0.56	8.52±0.48
F3	8.42±0.89	8.06±0.03	8.94±0.74	9.47±0.95	8.86±0.25

Data represents the mean ± SD (n = 3)

Adhesion testing was conducted to evaluate the ability of cream blush preparations to adhere to the skin, which is one of the critical parameters in determining the quality and user satisfaction [49]. Optimal adhesion ensures that the product has sufficient contact time on the skin, thereby providing a long-lasting cosmetic effect [50]. The adhesion test results presented in **Table 5** show that all formulas, namely F0, F1, F2, and F3, successfully meet the criteria for a good semisolid preparation, which is to have an adhesion of more than 4 seconds [51].

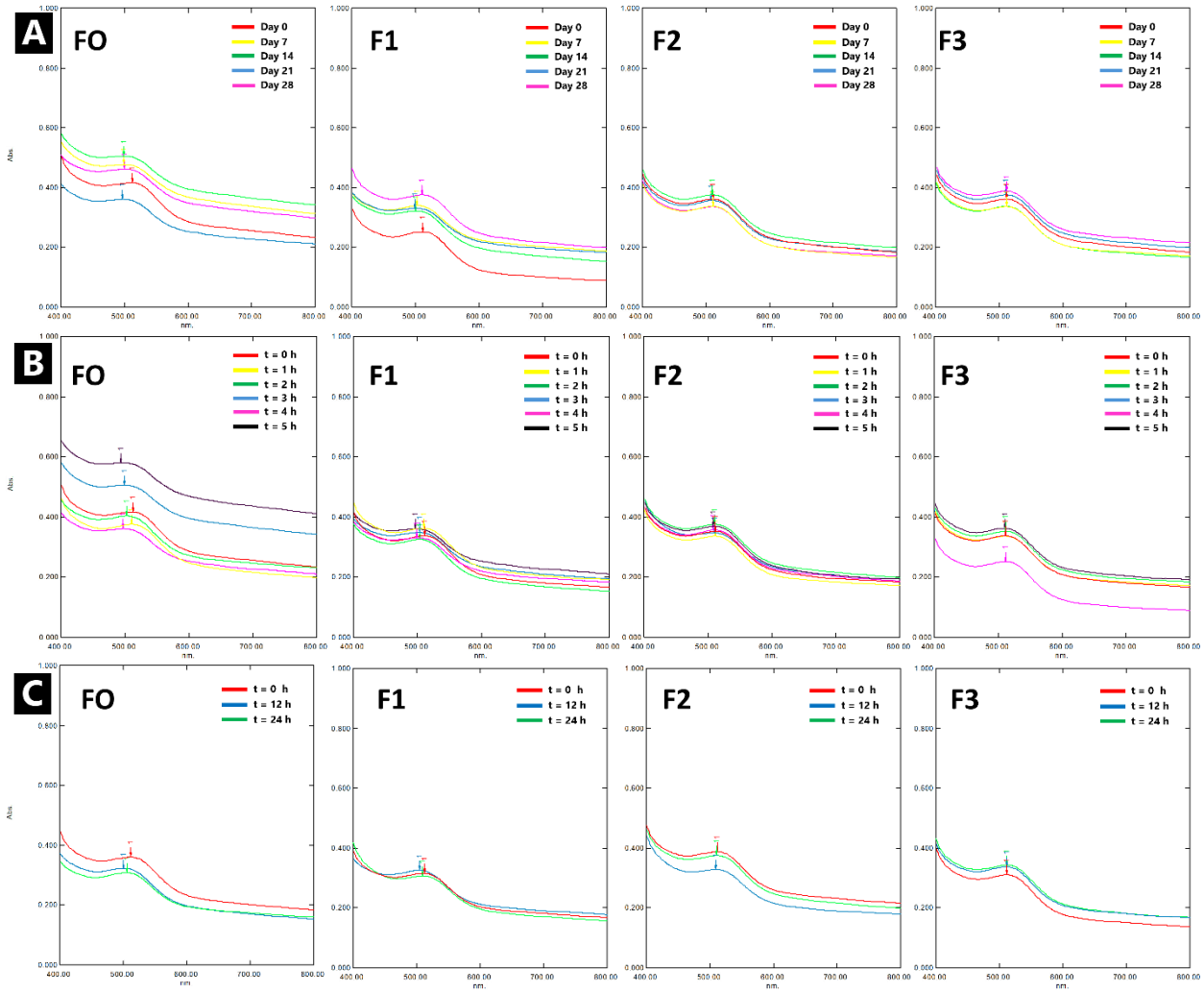

Figure 3. Visible spectrum profile evaluating the color stability of cream blush preparations based on *H. colorata* extract against: **(A)** storage duration, **(B)** 356 nm UV light exposure, and **(C)** polychromatic light exposure.

Evaluation of Physical Color Stability in Cream Blush Formulations

Color stability testing of cream blush preparations over storage duration showed a shift in λmax, indicating structural changes in the chromophore of the dye molecule [52]. The visible spectrum profile

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evaluating the color stability of cream blush preparations based on *H. colorata* extract is shown in **Figure 3.** The formula without BHT (F0) showed a significant hypochromic shift from 512 nm to 494.5 nm after 28 days of storage, indicating serious degradation of the chromophore [53,54]. A similar pattern was observed in UV and polychromatic light exposure tests, where F0 and F1 (0.0075%) showed the most significant color degradation. In contrast, formulations with higher BHT concentrations, namely F2 (0.05%) and F3 (0.1%), showed a much more minimal wavelength shift. This small shift indicates better stability. The wavelength shift clearly demonstrates the crucial role of BHT in maintaining the natural color stability of this preparation, as BHT effectively minimizes hypochromic color degradation due to damage to the chromophore conjugation system [55].

While UV-Vis Spectrophotometry is effective for detecting chemical degradation of anthocyanin chromophores, the method does not reflect the visual color perception of the cream formulation [56]. Thus, future studies are recommended to incorporate CIE *L*a*b** Colorimeter analysis to quantify the total color difference and validate the cosmetic stability from a visual quality perspective [57].

Analysis shows that formula F2 (0.05% BHT) reaches the point of saturation in effectiveness, equivalent to F3 (0.1%), so F2 is recommended as the optimal concentration because it is the lowest effective dose. This recommendation is supported by considerations of safety by minimizing synthetic additives and cost efficiency in production [58]. This study confirms that the highest concentration of BHT (F3, 0.1%) tested is still within the safe limits of cosmetic regulations (<0.5%) [11]. The recommendation of F2 (0.05%) as the optimal dose further supports the safety profile of the product, as it minimizes synthetic additives. Further research is needed to explore natural antioxidants as alternatives to BHT in order to increase market acceptance.

Conclusion

This study successfully demonstrated that the addition of the antioxidant Butylated Hydroxytoluene (BHT) is highly effective in maintaining physical stability and, in particular, the color stability of cream blush preparations based on *Hemigraphis colorata* extract as a natural colorant. Formulas without BHT (0%) and with the lowest concentration (0.0075%) experienced significant color degradation, marked by significant hypochromic shifts due to storage and exposure to light. Conversely, formulas containing BHT at concentrations of 0.05% and 0.1% were proven to optimally maintain anthocyanin pigment stability, minimize wavelength shifts, and preserve the physical quality of the preparation during 28 days of storage. Formula F2 (0.05%) is the optimal (lowest effective) concentration of BHT, based on considerations of effectiveness, safety, and cost. Thus, the use of BHT at the appropriate concentration is an essential formulation strategy for creating high-quality, natural pigment-based cosmetic products with a longer shelf life.

Conflict of Interest

The authors declare no conflict of interest regarding the conduct, writing, or publication of this article. All activities were carried out independently, based on scientific integrity and academic ethics.

Acknowledgment

We gratefully acknowledge the internal grant support (No: Skep/188/Unjani/VI/2025) from the LPPM of Universitas Jenderal Achmad Yani Cimahi, which enabled the publication of this research.

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