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Identification Formula For Hydroquinone Compound Content In Bulk Body Lotion Cosmetic Preparations Sold On E-Commerce

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Abstract

The distribution of skin-whitening cosmetics, especially body lotions, through e-commerce platforms is increasing and may contain hazardous ingredients such as hydroquinone. Hydroquinone is a compound that is prohibited for use in cosmetics because it can cause side effects such as dark spots on the skin, allergic reactions, irritation, brain damage, and cancer. This study aims to identify and determine the levels of hydroquinone in body lotion cosmetics sold on e-commerce platforms. This is an observational study with a descriptive approach. A total of three body lotion samples were analyzed qualitatively using a color reaction test with $FeCl_3$ reagent and thin-layer chromatography (TLC) method, and analyzed quantitatively using ultraviolet-visible spectrophotometry (UV-Vis). The hydroquinone content was determined based on the calibration curve of the standard solution at the maximum wavelength. The results showed that two of the three samples tested positive for hydroquinone in the qualitative test. Quantitative analysis showed that the hydroquinone content in sample 1 was (70.48 ± 0.0044)% and in sample 3 was (67.88 ± 0.0021)%. These levels do not meet cosmetic safety requirements according to the regulations of the Food and Drug Supervisory Agency (BPOM). It can be concluded that there are still body lotions circulating on e-commerce platforms that contain high levels of hydroquinone, so stricter supervision and increased public education regarding cosmetic safety are needed.

Keywords: Body lotion, E-Commerce, Hydroquinone, UV-Vis Spectrophotometry.

INTRODUCTION

Modern society increases the use of cosmetics as time goes by, therefore the types of cosmetics are also increasing. Cosmetics are materials or products designed to be used on the outside of the human body (epidermis, hair, nails, lips, and external genital organs) or teeth and oral mucous membranes, specifically to clean, scent, change the appearance, correct body odor, protect, or maintain the body to keep it in good condition.(BPOM, 2022).

Most Indonesian women desire clean, white, and bright skin to maintain an attractive appearance. In today's modern world, an attractive appearance is a must in the workplace and in social settings. To fulfill this desire, they use various methods, from natural skin care to very instant treatments with various types of cosmetics without paying more attention to whether the chemicals contained in these cosmetics can cause harmful effects on the skin later on.(Nurjanah et al., 2020).

The high demand for skin whitening products in Indonesia is influenced by the social perception that fair skin is considered more attractive and professional. A study of consumer behavior by(Rahmawati, 2020)states that over 65% of cosmetic users in Indonesia choose whitening products, even though many are unaware of the risks of harmful chemicals. This has led to increased consumption of instant whitening products, such as unbranded body lotions sold by the kilo, which are highly susceptible to containing hydroquinone.

Various cosmetic preparations, one of which is body lotion, are often used to brighten the skin.(Maulina et al., 2021)This preparation has several advantages, including being a source of skin hydration, providing an oil layer similar to sebum, softening hands and body without leaving a greasy feeling, and being easy to use. Given that prolonged and excessive use of lotion can be risky for health, it is important to pay attention to the composition and use of any harmful ingredients.(Megasari et al., 2022).

According to the head of the regulation (BPOM Regulation Number 17 of 2022) Article 6 paragraph (1) concerning the technical requirements for cosmetic ingredients, it is stated that hydroquinone and its compounds are included in the list of ingredients that are prohibited from being

added to cosmetics. Hydroquinone is a dangerous chemical that can cause black spots on the skin, allergic reactions, irritation, brain damage, and cancer. It is often found added to whitening lotions to speed up the whitening process or lightening of dark spots in a relatively short time, for example, within a period of 7 days the skin color changes will appear brighter.(Rahmawati & Susanti, 2021).

WHO(2019)states that long-term exposure to hydroquinone can cause ochronosis, a permanent skin darkening condition caused by melanocyte damage. In addition, reportsToxicologyA 2021 review stated that hydroquinone is mutagenic and carcinogenic at high doses, so its unsupervised use in cosmetics poses a serious risk to the public. Qualitative testing for hazardous substances like hydroquinone can use thin-layer chromatography and UV-Vis spectrophotometry.

Over the past five years, cosmetic sales through e-commerce platforms have increased significantly. The Indonesian Food and Drug Authority (BPOM) reports that illegal cosmetics are often found in products sold online, particularly on e-commerce platforms that provide products without strict verification of distribution permits.(BPOM, 2021). In addition, the report(Statista, 2023)Data shows that the "Beauty and Personal Care" category is among the top three most purchased products online in Indonesia. This situation makes e-commerce a distribution channel for high-risk cosmetic products containing hazardous ingredients, including hydroquinone.

Several studies have shown that lotions contain dangerous chemicals such as hydroquinone in body lotion preparations. Based on the results of the research conducted(Alawiyah et al., 2024)There were two body lotion samples containing hydroquinone. Sample A had a hydroquinone content of 5.6% and Sample B had a content of 6.93%. Based on the results of monitoring by the Jayapura Food and Drug Monitoring Agency (BPOM) in 2018, 430 illegal cosmetics were identified that did not have permits or contained hazardous materials.(Bakri et al., 2022). Based on the results of the tests carried out(Andalia et al., 2023)Of the six samples tested, hydroquinone was found. Based on research conducted(Burdah et al., 2023)Of the five samples tested, only one sample contained hydroquinone. Based on the research conducted(Pradiningsih et al., 2022)Of the three samples tested, one sample contained hydroquinone.

Further monitoring and analysis of body lotion products circulating in the community is crucial. Therefore, the research title chosen is based on the background of determining the extent to which hydroquinone is still found in body lotion preparations, as well as the importance of educating the public about the dangers of its use.

RESEARCH METHODS

Types and Methods of Research

This research is an observational study with a descriptive approach. The methods used include qualitative analysis using $FeCl_3$ and TLC, as well as quantitative analysis using UV-Vis spectrophotometry to determine hydroquinone levels.

Data Analysis Instruments and Techniques

The tools used in this study were analytical balance (Shimadzu®), hotplate (WiseStir), UV-Vis Spectrophotometer, filter paper, capillary tube, rubber bulb, measuring pipette (pyrex®), funnel, beaker glass (pyrex®), test tube (pyrex®), Erlenmeyer flask (pyrex®), measuring glass (pyrex®), measuring flask (pyrex®), watch glass, stirring rod, spatula, dropper pipette, plastic clip, Chamber, TLC plate Silica gel G60 F254 (Merck), dropper plate, UV lamp 254 nm and 366 nm (Camag). The materials used in this study were: distilled water, aluminum foil, Hydroquinone (Merck) as a standard, Body lotion as a sample, 95% ethanol (Brataco Chemika) as a sample solvent, 1% phloroglucine reagent, 0.5 N NaOH, FeCl3, chloroform (Merck) and methanol (Merck) as eluents.

Research Procedures

Sampling

A simple random sampling method was used to sample body lotions sold freely on Shopee, reflecting the high consumer usage trend. Three body lotions sold on Shopee were used.

Qualitative Analysis of Hydroquinone

FeCl3 Color Reagent Test

A 2 ml sample of body lotion from the TLC test solution preparation process was placed in a test tube, then 4 drops of FeCl3 reagent were added. The sample was confirmed to contain hydroquinone, indicated by a color change from green to black.(Rohmah et al., 2025).

Thin Layer Chromatography (TLC) Test

Preparation of test solution

The preparation of the test solution begins by weighing 5 grams of body lotion sample and dissolving it in 8 mL of 95% ethanol. From this solution, 2 mL is taken and dissolved in 95% ethanol in a 10 mL volumetric flask to the mark. The mixture is then homogenized using a water bath at 60ºC for 10 minutes, then placed in an ice bath until the wax and fat separate from the liquid phase. The solution is then filtered using filter paper for TLC analysis.(Sari et al., 2021).

Preparation of standard solution

The hydroquinone solution is prepared by weighing 500 mg of pure hydroquinone and dissolving it in 4 mL of 95% ethanol. From this solution, 0.5 mL is taken and then dissolved in 95% ethanol in a 10 mL volumetric flask up to the mark.(Sari et al., 2021).

Preparation of eluent

The elution solution is made by preparing 5 mL of eluent, namely: a mixtureChloroform : methanol(1 : 1)(Werdiningsih, 2024).

Sample identification by TLC

Sample identification was performed using the thin layer chromatography (TLC) method. A 5 x 7 cm TLC plate was oven-heated at 105ºC for 1 hour for activation. Then, a pencil line was drawn at 1 cm from the bottom and 1 cm from the top. The sample was then spotted onto the TLC plate using a capillary tube at a distance of 1 cm from the bottom of the plate. The distance between spots was 1 cm. The sample was then left for a while to dry. The TLC plate containing the sample was placed into a chamber saturated with a mobile phase in the form ofchloroform : methanol(1 : 1). Leave it until the TLC plate is completely eluted to the upper limit line, then the TLC plate is removed and dried in air at room temperature. Observe the spots visually and under UV light at 254 nm and UV light at 366 nm.(Werdiningsih, 2024).

Data analysis

The Rf value is calculated using the formula:

$$\text{Nilai } Rf = \frac{\text{Jarak yang di tempuh oleh zat yang teliti}}{\text{jarak yang ditempuh pelarut}}$$

Compare the Rf value between the sample and the reference standard.If the color of the stain between the standard and the sample is the same and the Rf value between the standard and the sample is the same or close to each other with a difference of ≤ 0.2.

Quantitative Analysis of Hydroquinone Levels Using UV-Vis Spectrophotometry

Preparation of 100 ppm standard solution

Weigh 10 mg of pure hydroquinone, dissolve it to the mark with 95% ethanol in a 100 mL volumetric flask, and shake until homogeneous. This will obtain the standard concentration of hydroquinone.(Sari et al., 2021).

Preparation of a series of standard solutions

From a concentration of 100 ppm, a series of concentrations of 1, 2, 3, 4, 5, and 10 ppm was prepared. Place them in a 10 mL volumetric flask and then dissolve them in 95% ethanol up to the mark.(Sari et al., 2021).

Determination of maximum wavelength

The maximum wavelength of hydroquinone was determined by taking 5 mL of hydroquinone working standard solution with a concentration of 3 ppm, then adding 1 mL each of 1% phloroglucin reagent and 0.5 N NaOH. The mixture was heated in a water bath at 70ºC for 15 minutes. After heating, the solution was cooled in water until it reached a temperature of 25ºC, then 95% ethanol was added to a volume of exactly 25 mL into a volumetric flask and shaken until homogeneous. Next, the solution was analyzed using a UV-Vis spectrophotometer to determine the maximum wavelength in the range of 400–700 nm.(Sari et al., 2021).

Creating a standard curve

The hydroquinone standard curve was prepared by preparing working standard solutions at concentrations of 1 ppm, 2 ppm, 3 ppm, 4 ppm, 5 ppm, and 10 ppm. 5 mL of each solution was taken, then 1 mL of 1% phloroglucin reagent and 1 mL of 0.5 N NaOH were added. The mixture was then heated in a water bath at 70ºC for 15 minutes. After heating, the solution was cooled in water until it reached 25ºC, then 95% ethanol was added to the volume to reach 25 mL in a volumetric flask and shaken until homogeneous. The absorbance of each solution was measured at a predetermined maximum wavelength using a UV-Vis spectrophotometer. Furthermore, the relationship between concentration and absorbance was used to create a standard curve and determine the linear regression equation.(Sari et al., 2021).

Determination of sample content

Determination of hydroquinone levels in body lotion samples was carried out by weighing 10 mg of each sample, then dissolving it using 95% ethanol in a 25 mL beaker. The solution was then filtered into a 10 mL volumetric flask and 95% ethanol was added until it reached the limit mark. From the sample solution obtained, 0.3 mL was taken using a micropipette and placed into a 10 mL volumetric flask, then 95% ethanol was added to the limit mark to obtain a solution with a concentration of 3 ppm. Next, 5 mL of the solution was taken and placed into a test tube, then 1 mL each of 1% phloroglucin reagent and 0.5 N NaOH were added. The mixture was heated in a water bath at 70ºC for 15 minutes, then cooled in water until it reached a temperature of 25ºC. After that, the solution was added with 95% ethanol until the volume was exactly 10 mL in the volumetric flask. The absorbance of the solution was measured using a UV-Vis spectrophotometer at a wavelength range of 400–700 nm. Each sample was analyzed in triplicate to obtain more accurate results.(Sari et al., 2021).

Data analysis

The quantitative test measures the absorbance of the identified test analyte in the qualitative test at the maximum wavelength, then the concentration is calculated based on the regression equation obtained in determining the standard curve.

$$y = bx \pm a$$

Where:

y = absorbance
a = intercept
b = slope
x = concentration(Dwi et al., 2025)

The level in the sample is calculated by regressing the absorbance results with the line equation obtained and then calculated using the formula:

$$Kadar\ (\%) = \frac{C\ x\ V\ x\ Fp}{W} x100\%$$

Where:

C = concentration (ppm)
V = volume of solution (L)
Fp = dilution factor
W = sample weight (mg)(Dwi et al., 2025)

RESULTS AND DISCUSSION

This study was conducted with three samples using qualitative and quantitative methods on body lotion samples. The qualitative test used was a color reagent test with FeCl3. and thin-layer chromatography tests, and the quantitative test used was UV-Vis spectrophotometry. Sampling was conducted using simple random sampling. This technique is a method of randomly selecting sample members from a population without considering the strata within the population.(Sugiyono, 2020).

Qualitative Analysis Results

FeCl3 Dye Test

Testing the color reagent with FeCl3, the sample is said to be positive for containing hydroquinone, indicated by a color change reaction from green to black.(Rohmah et al., 2025)The results of the color reagent test with FeCl3 carried out on body lotion samples can be seen in Table 1.

Table 1. Color Reaction Results on Body Lotion

Sample	Reaction After Addition of FeCl3
Hydroquinone standard	(+) produces a green solution that turns black over time
1	(+) produces a green solution that turns black over time
2	(-) produces a yellow precipitate
3	(+) produces a green solution that turns black over time

The qualitative analysis in this study aims to detect the presence of hydroquinone compounds in body lotion preparations circulating in the market using a color test with $FeCl_3$ reagent. $FeCl_3$ reagent is used because it is able to form colored complexes with phenolic compounds, including hydroquinone, through the coordination of Fe^{3+} ions with phenolic hydroxyl groups. The formation of the iron (III)–phenolic complex is indicated by a change in the color of the solution from green to black as an indicator of a positive result.

Based on Table 1, the standard hydroquinone test as a positive control showed a gradual green color change to black after the addition of $FeCl_3$. These results indicate that the $FeCl_3$ reagent and the test method used were in good condition and can be used as a valid comparison. This color change is consistent with the complex formation mechanism between Fe^{3+} and the phenolic group of hydroquinone that was carried out in the study.(Wahyuningsih & Kusumowati, 2024;Rohmah et al., 2025).

The results of the sample test showed that samples 1 and 3 experienced a green color change that then turned black, similar to the hydroquinone standard, so that both were declared positive (+) for containing hydroquinone or phenolic compounds with the same reaction characteristics. In contrast, sample 2 did not show a typical color change, but instead formed a yellow precipitate, so that it was qualitatively declared negative for the presence of hydroquinone.

This study indicates that not all body lotion products on the market meet cosmetic safety standards, considering that hydroquinone is a substance whose use is prohibited or restricted due to its potential side effects on the skin. However, the $FeCl_3$ test is qualitative and is only used as an initial screening method. Therefore, positive results in this study need to be further confirmed using advanced analytical methods, such as Thin Layer Chromatography (TLC) and quantitative analysis with UV-Vis spectrophotometry, to determine the hydroquinone levels in the samples.

Thin Layer Chromatography (TLC) Test

Thin Layer Chromatography (TLC) is a qualitative analysis method used to identify a compound based on the retention factor (Rf) value and the similarity of the stain pattern between the sample and the reference standard.(Suharyani et al., 2022).

TLC testing was carried out using a stationary phase of silica gel GF254 and a mobile phase in the form of a mixture of chloroform: methanol (1: 1). Silica gel GF_{254} is used as a stationary phase in Thin Layer Chromatography (TLC) analysis because it has polar properties and good absorption

capabilities for compounds containing polar groups, such as hydroquinone which has a phenolic hydroxyl group. Silica gel GF_{254} contains a fluorescent indicator that will fluoresce under 254 nm UV light. The presence of this indicator facilitates the visualization of spots of UV-active compounds, where hydroquinone will appear as a dark spot on a fluorescent background.(Werdiningsih, 2024).

TLC plate observation was carried out using UV light at 254 nm and 366 nm because the hydroquinone compound has several functional groups that are UV-active, so it can be detected in TLC observations using UV light at 254 nm and 366 nm. The main functional groups are the chromophore group in the form of an aromatic ring (benzene) and the auxochrome group in the form of phenolic hydroxyl (-OH). The results of the Rf value calculation from thin layer chromatography can be seen in table 2.

Table 2. Rf value with chloroform : methanol eluent (1 : 1)

Sample	Rf value
Hydroquinone standard	0.94
1	0.85
2	-
3	0.81

Table 2 shows that the hydroquinone standard produced an Rf value of 0.94. A high Rf value indicates a greater affinity of hydroquinone for the mobile phase than the stationary phase, and confirms the purity of the standard and the suitability of the TLC system used. This standard Rf value was used as a comparison in identifying hydroquinone in body lotion samples.

Sample 1 produced a stain with an Rf value of 0.85, which is close to the Rf value of the hydroquinone standard. The difference in Rf values is thought to be influenced by the characteristics of the sample matrix, the compound concentration, and interactions with other components in the cosmetic preparation. The close Rf values between sample 1 and the standard indicate that sample 1 is positive for hydroquinone, in line with the results of the $FeCl_3$ color test, which also showed a positive result.

In sample 2, no spots were observed that were parallel to or close to the Rf value of the hydroquinone standard. This indicates that sample 2 does not contain a compound with chromatographic characteristics similar to hydroquinone. These results are consistent with the previous $FeCl_3$ color test, so sample 2 was qualitatively negative for the presence of hydroquinone.

Sample 3 showed a stain with an Rf value of 0.81, which is still relatively close to the Rf value of the hydroquinone standard. The difference in the lower Rf value is thought to be caused by the influence of additional ingredients in the body lotion preparation which are more polar and interact with the stationary phase. The similarity in stain characteristics between sample 3 and the hydroquinone standard indicates that sample 3 is positive for hydroquinone, according to the results of the $FeCl_3$ color test.

The agreement between the $FeCl_3$ color test and the TLC test indicates that both qualitative methods support each other in identifying the presence of hydroquinone in body lotion preparations. However, because TLC is qualitative, further analysis using UV-Vis spectrophotometry is required to quantitatively determine hydroquinone levels.

Quantitative Analysis Results

Maximum Wavelength (λmax) Results of Hydroquinone

Determining the maximum wavelength (λmax) is a crucial initial step in quantitative analysis using UV-Vis spectrophotometry. The purpose of determining λmax is to determine the wavelength at which the hydroquinone compound exhibits maximum absorption, allowing for optimal sensitivity and accuracy in subsequent analysis.(Wahyuningsih & Kusumowati, 2024). The test results from several wavelengths, the absorbance results obtained can be seen in table 3.

Table 3. Maximum Wavelength Absorbance (λmax) of Hydroquinone

Wavelength (nm)	Absorbance
400	0.682
405	0.468
410	0.279
415	0.243
420	0.227
425	0.222
430	0.207
435	0.193
440	0.157
445	0.136
450	0.105
455	0.087
460	0.075

Based on Table 3, the absorbance measurements of the standard hydroquinone solution in the 400–460 nm wavelength range show variations in absorbance values at each wavelength. The highest absorbance value was obtained at 400 nm, while the absorbance decreased with increasing wavelength, reaching its lowest value at 460 nm. This pattern indicates that hydroquinone has maximum absorption at shorter wavelengths.

Based on these data, the maximum wavelength (λmax) of hydroquinone was set at 400 nm because it provided the highest absorbance value compared to other wavelengths. This determination of λmax is in accordance with the principle of UV-Vis spectrophotometry, where measurements are made at the maximum wavelength to increase method sensitivity and minimize analytical errors.(Wahyuningsih & Kusumowati, 2024).

The 400 nm wavelength was then used as the analytical wavelength for measuring the absorbance of the standard solution and test samples. This selection of λmax ensures that the measured absorbance changes directly reflect differences in hydroquinone concentration, allowing for more accurate determination of hydroquinone levels in body lotion samples.

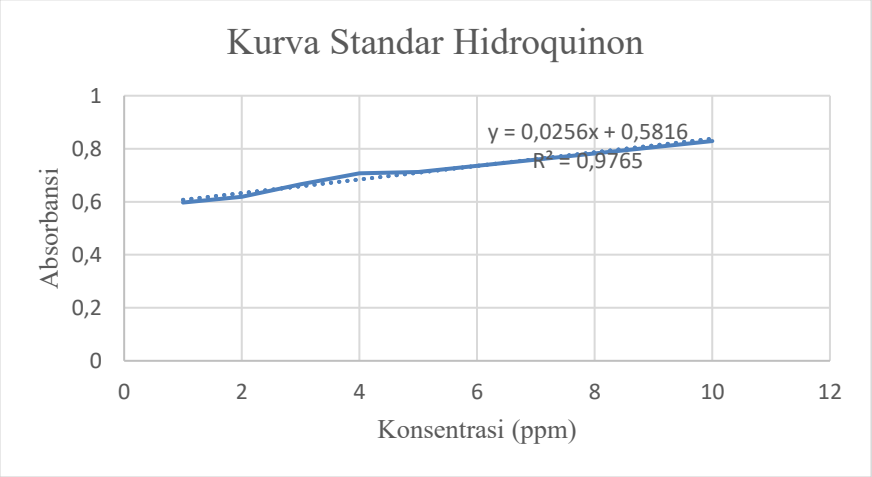
Calibration Curve Measurement Results of Hydroquinone Standard Solution

A standard curve for hydroquinone was prepared using standard solutions with varying concentrations of 1, 2, 3, 4, 5, and 10 ppm. The absorbance results for several concentration series are shown in Table 4.

Table 4. Hydroquinone Standard Curve Absorption

Concentration (ppm)	Absorbance
1	**0.597**
2	**0.619**
3	**0.666**
4	**0.707**
5	**0.712**
10	**0.829**

The absorbance values are then used to construct a standard curve graph depicting the relationship between hydroquinone concentration and absorbance. This standard curve serves as the basis for determining the hydroquinone content in test samples. Figure 1 shows a standard curve graph for hydroquinone.



Picture1. Regression Equation from Hydroquinone Standard Curve Graph

Based on Table 4, the measurement results show that the absorbance value increases with increasing hydroquinone concentration. At a concentration of 1 ppm, the absorbance was 0.597, while at the highest concentration, 10 ppm, the absorbance was 0.829. This pattern indicates a linear relationship between concentration and absorbance, which is consistent with spectrophotometric theory.

Based on these data, Figure 1 shows a graph of the relationship between concentration (x-axis) and absorbance (y-axis), resulting in a standard curve for hydroquinone. The resulting standard curve shows a straight line with the linear regression equation:

"y = 0.0256x + 0.5816"

The coefficient of determination (R^2) value obtained was 0.9765, indicating that 97.65% of the absorbance variation was influenced by the hydroquinone concentration, while the remainder was influenced by other factors such as measurement error or instrument conditions. The R^2 value approaching 1 indicates that the standard curve has a good level of linearity and is suitable for use in determining hydroquinone levels in samples.(Victoria et al., 2022).

Results of Determination of Hydroquinone Levels in Samples

Determination of hydroquinone levels in body lotion samples was carried out as the final stage of quantitative analysis using the UV-Vis spectrophotometry method. The calculation of hydroquinone levels was based on the previously obtained hydroquinone standard curve regression equation, which is a linear relationship between concentration and absorbance. The sample absorbance value obtained from the measurement was then entered into the regression equation to determine the hydroquinone concentration in the test solution, then converted into hydroquinone levels in the body lotion preparation (% w/w) by taking into account the sample weight, solution volume, and dilution factor.(Kartikasari, 2023). The test results on the body lotion samples obtained levels can be seen in table 5.

Table 5. Sample Content Determination Results

Sample	Content (%)
1	70.48 ± 0.0044
3	67.88 ± 0.0021

Based on Table 5, the results of the quantitative analysis show that samples 1 and 3 contain very high levels of hydroquinone. Sample 1 has a hydroquinone content of (70.48 ± 0.0044)%, while sample 3 has (67.88 ± 0.0021)%. This finding is in line with the results of the previous qualitative analysis, where both samples showed a positive reaction in the $FeCl_3$ color test and had Rf values close

to the hydroquinone standard in the Thin Layer Chromatography (TLC) test. In contrast, sample 2 did not show positive results in either the qualitative or TLC tests.

UV-Vis spectrophotometric analysis produced a hydroquinone standard curve with a good linear relationship between concentration and absorbance, indicated by a coefficient of determination (R^2) of 0.9765. Based on this standard curve, the hydroquinone levels in the body lotion samples can be determined accurately. The hydroquinone levels found in samples 1 and 3 far exceed the safe limit and do not meet cosmetic safety requirements, considering that hydroquinone is prohibited for use in body lotion cosmetic preparations according to the regulations of the Food and Drug Supervisory Agency (BPOM).(Shandra et al., 2025).

High levels of hydroquinone in body lotion preparations have the potential to cause negative impacts on skin health, such as irritation, hyperpigmentation, and long-term skin damage. Overall, the results of this study indicate that there are still body lotion products on the market that contain very high levels of hydroquinone. Therefore, stricter monitoring of the distribution of cosmetics and increased public awareness in choosing safe products are needed. These findings are expected to provide a scientific basis for consumers, health professionals, and relevant agencies in their efforts to ensure the safety of cosmetics sold in the community.

CONCLUSION

This study found that two of the three bulk body lotion samples sold on e-commerce sites tested positive for hydroquinone, confirmed by $FeCl_3$ (blackish-green color change) and TLC (Rf 0.85 and 0.81, close to the standard of 0.94). Quantitative UV-Vis analysis (λmax 400 nm, R^2=0.9765) showed extreme levels of 70.48 ± 0.0044% in sample 1 and 67.88 ± 0.0021% in sample 3, far exceeding the BPOM's safety limit which completely prohibits hydroquinone in cosmetics. These findings underscore the risk of illegal product circulation on online platforms that ignore safety regulations.

Limitations of the study include a limited sample size (only three products), a descriptive approach without HPLC analysis for high-precision confirmation, and reliance on simple random sampling from Shopee without verified sales volume. Suggestions for further research include broader sampling, in vivo toxicity testing, and multi-platform e-commerce monitoring. Practically, these results encourage the Indonesian Food and Drug Authority (BPOM) to tighten digital oversight, conduct consumer education campaigns on the dangers of ochronosis and the carcinogenicity of hydroquinone, and encourage industry to develop safe natural whitening alternatives.

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