

Analysis of Vitamin C Content in Facial Serum Using UV-Vis Spectrophotometric Method

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ABSTRACT

Facial serum is a category of skin care products designed to deliver concentrated active ingredients that promote the penetration of bioactive compounds into deeper layers of the skin, targeting various skin problems such as aging, hyperpigmentation, and acne. According to the literature, stable formulations of vitamin C at the right concentration can significantly reduce signs of aging and improve skin radiance. This study aims to determine the concentration of vitamin C contained in commercially available facial serums claimed to contain vitamin C, using the UV-Visible spectrophotometry method. Three samples were analyzed, namely; Serum 1, Serum 2, and Serum 3. A calibration curve was obtained using standard series concentrations of 2 ppm, 4 ppm, 6 ppm, and 8 ppm at an optimum wavelength of 241.50 nm, resulting in a regression equation of $y = 0.0242x + 0.3022$ with a correlation coefficient of $r = 0.9975$ and a determination coefficient of $R^2 = 0.9950$. The limit of detection (LOD) was 0.54 ppm and the limit of quantification (LOQ) was 1.81 ppm. The results of this study indicate that all tested samples contained vitamin C, with concentrations in Serum 1 = 338 mg/L, Serum 2 = 267.7 mg/L, and Serum 3 = 284.2 mg/L.

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Introduction

Ascorbic acid, commonly known as Vitamin C, has garnered significant attention in the field of dermatology and cosmetic science due to its potent antioxidant properties and roles in collagen synthesis, photo-protection, and skin rejuvenation [1][2]. The popularity of Vitamin C in facial serums stems from its ability to promote skin brightness, reduce the appearance of fine lines, and provide an overall youthful glow [2]. With the increasing consumer demand for effective skincare products, quantifying the Vitamin C content in these formulations has become imperative. Furthermore, accurate measurements of Vitamin C content are vital in ensuring product efficacy and compliance with industry standards and regulations [3][4].

Emerging research indicates that the stability of Vitamin C within formulations is influenced by several factors, including pH, light exposure, and the presence of various stabilizing

agents [1][5]. As such, the analytical assessment of Vitamin C content not only highlights its efficacy but also provides insights into the overall stability and viability of the cosmetic product. Additionally, studies have shown that formulation components can interact with ascorbic acid, resulting in degradation or enhanced stability, thereby influencing the final product's effectiveness [6][7].

As time goes by, public awareness of the importance of skin care is increasing. This has led to a surge in demand for skin care products. Unfortunately, many companies are exploiting this situation to profit unjustly. Skincare companies often leverage buzzwords and scientific jargon to attract consumers, leading to inflated expectations about product performance. Terms such as "clinically proven" or "dermatologist recommended" frequently accompany bold claims of dramatic results [8]. However, studies indicate that many of these

assertions lack rigorous scientific backing or are based on small sample sizes and short-term assessments, misleading consumers into believing they can achieve unattainable results [9]. For instance, a product may claim to diminish fine lines and wrinkles within days, yet credible research may reveal that significant results typically take several weeks or months to manifest, if they occur at all [10].

Accurate determination of Vitamin C levels in cosmetic products is crucial to ensure product efficacy and consumer safety. The analytical technique used in this study was UV-Vis spectrophotometry due to its ease of use and efficiency. According to the Indonesian Food and Drug Monitoring Agency (BPOM) Regulation Number 29 of 2023 concerning the safety and quality requirements for antioxidant health supplement products, the maximum permissible limit for vitamin C is 1,000 mg/kg [11]. The UV-Vis spectrophotometry technique operates on the principle that different compounds absorb light at specific wavelengths. For Vitamin C, the absorbance maxima is typically reported around 265 nm.

Materials and Method

Materials

The instruments used for the analysis of vitamin C content included a UV-Vis PerkinElmer Lambda 25, an analytical balance, micropipette, a vortex mixer, glassware, and filter paper.

The chemicals used for the analysis included ascorbic acid, distilled water, and three vitamin C facial serum samples, namely vitamin C facial serum (1), vitamin C facial serum (2), and vitamin C facial serum (3), which were obtained from supermarkets in Manado City.

Procedure

1. Preparation of vitamin C facial serum sample

Each sample was pipetted 10 mL and filled with distilled water into a 100 mL measuring flask and then homogenized.

2. Preparation of Standard Ascorbic Acid Solution

A 100 ppm vitamin C stock solution was prepared by weighing 25 mg of ascorbic acid and dissolving it in a 250 mL volumetric flask with distilled water, then homogenizing it. Standard

solutions were prepared in four concentrations: 2 ppm, 4 ppm, 6 ppm, and 8 ppm.

3. Determination of Optimum Wavelength

The optimum wavelength of vitamin C was determined by measuring a 10 ppm vitamin C solution from a stock solution using a UV-Vis spectrophotometer at a wavelength of 200 to 300 nm. The optimum absorption wavelength was selected based on the maximum absorbance value.

4. Construction of the Calibration Curve

A calibration curve was created by measuring the absorbance of 2 ppm, 4 ppm, 6 ppm, and 8 ppm working solutions at the optimum wavelength. A calibration curve was then created by plotting the absorbance value as the y-axis and the concentration as the x-axis at a wavelength of 200-300 nm.

5. Determination of Vitamin C content in Facial Serum Samples

A 10 mL concentrated facial serum sample solution was pipetted, then added to a 100 mL volumetric flask with distilled water and homogenized. Once all the sample solutions were ready, the absorbance of the samples was measured.

Data Analysis

To analyze vitamin C in facial serum samples, a UV-Visible spectrophotometry method was used. Vitamin C content was then calculated using a linear regression equation.

Result and Discussion

Determination of Optimum Wavelength

The optimal wavelength of vitamin C for UV-Vis spectrophotometric analysis is usually 265 nm, but sometimes below 265 nm the sensitivity and specificity of vitamin C tend to increase. Optimal wavelengths for these analyses can occasionally lie below 265 nm, which may enhance sensitivity and specificity. Wardani conducted a study comparing linear regression at wavelengths of 265 nm and 243 nm and reported an increase in linear regression at 243 nm [12]. Therefore, it can be assumed that a wavelength around 240 nm is optimal for vitamin C analysis.

In the determination of the optimum wavelength, a characteristic absorption peak was observed at 241.50 nm. This peak corresponds to the electronic transition within the ascorbic acid molecule. The obtained wavelength is slightly lower than the commonly reported maximum wavelength for ascorbic acid. This variation is likely due to the high instability of ascorbic acid in neutral or alkaline aqueous solutions, where it undergoes rapid oxidation [13].

However, as with any analytical method, the accuracy and reliability of the measurement results can be affected by several factors, including the storage conditions of the solution and the sample preparation process. These factors can significantly affect the vitamin C content in the solution [14]. It has been reported that temperature and storage duration can cause a decrease in vitamin C levels. Therefore, careful preparation and proper storage of vitamin C solutions are essential to ensure reliable analytical results.

Construction of Calibration Curve

In this study, standard series of 2, 4, 6, and 8 ppm were prepared from a 100 ppm stock solution. By plotting the y-axis against the x-axis, the results shown in Figure 2 are obtained, where the x-axis represents the concentration of the standard series and the y-axis represents the absorbance of each standard solution concentration. The value of the linear regression equation is $y = 0,0242x + 0,3022$ with a coefficient of determination $R^2 = 0,9951$. From the coefficient of determination value, the correlation coefficient value can be calculated = 0.9975 which indicates a positive correlation between variables x and y.

Based on acceptance standards, an acceptable calibration coefficient is 0.99 or higher. If the correlation coefficient is lower than that, the preparation of the standard series solution must be repeated and remeasured [11]. From the results obtained, it can be concluded that this calibration curve is acceptable and meets the Lambert Beer rule.

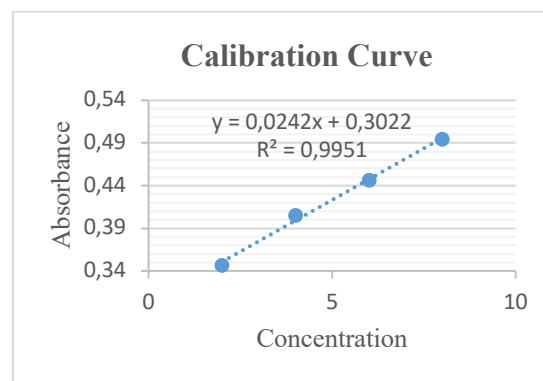


Figure 2. Calibration Curve of Vitamin C

Limit of Detection (LOD) and Limit of Quantitation (LOQ)

The Limit of Detection (LOD) is the lowest value that can be detected by an analytical method. The LOD value indicates how sensitive an analytical method is in detecting a particular compound in a sample. Meanwhile, the Limit of Quantification (LOQ) is the lowest limit value that can be quantified with adequate accuracy and precision. The LOQ value indicates how accurate and precise an analytical method is in measuring the amount of a particular compound in a sample [15].

By using the linear regression equation $y = 0,0242x + 0,3022$, the limit of detection and limit of quantification can be calculated. After calculating the LOD value, it was obtained at 0,54 ppm and the LOQ at 0,81 ppm. From the LOD value, it can be seen that the UV-Vis spectrophotometry method can detect the presence of Vitamin C content with a detection limit of 0,54 ppm, which means that Vitamin C with a concentration of 0,54 ppm can be detected but cannot be quantified while concentrations below 0,54 ppm will not be detectable.

From the LOQ value, it can be seen that the concentration limit that can be measured quantitatively with acceptable accuracy and precision is 1,81 ppm, which means that concentrations below 1,81 ppm cannot be quantified.

Determination of Vitamin C content in Facial Serum Samples

Quantification of vitamin C levels in facial serum was carried out using a linear regression equation that had been determined on a standard curve by entering the absorbance of each sample. From the measurement data that has been carried out, the absorption and obtained levels of each sample are shown in table 1. With the results obtained, it can be concluded that the three samples that have been tested do contain vitamin C with the amount of content as stated in table 1.

Tabel 1. Vitamin C content in Facial Serum

Sample	Absorbance	Content (mg/L)
Serum 1	0,384	338 mg/L
Serum 2	0,367	267,7 mg/L
Serum 3	0,374	284,2 mg/L

Referring to the Regulation of the Food and Drug Supervisory Agency Number 29 of 2023 concerning the Maximum Limit of Vitamin C Content in the Antioxidant Category in Finished Products, which is 1000 mg/kg. All test serum samples in this study can be said to be safe for use as skin care products because they have vitamin C content that does not exceed the safe limit and can provide maximum care with the amount of content in serum 1 = 338 mg/L, serum 2 = 267,7 mg/L and serum 3 = 284,2 mg/L. Serum 1 has a higher vitamin C content and serum 2 has a lower amount of content while serum 3 is in the middle of the two.

Author Contribution

Susanti Kamau - investigation, data curation, formal analysis, writing. Abdon Saiya - Validation, and writing. Vlagia Paat Conceptualization, methodology design, writing.review

Conclusion

This study was conducted with the main objective to determine the vitamin C content in facial serum samples using the UV-Vis

Spectrophotometry method. The analysis concluded that the three samples tested did contain vitamin C at levels that meet the requirements of the Food and Drug Supervisory Agency Regulation Number 29 of 2023 concerning the safety and quality requirements for antioxidant health supplements, which has a maximum limit of 1000 mg/kg. The limit of detection (LOD) = 0.54 ppm and a limit of quantification (LOQ) = 1.81 ppm. The vitamin C content in facial serum samples was successfully analyzed using the UV-Vis spectrophotometry method at a wavelength of 241.50 nm with total vitamin C levels in serum 1 = 338 mg/L, serum 2 = 267.7 mg/L, and serum 3 = 284.2 mg/L.

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