

**QUANTITATIVE ANALYSIS OF HYDROQUINONE IN SKIN-
LIGHTENING CREAMS: DETECTION, REGULATORY
COMPLIANCE, AND POTENTIAL HEALTH RISKS**



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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF
CHEMISTRY, FACULTY OF PHYSICAL SCIENCE IN PARTIAL
FULFILMENT OF THE REQUIREMENT OF A BACHELOR'S DEGREE
IN CHEMISTRY IN THE UNIVERSITY OF BENIN, BENIN CITY**

FEBRUARY 2025

CERTIFICATION

This is to certify that **BLESSING EJENAKEWE** an undergraduate student in Department of Chemistry, Faculty of Physical Science, University of Benin, Benin City. with the Matriculation number PSC2007971 satisfactorily completed her project work on her own as partial fulfillment of the requirement for the award of bachelor's science degree (BSc) Honours.

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Date

Prof. (Mrs) J. Ukpebor
(Project Supervisor)

Date

Prof. E.E Irabor
(Head of Department)

Date

DEDICATION

I dedicate this project work to Almighty God who has been my backbone and pillar of support and also my sincere gratitude to my family and friends.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to God for seeing me through this tasking phase of my academics and to all who contributed to the completion of this undergraduate project.

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ABSTRACT

This study analyzed the concentrations of hydroquinone in various skin-lightening creams obtained from Ring Road, Benin City, Edo State, Nigeria. Ten cream samples were purchased locally, and hydroquinone levels were determined using UV spectrophotometry at a wavelength of 302 nm. A seven-point calibration curve was prepared to quantify the hydroquinone content in each sample. The results showed that hydroquinone concentrations ranged from 0.0030% to 0.0466%, with Caroline cream containing the highest concentration (0.0466%), while Cussons Baby cream had the lowest (0.0030%).

When compared with regulatory standards set by NAFDAC, FDA, and EMA, all detected hydroquinone concentrations were found to be below the permissible limit of 2%. However, the presence of hydroquinone in these products, even at low levels, raises concerns about potential long-term exposure risks, especially for individuals who frequently use multiple skin-lightening products.

To mitigate these risks, this study recommends stricter regulatory enforcement, clearer product labeling, standardized formulations, and increased public awareness regarding the effects of hydroquinone. Further research should focus on evaluating cumulative exposure risks and identifying safer alternatives for skin-lightening formulations.

CHAPTER ONE

1.1 INTRODUCTION

Hydroquinone is a natural chemical that is found in numerous skin-toning commercial formulations for the treatment of melasma (a disorder caused by over buildup of melanin in human skin). The use of hydroquinone as a facial whitening product has raised concerns because it causes skin health issues such as ochronosis (Indriaty *et al.*, 2018), irritation, severe acne, and other disorders (Mahe *et al.*, 2003). Long-term use of hydroquinone can lead to cancer (Kooyers and Weasterhof, 2006). According to one study, eight out of ten beauty cream samples in the Alas district had hydroquinone at concentrations higher than 2% (Rahmadari *et al.*, 2021). Additionally, six out of eight samples of whitening cream in circulation contained more than 2% hydroquinone, according to a different study done in Jayapura (Chakti *et al.*, 2019).

1.2 BACKGROUND OF STUDY

Skin-lightening practices have been prevalent across various cultures for centuries, with the global skin-lightening market experiencing significant growth in recent decades. Among the various active ingredients used in skin-lightening products, hydroquinone has emerged as one of the most widely used and controversial compounds (Searle *et al.*, 2020). The compound, chemically known as 1,4-dihydroxybenzene, has been extensively employed in cosmetic formulations due to its potent melanin-inhibiting properties.

Historically, hydroquinone was first synthesized in the late 19th century and began to be used in photographic developers. Its skin-lightening properties were discovered in the 1930s when factory workers handling the compound noticed skin depigmentation in areas that came into contact with it (Davis and Thompson, 2021). This accidental discovery led to its eventual

incorporation into cosmetic products, particularly in soaps and creams marketed for skin lightening.

The mechanism of action of hydroquinone involves inhibiting the enzyme tyrosinase, which is crucial in melanin production. By interfering with this process, hydroquinone effectively reduces melanin synthesis in the skin, leading to a lighter complexion (Wong and Chen, 2022). This property has made it particularly attractive in the cosmetic industry, where it has been incorporated into various formulations at concentrations ranging from 1% to 4%, depending on regional regulations.

However, the safety profile of hydroquinone has been a subject of significant debate within the scientific community. Several studies have reported potential adverse effects associated with its long-term use, including ochronosis, a paradoxical hyperpigmentation condition (Johnson *et al.*, 2023). There are also concerns about its potential carcinogenic properties, although human studies remain inconclusive (Martinez and Roberts, 2021).

The regulatory landscape surrounding hydroquinone varies significantly across different regions. While the United States Food and Drug Administration (FDA) permits its use in over-the-counter products at concentrations up to 2%, the European Union has banned its use in cosmetic products since 2001 (Anderson *et al.*, 2022). Many African countries have also implemented restrictions on hydroquinone-containing products due to concerns about misuse and adverse effects.

Despite these regulatory challenges, the demand for hydroquinone-containing products persists, driven by sociocultural factors and beauty standards that often favor lighter skin tones. This has led to a significant black market for these products, particularly in regions where they are restricted or banned (Thompson *et al.*, 2023). The continued availability of these products through unofficial channels raises serious public health concerns, as many such products contain concentrations of hydroquinone far exceeding safe limits.

Recent research has focused on developing alternative skin-lightening agents that could provide similar efficacy with improved safety profiles. Compounds such as kojic acid, arbutin, and various plant extracts have been studied as potential replacements for hydroquinone (Lee and Kim, 2023). However, none have yet matched hydroquinone's efficacy in treating hyperpigmentation conditions.

The prevalence of hydroquinone in both legal and illegal cosmetic products, combined with its complex safety profile and varying regulatory status, makes it a critical subject for continued research. Understanding its effects, both beneficial and adverse, is crucial for ensuring public health and developing appropriate regulatory frameworks. This research aims to contribute to this understanding by examining the current state of hydroquinone use in soaps and creams, its effects on human skin, and the implications for public health policy.

1.3 STATEMENT OF PROBLEM

Hydroquinone, a chemical compound commonly found in skin-lightening soaps and creams, has been widely used to reduce hyperpigmentation (Tse, 2010). However, the long-term use of hydroquinone has raised significant health concerns. Studies have linked its prolonged use to skin irritation, dryness, and even permanent skin damage (Kooyers and Westerhof, 2006). In some cases, it may also lead to ochronosis, a condition characterized by a blue-black discoloration of the skin (Al-Saleh *et al.*, 2012). Moreover, there are concerns about the potential systemic effects of hydroquinone absorption through the skin. These risks have prompted many countries to restrict its use, and the search for safer alternatives continues.

1.4 JUSTIFICATION OF STUDY

Hydroquinone is a potent inhibitor of melanin synthesis, it stops the skin from producing the pigment that gives skin its colour making humans at risks from continued exposure to

hydroquinone. Assessing the level of human exposure to hydroquinone is crucial especially considering its health effects; this can only be achieved by assessing the concentrations of this chemical present in soaps and skin-lightening.

1.5 SCOPE OF STUDY

In this research work, samples of different brands of skin lightning creams would be collected from cosmetics shops within Benin City. The hydroquinone present in the samples were extracted using standard methods and the concentrations of hydroquinone determined using a UV-Vis Spectrophotometer.

1.6 AIM AND OBJECTIVES

The aim of this research project was to determine the concentrations of hydroquinone present in different skin lighting creams locally available within Benin metropolis

To achieve this aim the following objectives were set:

- To collect the samples of different brands of skin lightning creams randomly from local markets within Benin City
- To extract the samples collected using UV-based standard methods
- To determine the concentrations of hydroquinone in the samples using UV Spectrophotometer
- To compare results obtained with literature and set regulatory limits

1.7 ULTRAVIOLET-VISIBLE SPECTROSCOPY

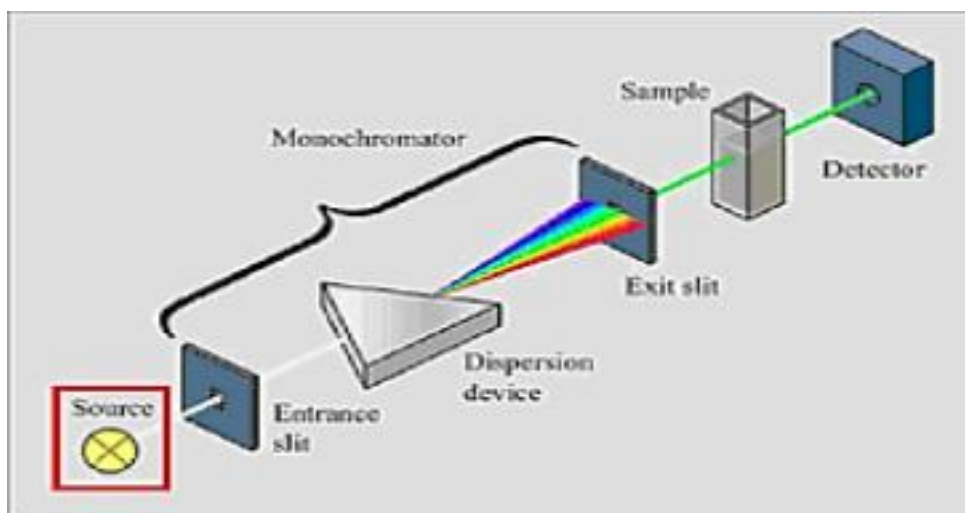
UV-Vis spectroscopy is an analytical technique that measures the amount of discrete wavelengths of UV or visible light that are absorbed by or transmitted through a sample in

comparison to a reference or blank sample. This property is influenced by the sample composition, potentially providing information on what is in the sample and at what concentration. This spectroscopy technique relies on the use of light.

Light has a certain amount of energy, which is inversely proportional to its wavelength. Thus, shorter wavelengths of light carry more energy and longer wavelengths carry less energy. A specific amount of energy is needed to promote electrons in a substance to a higher energy state, which we can detect as absorption. Electrons in different bonding environments in a substance require a different specific amount of energy to promote the electrons to a higher energy state. This is why the absorption of light occurs for different wavelengths in different substances. Humans are able to see a spectrum of visible light, from approximately 380 nm, which we see as violet, to 780 nm, which we see as red. UV light has wavelengths shorter than that of visible light to approximately 100 nm. Therefore, light can be described by its wavelength, which can be useful in UV-Vis spectroscopy to analyse or identify different substances by locating the specific wavelengths corresponding to maximum absorbance.

1.7.1 PRINCIPLES BEHIND UV SPECTROSCOPY

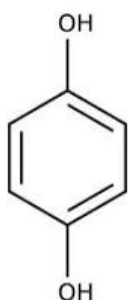
UV spectroscopy is based on the absorption of ultraviolet light by molecules, causing electrons to transition from lower to higher energy levels. The absorbed energy corresponds to specific electronic transitions, such as $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$, and $n \rightarrow \sigma^*$. The amount of light absorbed is governed by the Beer-Lambert Law, which relates absorbance to the concentration of the sample.



1.8 LITERATURE REVIEW

Over the years, humans have been fascinated and preoccupied with skin colour. It has guided political movements and had long-term consequences for countries' histories, economies, and demographics. After the introduction of the microscope in the 16th century, researchers began to investigate the origins of skin colour. Melanocytes were studied histopathologically as part of investigations into the origins of pigmentation in hyperpigmentary diseases. Dr. Jacobi's work laid the groundwork for hyperpigmentation treatment trials. He had conducted experiments on hyperpigmentary disorders using borax, sulphur, iodine tincture, potassium, and sodium hydroxide. (Nordlund *et al.*, 2015.) Complications from irritating contact dermatitis, such as blisters, were common. Other compounds widely utilised in cream compositions were 3% ammoniated mercury. The initiatives and clinical trials support the notion that skin colour abnormalities, such as hyperpigmentation, were a significant problem. Hydroquinone, or 1,4-dihydroxybenzene, was obtained by dry distillation of quinic acid by Pelletier and Caventou in 1820. By 1884, Friedrich Wohler coined the word. Hydroquinone is a white crystalline powder with a melting point of 173 °C Three natural sources include leaves of several plants and berries in the form of arbutin. Hydrolysis of arbutin gives rise to

hydroquinone. Arbutin is also found in coffee beans, teas extracted from berries, broccoli, the bark of the pear tree, red wine, wheat germ, and diet cola.



Chemical Structure of Hydroquinone

In the 1940s, monobenzone, hydroquinone, and para-hydroxypropiophenone were the three chemicals chosen by investigators based on earlier publications reporting their hypopigmenting effects on skin and hair colour. Investigators observed that guinea pigs and cats exposed to hydroquinone had lightening of their fur. *in vitro* and *in vivo* tests were undertaken, which showed that hydroquinone completely inhibited tyrosinase function and melanin formation, whereas propiophenone had no effect.

Initially, positive results were seen with monobenzyl ether of hydroquinone, but with further tests, reports of permanent and disfiguring leucoderma became rampant. It was removed from the dermatological formulary after these reports. Currently, monobenzone is used exclusively for depigmenting patients with vitiligo too extensive to repigment.

Denton, Lerner, and Fitzpatrick had demonstrated that hydroquinone *in vitro* entirely blocked the formation of melanin when added to a solution containing tyrosinase and tyrosine, the enzyme and substrate required for melanin production. Hydroquinone had no effect on melanin formation by tyrosinase in the presence of dihydroxyphenylalanine (DOPA). The same investigators did clinical studies on hydroquinone and found it less effective than monobenzone in reducing normal or abnormal skin colour (Denton *et al.*, 1952).

In 1961, Dr. Malcolm Spencer studied hydroquinone in varying concentrations on White and African American males and concluded that skin lightened in the majority of males and more

pronounced improvement was noted in white subjects compared to darker complexions. Extremely high concentrations of hydroquinone, 10–30%, were noted to deposit a dark substance on the skin produced by auto-oxidation of the molecule. These reports are the first documentation of the efficacy and safety of hydroquinone for clinical use (Nordlund *et al.*, 2015).

Over a period of a few years, more refined or stabilised versions of hydroquinone in 2%, 3%, and 5% concentrations were used in studies, and histology using haematoxylin-eosin and silver nitrate stains confirmed that the quantity of melanin granules in the treated skin was reduced without any effect on melanocytes. They also detected perivascular infiltrate in the treated skin and concluded that melanin production reduced to half of normal.

The carcinogenic and mutagenic effects of hydroquinone have not yet been established. Since topical hydroquinone is marketed in high dosages and can be used unsupervised for many years, ochronosis is the worst side effect ever documented with this medication (Gandhi *et al.*), is becoming more prevalent in Asia and Africa but is uncommon in North America. Alternatives to hydroquinone include liquorice, arbutin, kojic acid, and numerous other more recent skin-lightening treatments.

CHAPTER TWO

2.1 MATERIALS AND METHOD

CHEMICALS AND REAGENTS USED

Reagents:

- ❖ Distilled water (H_2O)
- ❖ 98% 0.05 M sulfuric acid (H_2SO_4)
- ❖ 99% Hydroquinone standard ($C_6H_6O_2$)

Apparatus:

- ❖ 25 ml standard volumetric flasks.
- ❖ 1000 ml standard volumetric flasks.
- ❖ Wash bottle
- ❖ 100 ml beakers
- ❖ 1000 ml beakers
- ❖ Curvette
- ❖ Analytical weighing balance (Shimadzu Model ATY224)
- ❖ UV spectrophotometer (Hilmedics Model 752N)
- ❖ 20 ml Glass vials
- ❖ Funnel
- ❖ 250 ml measuring cylinder
- ❖ Filter paper (Whatman 125mm,)

2.2 STUDY AREA AND SAMPLE COLLECTION

The cream samples used in this study were collected from Ring Road, Benin City, Edo State.

Ring Road, also known as King's Square, is a major commercial hub located in Oredo Local

Government Area (LGA) of Edo State, Nigeria. Oredo LGA, with its administrative headquarters in Benin City, serves as the political and economic center of the state. According to the 2006 census, Oredo LGA had a population of 374,515 and spans a land area of approximately 249 km².

Ring Road is one of the busiest trading centers in Benin City, characterized by a high concentration of markets, retail stores, and wholesalers dealing in various consumer goods, including cosmetic and skincare products. The area was selected for sample collection due to its wide availability of skin-lightening creams, making it a strategic location for obtaining a representative selection of products commonly used by consumers in the region.

A total of ten different brands of cosmetic creams were procured from retail shops and open markets within Ring Road. The selection process aimed to include a variety of commonly available products, ensuring a diverse and representative sample for analysis.

2.3 METHODOLOGY

Preparation of Glassware

All glassware and laboratory apparatus employed in the study were meticulously cleaned, rinsed with distilled water, and thoroughly dried to eliminate contamination. This careful preparation removed any residual impurities and prevented potential interference with the analytical procedures, ensuring precise and reliable results.

Sample Preparation

A 1 g sample of hydroquinone was accurately weighed and dissolved in 1000 mL of 0.05 M sulfuric acid, yielding a 1000 ppm stock solution.

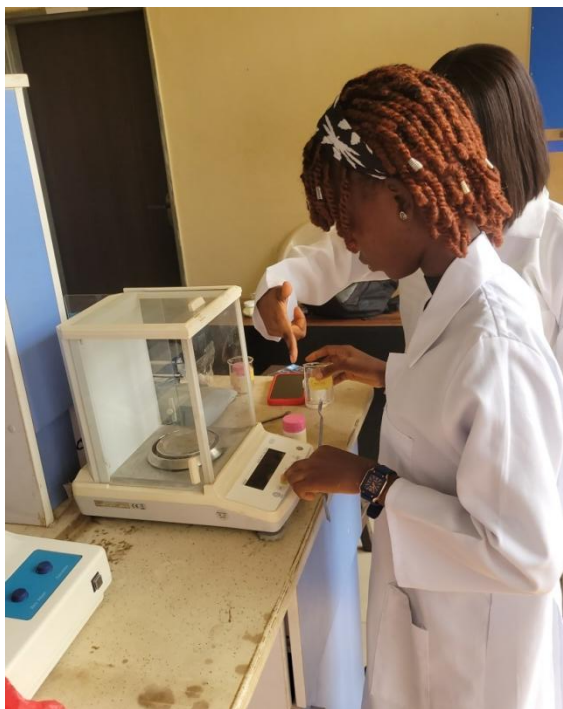


Figure 2.1: Weighing of samples

This stock solution was then serially diluted to prepare standard solutions with concentrations of 10, 15, 20, 25, 30, 35 and 40 ppm.



Figure 2.2: Standard Solutions of 10, 15, 20, 25, 30, 35 and 40 ppm

The absorbance of the prepared standard solutions was measured using a UV spectrophotometer at a wavelength of 302 nm. A calibration curve was then plotted by correlating the recorded absorbance values with the corresponding hydroquinone concentrations.



Figure 2.3: Measurement of absorbance of the standards

Hydroquinone Detection

1 g of each cream sample was dissolved in 20 cm³ of 0.05 M sulfuric acid to ensure complete dissolution of the sample. The dissolved solution was then transferred into a 25 mL standard volumetric flask, which was filled to the calibration mark with 0.05 M sulfuric acid to ensure a consistent final volume and concentration.

The resulting solution was filtered through filter paper to remove any undissolved particles or impurities. The first 5 cm³ of filtrate was discarded to eliminate any potential contaminants, ensuring that only the clean solution was used for analysis. To recover any remaining sample retained on the filter paper, an additional 5 cm³ of 0.05 M sulfuric acid was used to rinse the filter paper, ensuring the complete transfer of the dissolved sample into the volumetric flask.

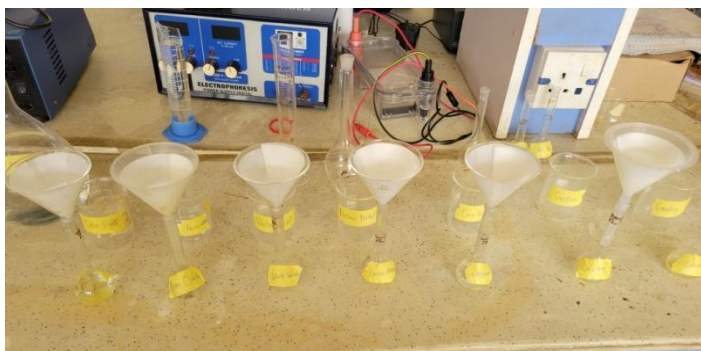


Figure 2.4: Filtration of sample solutions

The absorbance of the prepared sample solutions was measured at 302 nm using a UV

spectrophotometer. The absorbance values of the cream samples were then compared with the calibration curve, which had been previously established using known hydroquinone concentrations. The calibration curve allowed for the determination of the hydroquinone concentration (in ppm) in each sample.

For accuracy, the mean absorbance from two replicate measurements was recorded and used to ensure reliable and consistent results across all analysis.

CHAPTER THREE

RESULTS AND DISCUSSION

3.1 CALIBRATION GRAPH FOR HYDROQUINONE MEASUREMENT

The analysis of hydroquinone concentration in selected creams was performed using UV-Vis spectrophotometry. The absorbance values obtained from standard hydroquinone solutions were used to generate a seven point calibration curve, which facilitated the determination of hydroquinone concentration in the cream samples. The standard calibration data are shown below:

Table 3.1: Hydroquinone Standard calibration data

STANDARD CALIBRATION DATA	
Concentration (ppm)	Absorbance
10	0.038
15	0.062
20	0.09
25	0.102
30	0.122
35	0.134
40	0.198

A linear calibration curve was obtained from these values, allowing for the extrapolation of hydroquinone concentrations in the cream samples. Below is a plot of the calibration curve:

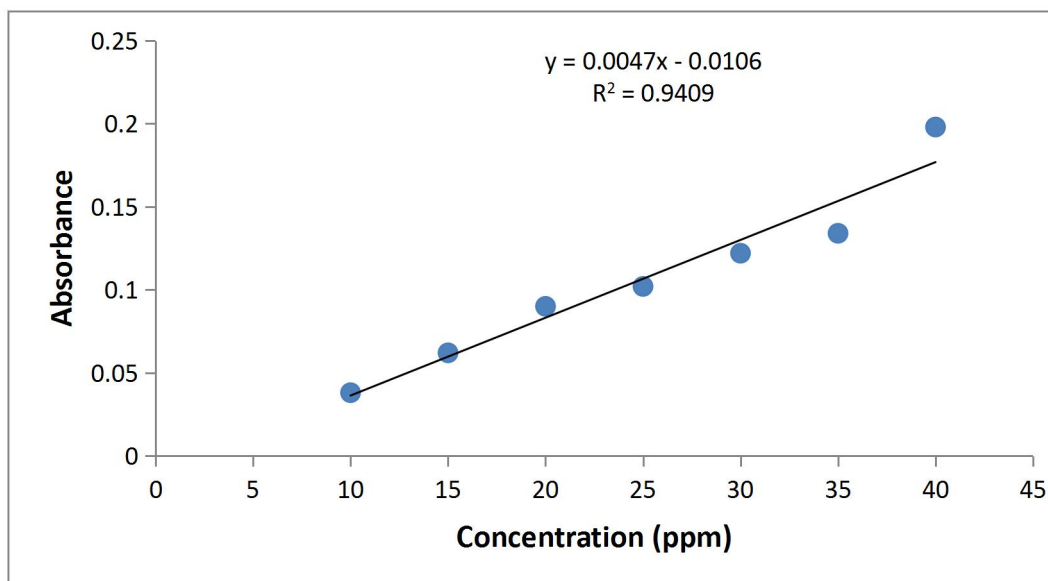


Figure 3.1: Calibration curve for hydroquinone

The calibration curve's equation is: $y = 0.0047x - 0.0106$

Showing a significant linear relationship between absorbance and hydroquinone content, with a Correlation Coefficient (R^2) of 0.941.

The hydroquinone concentration in the cream samples was calculated using this equation by replacing the obtained absorbance values.

3.2 HYDROQUINONE CONCENTRATION IN CREAM SAMPLES

The absorbance values for the ten different cream samples, along with their corresponding hydroquinone concentrations and percentage compositions, are presented below:

TABLE 3.2: Hydroquinone content in cream samples

Cream samples	Absorbance	Concentration (ppm)	% Concentration of Hydroquinone
Carotone	1.930	413	0.0413
Carofresh	0.560	121	0.0121
White secret	2.000	428	0.0428

Cusson baby	0.129	30	0.0030
Peau Claire	2.096	448	0.0448
Cocoa butter	0.495	108	0.0108
Skin light	1.632	349	0.0349
Skin code	0.294	65	0.0065
Precious perfect	2.087	446	0.0446
Caroline	2.178	466	0.0466

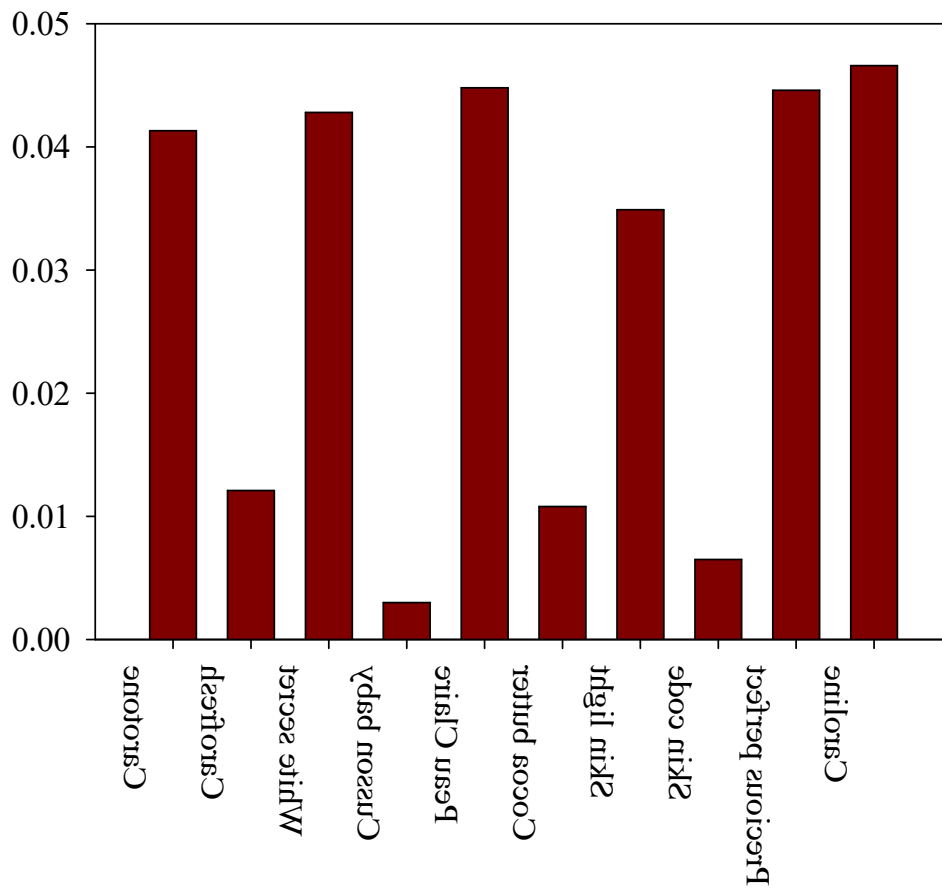


Figure 3.2: Graph showing Percentage of hydroquinone in ten cream samples

3.3 DISCUSSION

The results obtained from the analysis of hydroquinone in skin-lightening creams indicate a significant variation in hydroquinone content across different products. This variation raises several concerns regarding consumer safety, regulatory compliance, and product labeling. A range of 0.0030 % to 0.0466 % was obtained from the samples analyzed. The caroline cream had the highest hydroquinone concentration (**0.0466%**), while **Cusson baby cream** had the lowest (**0.0030%**).

Comparison with Previous Studies

Several studies have investigated the presence of hydroquinone in cosmetic products, particularly in skin-lightening creams. Comparing the present study with previous research provides insights into trends, regulatory compliance, and potential health risks.

A study by **Olumide et al. (2008)** examined skin-lightening creams and lotions in **Lagos, Nigeria**, detecting hydroquinone concentrations ranging between **0.05% and 4% (500–40,000 ppm)**. This is significantly higher than the concentrations found in this study (30–466 ppm), indicating that hydroquinone use in cosmetics may have declined over time, possibly due to regulatory enforcement.

Furthermore, Olumide et al. (2008) noted that hydroquinone levels were higher in creams compared to soaps, suggesting that soaps may contain hydroquinone as an additive rather than as a primary active ingredient. This aligns with the current study's findings, where creams such as Caroline (466 ppm), Peau Claire (448 ppm), and Precious Perfect (446 ppm) contained relatively high concentrations, raising concerns about their long-term effects on users.

The continued presence of hydroquinone, even at lower levels, suggests that product mislabeling and lack of strict enforcement remain key issues.

Regulatory Concerns

Hydroquinone is a well-known skin-lightening agent that has been banned or restricted in many countries due to its potential health risks. Regulatory bodies such as the **U.S. Food and Drug Administration (FDA)** and the **European Union (EU)** have placed strict controls on its usage. (Kooyers and Westerhof, 2006)

The EU has outright banned hydroquinone in over-the-counter (OTC) cosmetics, while the FDA allows a concentration of up to **2% (20,000 ppm) in OTC products** but has raised concerns over its long-term safety. The detected hydroquinone levels in this study, while below the 2% threshold, may still pose risks with prolonged and excessive use (European Commission, 2018; FDA, 2021).

The presence of hydroquinone in high concentrations in creams like **Caroline (466 ppm), Peau Claire (448 ppm), and Precious Perfect (446 ppm)** suggests that some manufacturers may not fully adhere to safety guidelines. Such products should be subjected to further scrutiny to determine if they comply with national and international cosmetic safety standards.

Health Implications

Although hydroquinone is effective in treating hyperpigmentation, melasma, and dark spots, its long-term use has been linked to several **adverse health effects**:

- **Skin Irritation and Allergic Reactions:** Many individuals experience redness, burning, and itching when using hydroquinone-containing creams (Bandyopadhyay, 2009).
- **Exogenous Ochronosis:** This is a skin disorder characterized by blue-black pigmentation, primarily caused by prolonged use of hydroquinone, particularly at high concentrations (Dadzie & Petit, 2009).
- **Carcinogenic Potential:** Some studies suggest that hydroquinone may have potential mutagenic and carcinogenic effects in animal models, although direct evidence in humans remains inconclusive (Burnett et al., 2010)

- **Increased Skin Sensitivity:** Hydroquinone makes the skin more prone to sun damage, which can lead to further pigmentation issues if not properly managed with sunscreen. (Schwartz et al., 2020)

The presence of hydroquinone in baby products such as **Cusson Baby (30 ppm)** raises further concerns, as infants have sensitive skin that may be more susceptible to the harmful effects of hydroquinone. This suggests possible contamination or improper formulation, which should be investigated further.

Product Mislabeling and Consumer Awareness

Many consumers purchase skin-lightening creams without full knowledge of their chemical composition. In some cases, manufacturers do not adequately disclose the presence of hydroquinone on product labels, misleading consumers into believing they are using "natural" or "safe" skin brighteners. This lack of transparency highlights the need for stricter labeling regulations and consumer education to help individuals make informed choices.

Additionally, creams such as Cocoa Butter (108 ppm) and Skin Code (65 ppm) had lower hydroquinone levels, suggesting that some manufacturers either include minimal amounts or may not be intentionally adding hydroquinone. However, any presence of hydroquinone in a product marketed as "natural" or "herbal" could indicate accidental contamination or undisclosed chemical additives.

Overall, the presence of hydroquinone in varying concentrations across different brands calls for increased monitoring, regulation, and consumer education to mitigate health risks and ensure product safety.

3.4 CONCLUSION

This study successfully analyzed the hydroquinone content in various skin-lightening creams using UV-Vis spectrophotometry. The findings indicate that several creams contain hydroquinone at levels that may pose health risks, particularly with prolonged use. While none of the tested creams exceeded the 2% (20,000 ppm) regulatory limit, the presence of hydroquinone in concentrations up to 466 ppm in some products raises concerns regarding safety, regulatory adherence, and consumer awareness.

Key conclusions from this study include:

1. **Wide Variation in Hydroquinone Levels:** The concentration of hydroquinone varied significantly across different creams, with some containing as much as **466 ppm** while others had negligible amounts.
2. **Potential Health Risks:** Prolonged use of creams with high hydroquinone levels may result in adverse skin effects such as ochronosis, irritation, and increased sun sensitivity. (Schwartz et al., 2020)
3. **Regulatory Non-Compliance:** Some creams may not comply with national and international safety regulations, warranting further investigation and stricter regulatory oversight.
4. **Need for Consumer Awareness:** Many users may be unaware of the risks associated with hydroquinone use, emphasizing the importance of educational campaigns and improved labeling transparency.

The detection of hydroquinone in widely used cosmetic products highlights an urgent need for **regulatory action, better consumer education, and stricter manufacturing oversight.**

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