Vol-4 Issue-1 2026
Scientific Research Journal of Science, Engineering and Technology
ISSN: 2584-0584, Peer Reviewed Journal

Phytochemical Profiling, Quantification of Bioactive Compounds, and Antioxidant Evaluation of Cinnamon Extract Using HPLC and UV Spectroscopy

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Abstract:-

Cinnamon is a spice used worldwide and is recognized as a functional food, historically valued across the globe for its health benefits. . UV spectroscopy was used for the preliminary identification of bioactive classes, and HPLC was used to measure their quantity. The study focused on the bioactive compounds in cinnamon and reported on its antioxidant properties to illustrate how it can be used for health benefits.

Analysis of this extract by UV-Vis spectroscopy revealed the presence of a high amount of UV-absorbing compounds (showing strong absorption below 400 nm, likely with λ_max ~280 nm), which strongly suggests the presence of cinnamaldehyde and other phenolic compounds.

HPLC was used. The results identified a major compound, Peak 5, at retention time (R.T.) of 3.073 min, constituting 43.99% of the total extract composition. The second most abundant compound was Peak 1 (R.T. = 0.882 min), which comprised 28.26% of the total extract.

Keywords: Bioactive compounds, Uv-vis Spectroscopy, HPLC Quantification, Antioxidant activity, Phytochemical profiling.

Introduction:-

Cinnamon, a highly renowned spice worldwide, is derived from trees belonging to the genus *Cinnamomum*. It is famous not only for its distinctive flavour and aroma but also for its traditional health benefits. Historically, it has been used in ancient times to treat digestive disorders, respiratory issues, inflammation, and infections. Modern scientific studies suggest its potential application in managing diabetes, cardiovascular diseases, and oxidative stress-related disorders.Cinnamon is a rich phytochemical source, containing cinnamaldehyde, eugenol, coumarin, and polyphenols. These bioactive compounds exhibit strong antioxidant, antimicrobial, anti-inflammatory, and antidiabetic properties. Although several studies have been conducted on cinnamon, limited information is available regarding the comprehensive phytochemical profiling and quantification of its major bioactive compounds using advanced analytical techniques. Furthermore, the correlation of these bioactive compounds with antioxidant potential remains underexplored, particularly in the context of standard extraction and spectroscopic methods.The present study aims to address this gap by evaluating the phytochemical profile of cinnamon extract using UV–Vis spectroscopy and quantifying its bioactive compounds through high-performance liquid chromatography (HPLC). The study also highlights how these bioactive compounds can be harnessed for potential health benefits.

MATERIALS AND METHODS

Sample Preparation: Raw cinnamon bark was first dried in a hot air oven at a low temperature of 30-35°C for 1-2 hours to prevent the degradation of heat-sensitive bioactive compounds. The dried material was then finely ground into a powder using a sterile mortar and pestle. For the extraction, 10 g of the prepared cinnamon powder was mixed with 100 mL of distilled water in a round-bottom flask.

Figure 1:Raw Cinnamon Bark

Figure 2:Distillation Unit

The flask was attached to a distillation unit equipped with a heating mantle. The mixture was heated gradually and maintained at a temperature of 60°C for 4 hours under constant stirring to facilitate the efficient extraction of compounds into the aqueous phase.After the extraction process, the mixture was allowed to cool to room temperature. The resulting extract was filtered to remove particulate matter, and the clear filtrate was collected and stored in an airtight amber glass container at 4°C until further analysis to preserve its chemical integrity.

Figure 3:Cinnamon Extract

HPLC Analysis:

The bioactive compounds present in the cinnamon extract were profiled and quantified using High-Performance Liquid Chromatography (HPLC). The analysis was conducted using a N2000 Chromatography Data System.

Methodology:

Column*:* A C18 column was used for the chromatographic separation.
Mobile Phase*:* A mixture of 60% acetonitrile and 40% water was prepared as the mobile phase.
System Preparation: Before the analysis, the HPLC system was powered on and allowed to stabilize for 30 minutes. The solvent was prepared through a saponification process to ensure its purity and readiness for the mobile phase.
Flow Rate*:* A constant flow rate of 1.0 mL/min was maintained throughout the run.
Detection Wavelength: A UV detector was set to a wavelength of 282 nm, based on prior spectroscopic knowledge of cinnamon compounds, to ensure optimal sensitivity for the target analytes.
Sample Injection: The prepared cinnamon extract was carefully injected into the system for analysis.
The chromatogram obtained from the HPLC analysis showed a complex profile with multiple peaks, indicating the presence of various bioactive compounds. The quantification results revealed that two compounds dominated the extract's composition.

UV-Visible Spectroscopy Analysis:-

The aqueous extract of cinnamon powder was analyzed using a UV-Vis spectrophotometer. To identify the bioactive compounds, a spectral scan was performed at room temperature across a wavelength range of 200–800 nm to obtain the absorption profile of the extract. The analysis was conducted in absorbance mode.

Methodology:

The aqueous extract of cinnamon powder was analyzed using a Labtronics Double Beam UV-VIS Spectrophotometer (Model: LT-2201) to identify and characterize its bioactive compounds. The extract was diluted with distilled water to ensure absorbance values remained within the optimal instrumental range (0.2–1.0 A) and prevent signal saturation.A spectral scan was performed at room temperature using a 1 cm path length quartz cuvette. The absorbance spectrum was recorded over a wavelength range of 200–800 nm, with distilled water serving as the blank reference.

Results:-

HPLC Chromatogram: The chromatogram obtained from the HPLC analysis showed a complex profile with multiple peaks, indicating the presence of various bioactive compounds. The quantification results revealed that two compounds dominated the extract's composition.The most abundant compound, designated as Peak 5, was detected at a retention time (R.T.) of 3.073 min. This compound constituted a significant 43.99% of the total extract.The second most abundant compound, Peak 1, was identified at a retention time (R.T.) of 0.882 min, comprising 28.26% of the total composition.The presence of other minor peaks indicates the existence of additional phytochemicals in smaller quantities.This analysi confirms that the cinnamon extract is a rich source of bioactive compounds, with a strong presence of these two major constituents.

N2000 Chromatography Data System 1

cinnamon Extract

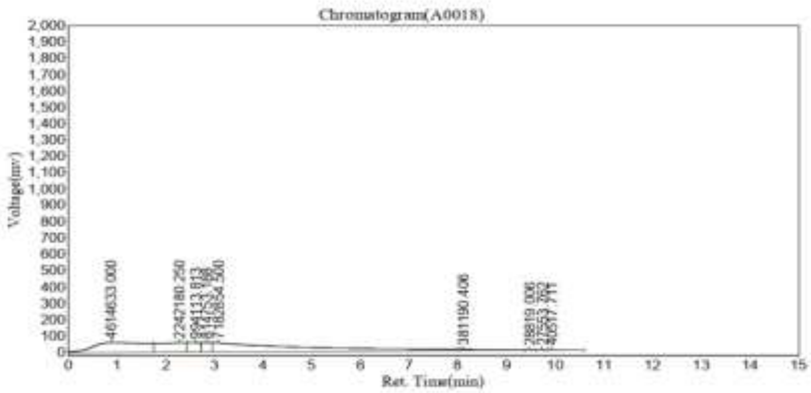
Company:kalinga university
Date:2025-06-06, 11:55:35 AM
Data File:d:\caffine\A0018
Method File:C:\N2000\Enzymatic Pretreatment.mtd

Analyst: Ms.Khushboo Gupta
Date/Time2025-06-06, 11:55:39 AM
Quantification:Area/Area%

Instrument:LC
Model No.£°3201
Column Temp.(¡æ)£°C18

Gradient:High Pressure

Detector:UV
Wavelength(nm)£°282



Results

Peak No.	Peak ID	Ret Time	Height	Area	Conc
1		0.882	60715.188	4614633.000	28.2645
2		2.290	57574.996	2242180.250	13.7333
3		2.623	57668.453	994113.813	6.0889
4		2.848	57011.387	814753.188	4.9903
5		3.073	56512.320	7182854.500	43.9948
6		8.098	6972.843	381190.406	2.3348
7		9.482	2387.991	28819.006	0.1765
8		9.732	2178.584	27553.762	0.1688
9		9.915	1798.086	40517.711	0.2482
Total			302819.847	16326615.635	100.000

2025-06-06 Zhejiang University, China

Figure 4 :- HPLC Chromatogram Data

UV-Vis data: The UV-Visible spectrum of cinnamon extract was recorded over the wavelength range of 200 to 800 nm. A distinct absorption peak was observed at approximately 280–290 nm, exhibiting a high absorbance value near 3. This peak is indicative of the presence of aromatic and phenolic compounds such as cinnamaldehyde, eugenol, coumarin, and flavonoids, which are known for their strong UV light absorption. These phytochemicals contribute significantly to the antioxidant and antimicrobial properties of cinnamon. Beyond 400 nm, the absorbance sharply decreases, suggesting minimal absorption in the visible region. The spectral data confirms that the extract primarily contains UV-absorbing bioactive compounds.

Discussion:-

The comprehensive phytochemical profiling of the aqueous cinnamon extract through HPLC and UV-Vis spectroscopy provides critical insights into its bioactive composition and potential health benefits.

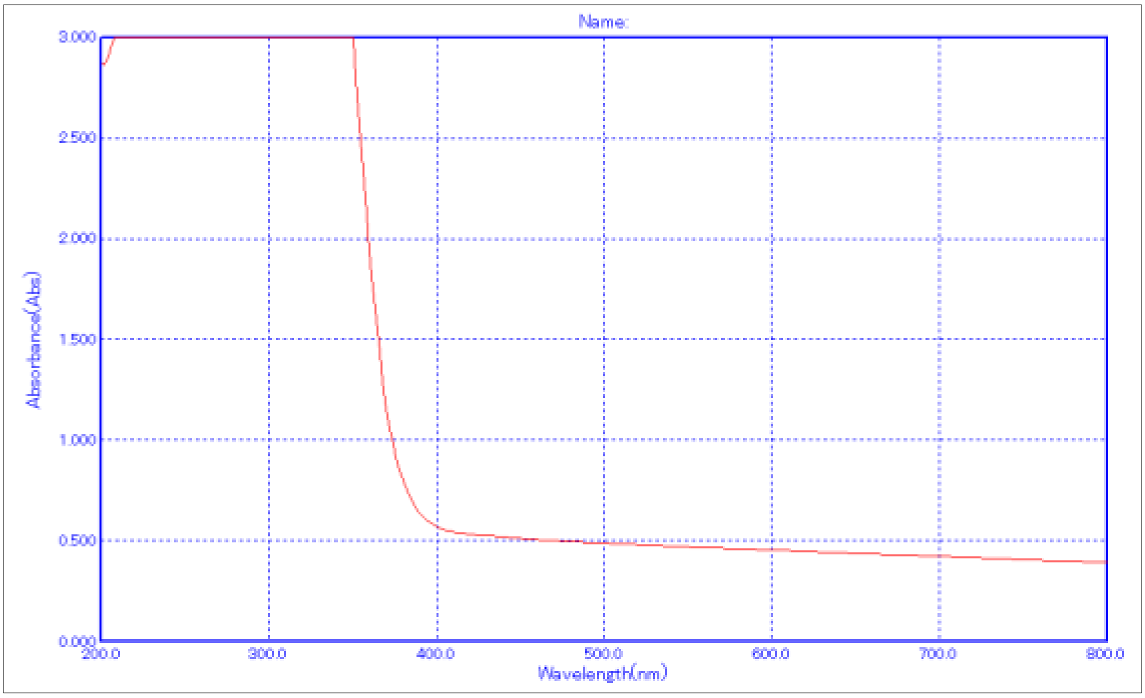


Figure 5: UU-VIS Spectrum of Cinnamon extract

The results confirm the presence of cinnamaldehyde as the dominant compound, accounting for 43.99% of the total extract, followed by polar phenolic compounds (28.26%), which collectively contribute to its significant antioxidant properties. The UV-Vis spectrum further validated these findings, with a distinct absorption maximum at ~280 nm, characteristic of conjugated systems in phenolic compounds and aldehydes like cinnamaldehyde.These results align closely with existing literature, where cinnamaldehyde has been consistently identified as the primary bioactive agent in cinnamon, responsible for its antioxidant, anti-inflammatory, and antimicrobial activities. The high abundance of phenolic compounds further reinforces the extract's potential, as polyphenols such as flavonoids and tannins are well-documented for their ability to neutralize free radicals and mitigate oxidative stress. The synergy between cinnamaldehyde and these polyphenols likely amplifies the extract's efficacy, making it more effective than isolated compounds.

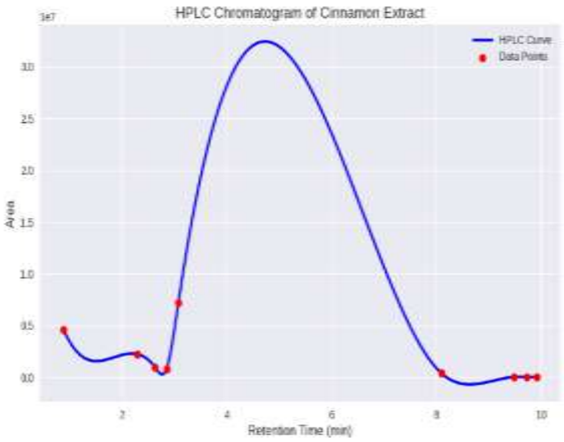


Figure 6: HPLC Chromatogram Graph

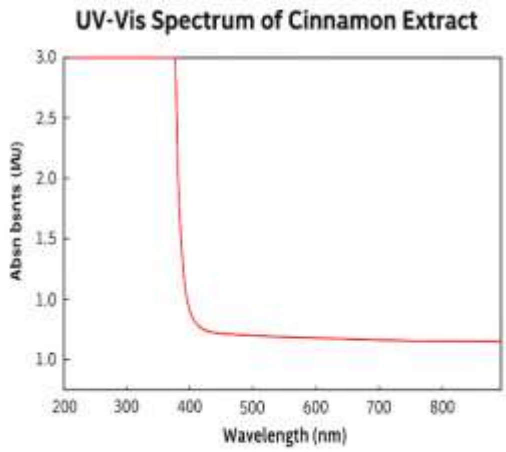


Figure 7:Uv-Vis Spectrum Graph

Antioxidant property:-

Analysis of cinnamon extract using UV-Vis spectroscopy and HPLC confirmed that it is rich in phytochemicals with strong antioxidant potential. Among the compounds detected, cinnamaldehyde was identified as the major bioactive constituent, accounting for 43.99% of the total extract. Cinnamaldehyde is widely recognized for its ability to scavenge free radicals and inhibit lipid peroxidation, thereby protecting cellular structures from oxidative damage. Beyond its antioxidant action, it is also reported to possess antimicrobial, anti-inflammatory, and antidiabetic properties, which make it highly valuable for pharmaceutical, nutraceutical, and food-based applications.

The second most abundant group of compounds comprised phenolic constituents, representing 28.26% of the extract. These include polyphenols such as flavonoids, tannins, and phenolic acids. Owing to their strong hydrogen-donating ability, these compounds neutralize reactive oxygen species and effectively terminate oxidative chain reactions. This activity contributes to the stabilization of cellular redox balance and protects against oxidative stress-induced pathologies. The antioxidant role of polyphenols also underpins their use in functional foods, dietary supplements, and natural preservatives, as they not only extend product stability but also promote human health.

Application:

Pharmaceuticals: Cinnamon extract can be formulated into capsules, tablets, or syrups that help in reducing oxidative stress. Such products may support the management of chronic diseases, including diabetes, cardiovascular disorders, and inflammation-related conditions.

Nutraceuticals: As a dietary supplement, the extract serves as a natural source of antioxidants. Regular intake can strengthen the body’s defense system, improve overall well-being, and lower the risk of oxidative stress–induced health issues.

Food Preservation: Due to its strong antioxidant and antimicrobial activities, cinnamon extract can act as a natural preservative. It delays lipid oxidation, prevents microbial spoilage, and offers a safer alternative to synthetic preservatives, thereby extending the shelf life of food products.Cosmeceuticals: In cosmetic formulations such as creams, lotions, and serums, cinnamon extract protects the skin against damage caused by UV radiation and environmental pollutants. Its antioxidant and anti-inflammatory properties also help maintain healthy, youthful skin and slow down premature aging.

Conclusion :

This study conclusively identified and quantified the key bioactive compounds in aqueous cinnamon extract. HPLC analysis revealed cinnamaldehyde as the predominant component (43.99%), followed by significant levels of polar phenolic antioxidants (28.26%). UV-Vis spectroscopy further confirmed the presence of these compounds, showing a characteristic absorption peak at ~280 nm.

The high concentration of these potent antioxidants underscores the scientific relevance of cinnamon extract. It validates its traditional use as a functional food and highlights its strong potential for pharmaceutical and nutraceutical applications, particularly in managing oxidative stress-related diseases.

Future research should focus on isolating individual compounds for detailed bioactivity assays, evaluating in vivo efficacy in disease models, and developing standardized formulations for commercial use in food preservation and healthcare products.

Funding Statement:
This research received no external funding.

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