Abhi International Journals of Applied Science (AIJAS)
ISSN(online): ……..
Vol. 2, Issue. 1, January 2025

Comparative Analysis of Botanical, Physicochemical, and Phytochemical Parameters of Zanthoxylum zanthoxyloides from Stem and Root Bark

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ARTICLE INFO

Article History:
Received December 18, 2024
Revised December 27, 2024
Accepted January 11, 2025
Available online January 29, 2025

Keywords:
Zanthoxylum zanthoxyloides,
Phytochemical analysis,
Antioxidant activity,
Physicochemical properties

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ABSTRACT

This study presents a comparative analysis of the botanical, physicochemical, and phytochemical properties of Zanthoxylum zanthoxyloides stem and root bark powders. The research underlines the possibility of their interchangeability in phytomedicine to promote sustainable resource utilization. Botanical characteristics, physicochemical parameters such as ash and moisture content, and phytochemical profiles were evaluated using methanolic and aqueous extracts. The similarities in botanical characteristics, physicochemical properties, and phytochemical profiles support the possibility of substitutability in traditional medicine. However, significant differences between the antioxidant activities of methanolic extracts from the stem bark and root bark suggest that methods of extraction significantly impact therapeutic optimization. The data obtained contribute to the standardization of phytomedicines based on Z. zanthoxyloides, supporting resource conservation and sustainable harvesting.

Introduction

This paper presents the botanical, physicochemical, and phytochemical parameters of Zanthoxylum zanthoxyloides, with a focus on the comparison between stem and root bark powders. The interest lies in understanding the rational use of this overexploited medicinal plant in Burkina Faso, where its roots are primarily used for therapeutic purposes. It was the comparative evaluation of these parameters where sub-research questions addressed botanical characteristics, physicochemical properties, phytochemical profiles, antioxidant activities, and the implications for standardization and rational use. This involves a quantitative method employing methanol and water extractions to analyse crucial independent variables in form of extraction yields and phenolic content, and their dependent variables; antioxidant activity, as well as ash content. This paper progresses from the review of literature towards methodology, findings, and conclusion for systematic discussion about similarities and differences in profiles for stem and root bark in implication to development for phytomedicine.

Literature Review

Literature related research studies are systematically examined based on differences in botanical characterizations, physicochemical properties, phytochemical profiles, antioxidant activities, and implications of differences regarding standardization and rational use based on five sub questions:. It was mentioned that comprehensive comparative studies have not been undertaken regarding stem and root bark, as well as limited analyses of antioxidant activities in various extracts. Therefore, this research gap has driven this study into detailing the comparisons while trying to base its hypotheses from these variables' relations.

Botanical Characteristics of Z. zanthoxyloides

General botany has described the preliminary work done about Z. zanthoxyloides concerning its basic characteristics of its morphological aspects, habitat, and the environment. However, these studies failed to include comparative analysis between stem and root bark. Subsequent research continued with morphological features but could not go up to a detailed comparison. Recent studies started comparing these parts but could not further go into the implications of their similarities. Hypothesis 1: The botanical characteristics of stem and root bark are similar, and thus there is a basis for interchangeable use in traditional medicine is proposed.

Physicochemical Properties Comparison

Early studies examined simple physicochemical properties such as moisture and ash content in Z. zanthoxyloides. However, these studies failed to compare the stem and root bark. Later studies gave more information on physicochemical analyses, but a comparative approach was not taken. Comparative studies have recently been initiated, and comprehensive evaluation has not been established. Hypothesis 2: Physicochemical properties of the powder derived from stem and root bark such as total ash, moisture content are similar and may require the same storage and processing conditions.

Analysis of Phytochemical Profiles

Initial studies focused on the phytochemical content of Z. zanthoxyloides, identifying key compounds. These lacked a comparative focus on stem and root bark. Mid-term studies began exploring differences but were limited in scope. Recent research has improved in comparing phytochemical profiles but still lacks depth. Hypothesis 3: The phytochemical profiles of methanolic extracts from stem and root bark are similar, indicating potential for similar therapeutic applications is proposed.

Antioxidant Activities in Various Extracts

These earlier studies on the antioxidant activities of Z. zanthoxyloides were mainly in general properties of the plant part without discrimination in the plant part. The further studies began assessing separate parts but lacked comparative data for most parts. Recent studies were initiated comparing between stem and root bark, lacking total analyses. Hypothesis 4: Based on the evidence, it suggests that the activities of methanolic extract from stem bark and root bark varied; methanolic extracts are the most active whereas aqueous are less active.

Implications for Standardization and Rational Use

Early literature covered general applications of Z. zanthoxyloides in traditional medicine. In them, the issue of standardization was not raised. Later literature brought the point of standardization onto the table but without detailed comparative data. More recent literature points towards standardization and without extensive evaluation of substitutional application. Hypothesis 5: The comparable profiles of the stem and root bark to be used interchangeably in standardization efforts for phytomedicine development is presented.

Method

This section describes the quantitative methodology used in comparing the botanical, physicochemical, and phytochemical parameters of Z. zanthoxyloides stem and root bark. It gives details on the methods of data collection, extraction procedures, and selection of variables for comprehensive analysis and accurate findings.

Data

The data for this study are collected by field collection of Z. zanthoxyloides samples from three sites in Burkina Faso and subsequent laboratory analysis. Botanical characterization includes morphological assessment, while physicochemical and phytochemical analyses are performed using methanol and water extraction methods. Sampling was carried out by stratified random sampling to ensure that there was representation of all groups. Screening criteria included plant

maturity and health. This will give robust data able to show the differences and similarities in botanical, physicochemical, and phytochemical parameters.

Variables

The independent variables are the extraction yields of methanol and water, phenolic and flavonoid content, and antioxidant activity levels. Botanical characteristics, physicochemical properties like moisture and ash content, and phytochemical profiles are the dependent variables. The control variables would be the environmental factors, like soil type and climatic conditions. Literature is backed up in terms of variable selection to ensure reliability and validity of measurement methods. Statistical analysis methods, including ANOVA and regression, are applied for the determination of relationships between the variables and hypotheses testing.

Results

Results start with the descriptive statistical comparison of the botanical, physicochemical, and phytochemical parameters between the stem and root bark of Z. zanthoxyloides. These comparisons provided a baseline of understanding similarities and differences between these two parts. The results prove hypotheses about similarities in botanical aspect, physicochemical properties, and phytochemical profiles, which were also identified with differences in antioxidant activities. The findings, therefore, highlighted the potential rational use and standardization in phytomedicine development.

Botanical Similarities Between Stem and Root Bark

This result supports Hypothesis 1, which stated that the botanical features of Z. zanthoxyloides stem and root bark are the same. Morphological observations show uniform features like fiber distribution and surface texture among samples collected from different sites. Key variables include leaf shape, bark texture, and presence of fibers. This similarity holds a profound implication that both parts can be used interchangeably by traditional medicine for sustainable harvesting. Empirical evidence obtained supports the botanical theories relating to part interchangeability that lead to the conclusions about conservation of resources. This finding is practical to the previous studies that lay emphasis on a single part because this clarifies that both stem and root bark can be used therapeutically.

Comparative physicochemical properties

This finding supports Hypothesis 2, which asserts that the physicochemical properties of Z. zanthoxyloides stem and root bark powders are similar. Analyses show comparative total ash and moisture content levels, with minimal variations across samples. Key variables include total ash, moisture, and insoluble ash in hydrochloric acid. This similarity suggests equivalent storage and processing requirements, making easier standardization possible. The significance of these findings lies in the potential for streamlined processing methods, reducing resource waste. Empirical results reinforce theories on plant material consistency, supporting the hypothesis that similar physicochemical properties enable interchangeable use. By addressing previous research gaps that lacked comparative analyses, this finding underscores the efficiency and practicality of using both stem and root bark in phytomedicine development.

Phytochemical Profile Similarities

This finding confirms Hypothesis 3, meaning that the phytochemical profiles of the methanolic extracts from both Z. zanthoxyloides stem and root bark are similar. HPTLC analyses indicate both extracts contain major components such as derivatives of gallic acid and chlorogenic acid. The major factors are phenol and flavonoid content. The empirical value indicates that there is no substantial difference between parts, thus interchangeable application in medicinal formulas. By highlighting the potential for resource optimization and sustainable harvesting, this finding addresses gaps in previous studies that mainly focused on separate parts of the plant. The results come in consonance with phytochemical theories on compound distribution. Actually, such

findings help focus much more on the practical development of effective phytomedicines using either the plant part.

Differences in Antioxidant Activities

This finding supports Hypothesis 4. Namely, the antioxidant activities significantly differ between methanolic extracts of the Z. zanthoxyloides stem and root bark. Analyses show higher DPPH inhibition and ferric reducing power in methanolic extracts compared to aqueous ones. Key variables include antioxidant activity levels and extract types. The significance of these differences suggests that methanolic extracts offer greater therapeutic benefits, highlighting the importance of extraction method selection. Empirical results reinforce theories on solvent influence on antioxidant activity, supporting the hypothesis that methanolic extracts are more effective. By highlighting the gaps in earlier research that had not made full comparisons, this finding underscores the importance of selection of the proper extraction method for maximum therapeutic use.

Implication for Standardization and Rational Use

This finding confirms Hypothesis 5 by pointing out implications of similar profiles for standardization and rational use of Z. zanthoxyloides in the development of phytomedicines. Analyses show that stem and root bark can be used interchangeably for resource conservation and sustainability. Key variables include botanical, physicochemical, and phytochemical similarities. The empirical significance suggests that standardization processes can incorporate both parts without compromising quality, facilitating efficient resource utilization. By addressing previous gaps that overlooked standardization implications, this finding underscores the practical benefits of using both plant parts, aligning with theories on sustainable resource management. The results emphasize the potential for developing comprehensive monographs and standardized protocols for Z. zanthoxyloides-based phytomedicines.

Conclusion

This study gives a comprehensive comparison of the botanical, physicochemical, and phytochemical parameters of Z. zanthoxyloides stem and root bark, which points out their similarities and differences. The findings point to the possibility of rational use and standardization in the development of phytomedicine, with important implications for sustainable harvesting practices and resource conservation. However, the research is limited by potential sample selection bias and reliance on specific extraction methods, which may affect generalizability. Future research should focus on other extraction methods and the influence of environmental factors on the plant profile so that the information can be developed further. Through these areas, future studies may provide more comprehensive insights into the medicinal potential of Z. zanthoxyloides and will support the effective and sustainable use of phytomedicine practices.

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