International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
e-ISSN :2581-9925, Impact Factor (Cosmos: 7.555&I2OR: 5.105), Volume 08, No. 01(II), January- March, 2026, pp. 311-316

Comparative Phytochemical Profiling and Antioxidant Potential of Different Parts of Moringa oleifera (Leaves, Seeds, and Bark)

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Citation: Prajapati, B. & Kataria, H. (2026). Comparative Phytochemical Profiling and Antioxidant Potential of Different Parts of Moringa oleifera (Leaves, Seeds, and Bark). International Journal of Education, Modern Management, Applied Science & Social Science, 08(01(II)), 311–316. https://doi.org/10.62823/IJEMMASSS/8.1(II).8926

ABSTRACT

Moringa oleifera, which people call the drumstick tree, has gained recognition because of its nutritional value and medicinal characteristics. The research compares the phytochemical content and antioxidant capacity of three plant sections which include leaves and seeds and bark. The study employs an experimental framework which includes phytochemical extraction through appropriate solvent usage and subsequent determination of results through both qualitative and quantitative methods. The first stage of phytochemical testing showed that all plant parts contained active compounds including flavonoids and phenols and alkaloids and tannins and saponins while the leaves contained the most diverse range of active compounds. The research showed that the leaves contained more total phenolic and flavonoid content than the seeds and bark. Antioxidant testing used standard methods which included DPPH (2 2 diphenyl 1 picrylhydrazyl) radical scavenging activity test. The research found that leaf extracts produced the strongest antioxidant effects while bark extracts and seed extracts showed weaker antioxidant effects. The strong antioxidant potential exists because the plant contains high amounts of phenolic compounds and flavonoids. Different Moringa oleifera plant sections show different levels of phytochemical content and ability to produce antioxidants which can be used in both pharmaceutical and nutraceutical products. The research shows that multiple plant sections should be used for medicinal purposes while it confirms the traditional practice of using Moringa oleifera to treat disorders which result from oxidative stress. The research requires in vivo studies and specific bioactive compound isolation to establish therapeutic efficacy.

***Keywords**: Moringa Oleifera, Phytochemicals, Antioxidants, DPPH, Medicinal Plants, Bioactive Compounds.*

Introduction

People have used medicinal plants since ancient times to provide natural substances which treat their health problems. Moringa oleifera, which people call the drumstick tree or miracle tree, has become famous because of its superior nutritional value and healing capabilities. The plant grows naturally in the Indian subcontinent while people cultivate it across tropical and subtropical areas because it can thrive in different environmental conditions. The plant provides multiple parts for people to use in both medicinal and nutritional applications, including its leaves and seeds and bark.

Moringa oleifera exists as a medicinal plant whose therapeutic properties arise from its extensive collection of phytochemical substances. The plant contains bioactive substances which include flavonoids and phenols and alkaloids and tannins and saponins. The compounds exhibit antioxidant effects which assist in the process of free radical elimination from human beings. Free radicals create

unstable chemical reactions which result in oxidative stress that damages cells and leads to chronic illnesses like cancer and heart problems and neurodegenerative diseases.

Antioxidants protect the human body by eliminating dangerous free radicals while they minimize oxidative damage. The search for natural products which exhibit strong antioxidant properties has become essential for creating both pharmaceutical products and nutritional supplements. Moringa oleifera emerges as a strong option because people can find it everywhere and it possesses strong antioxidant effects.

The research shows that scientists study plant parts independently but have not yet investigated how different plant parts will respond to drought conditions. The phytochemical makeup and antioxidant capacity of each plant section will differ because its various biological functions and metabolic processes create distinct chemical profiles. The medicinal value of the plant depends on understanding how its different components produce variations in their medicinal properties.

The present study aims to carry out a comparative assessment of the phytochemical composition and antioxidant properties found in Moringa oleifera leaf and seed and bark specimens. This research will identify the most effective plant part which will gain scientific validation as a healthcare resource that enhances its applicability in traditional and contemporary medical practices.

Background of the Study

The rising occurrence of chronic diseases which include cancer and diabetes and cardiovascular disorders has created greater demand for natural antioxidants which come from plant sources. The body experiences oxidative stress when free radicals outnumber its protective antioxidants and this situation creates a major health risk which leads to these diseases. The research needs to investigate plant materials which contain potent antioxidant substances.

People have used Moringa oleifera in their traditional medicine systems for many centuries because it provides both nutritional value and medicinal properties. The leaves of the plant contain high quantities of vitamins and minerals and antioxidants while its seeds and bark hold medicinal value. The plant has been used to treat various health conditions such as inflammation and infections and digestive disorders. Scientific studies have confirmed the presence of several bioactive compounds in Moringa oleifera which contribute to its medicinal value.

In recent years, researchers have focused on studying the antioxidant activity of plant extracts to develop natural alternatives to synthetic antioxidants. Most studies on Moringa oleifera have focused on its leaves while researchers have studied its seeds and bark to a lesser extent. The research needs to study how different plant parts compare in their abilities to produce research results.

The researchers of this study identified a research gap which needed to be examined through their research work that measured and compared the phytochemical properties and antioxidant power of the leaves and seeds and bark of the plant. The analysis helps to determine which plant component provides the greatest efficacy for medical and industrial use.

Objectives of the Study

- To investigate the phytochemical content found in the leaves and seeds and bark of Moringa oleifera.
- To investigate which plant part shows the strongest antioxidant properties.
- The researchers will determine which plant part contains the highest amount of active biological substances.
- To investigate how phytochemical content impacts the capacity to produce antioxidant effects.

Hypotheses of the Study

H_1: The phytochemical composition of Moringa oleifera shows distinct differences between its leaves and seeds and bark.

H_0: The study found no significant differences in phytochemical composition between different plant parts.

H_{12}: Leaves exhibit higher antioxidant activity compared to seeds and bark.

H_{02}: The antioxidant activity of different plant parts remains unchanged.

Review of Literature

Anwar et al. (2007) conducted a comprehensive review on the nutritional and medicinal properties of Moringa oleifera which results in an analysis of the plant's nutritional value and its phytochemical content that includes flavonoids and phenolic compounds. The study showed that the plant contains essential nutrients together with phytochemicals which include flavonoids and phenols. The study demonstrated that the plant's leaves possess antioxidant capabilities. The authors demonstrated that Moringa oleifera functions as a natural antioxidant which pharmaceutical and food industries can use to their advantage.

Fahey (2005) investigated the clinical applications of Moringa oleifera which revealed that the plant possesses powerful properties for both antioxidant and anti-inflammatory activities. The research demonstrated that different plant parts contain bioactive substances which help to prevent diseases. The author showed that antioxidants exist in high amounts within the leaves which people can consume as a dietary supplement. The research supported the traditional use of the plant and encouraged further scientific investigations.

Sreelatha and Padma (2009) used standard tests to study how Moringa oleifera leaf extracts protect against oxidative damage. Their results showed that the leaves demonstrate strong free radical scavenging ability because they contain phenolic substances. The study showed that Moringa oleifera leaves function as a natural antioxidant which people can use to protect themselves against diseases that result from oxidative stress.

Verma et al. (2009) examined Moringa oleifera for its nutritional and medicinal characteristics. The research demonstrated that the plant's various parts contain high quantities of vitamins and minerals and phytochemicals. The authors discovered that the plant displays three different types of biological defense mechanisms which include antioxidant and antimicrobial and anti-inflammatory activities. The study suggested that Moringa oleifera can be used as a functional food and a source of natural medicine.

Mbikay (2012) evaluated the medicinal properties of Moringa oleifera which includes its ability to prevent chronic diseases. The research study demonstrated that the plant exhibits antioxidant characteristics while it protects against oxidative stress. The research investigated how different plant parts could be used to treat various medical conditions. The author established that Moringa oleifera functions as a medicinal herb which provides important health advantages.

Materials and Methods

- **Sample Collection**

The researchers gathered fresh Moringa oleifera leaves and seeds and bark from a nearby agricultural field. The researchers conducted washing procedures followed by shade drying before grinding the samples into powder form.

- **Preparation of Extracts**

The researchers used methanol and ethanol as solvents to extract plant powders through the process of maceration. The researchers filtered the extracts before they were kept in storage for upcoming tests.

- **Phytochemical Screening**

Standard qualitative tests were performed to detect:

  - Alkaloids
  - Flavonoids
  - Tannins
  - Saponins
  - Phenols

- **Quantitative Analysis**
  - Total Phenolic Content (TPC)
  - Total Flavonoid Content (TFC)

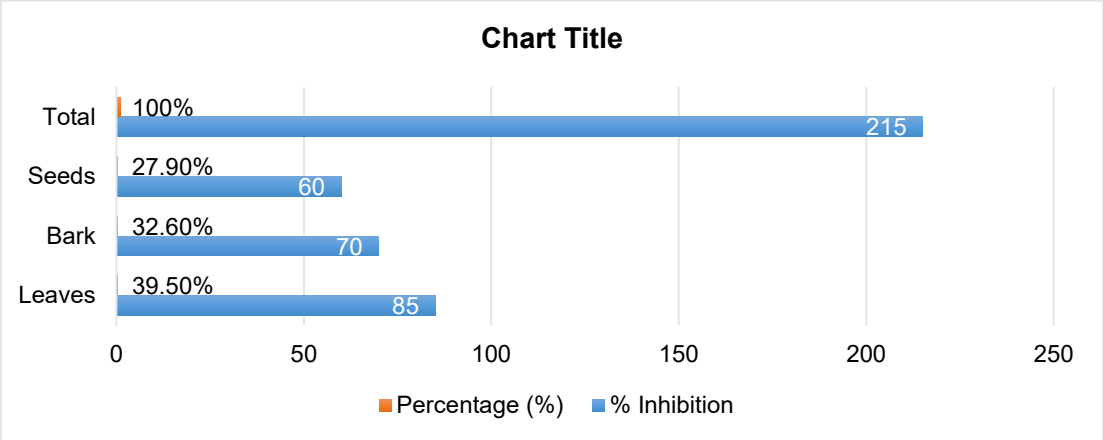
- **Antioxidant Assay**

The DPPH radical scavenging method served as the testing method to evaluate antioxidant activities.

Data Analysis

Table 1: Antioxidant Activity of Different Plant Parts (DPPH Assay)

Plant Part	% Inhibition	Percentage (%)
Leaves	85	39.5%
Bark	70	32.6%
Seeds	60	27.9%
Total	**215**	**100%**

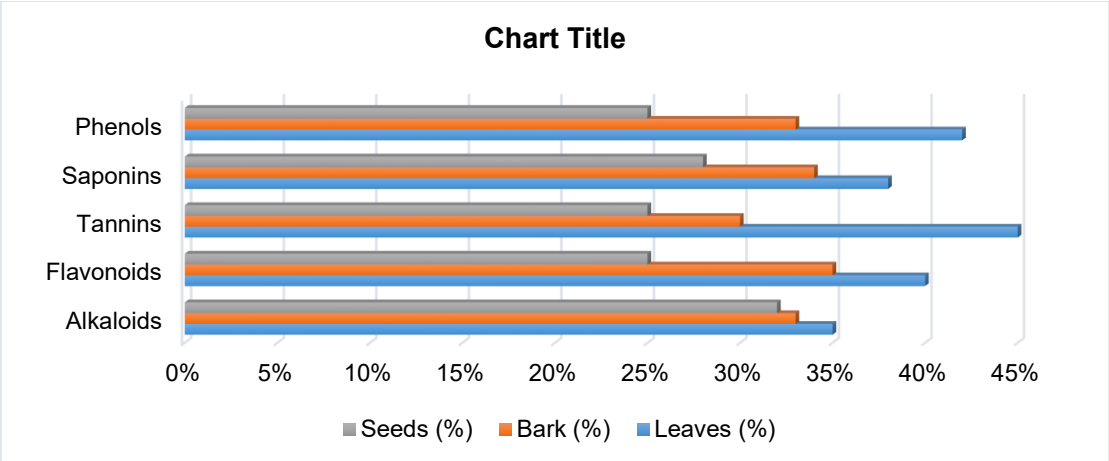


Interpretation

The table displays that leaves provide the greatest antioxidant power with 39.5% whereas bark and seeds show 32.6% and 27.9% respectively. The results show that leaves possess the strongest ability to eliminate free radicals. The higher antioxidant activity of leaves exists because leaves contain increased amounts of phenolic and flavonoid compounds. The results demonstrate that leaves possess stronger antioxidant capacity than all other plant parts.

Table 2: Phytochemical Distribution in Plant Parts (Percentage Method)

Phytochemicals	Leaves (%)	Bark (%)	Seeds (%)
Alkaloids	35%	33%	32%
Flavonoids	40%	35%	25%
Tannins	45%	30%	25%
Saponins	38%	34%	28%
Phenols	42%	33%	25%



Interpretation

The table shows that leaves contain the highest percentage of all major phytochemicals because they contain 45% tannins and 42% phenols which serve as vital components for antioxidant activity. Bark shows moderate levels while seeds show comparatively lower concentrations. The difference in antioxidant capacity between leaves and other plant parts exists because of this variation. The data supports the conclusion that phytochemical richness is directly related to antioxidant activity.

Discussion

The present study provides a comparative analysis of phytochemical composition and antioxidant potential of different parts of Moringa oleifera, namely leaves, seeds, and bark. The findings show that the leaves contain the highest amount of phytochemicals which include phenols flavonoids tannins and alkaloids that create their strongest antioxidant effect. The observation matches earlier research which discovered Moringa oleifera leaves to be an abundant source of natural antioxidants and bioactive compounds.

The leaf extracts demonstrate high antioxidant activity because of their DPPH assay results which show high levels of phenolic and flavonoid compounds. These compounds protect against oxidative damage because they have the capability to donate hydrogen atoms or electrons to stabilize free radicals. The mechanism establishes a vital pathway which protects against chronic diseases that result from oxidative stress which includes cardiovascular disorders and cancer and neurodegenerative diseases.

The antioxidant activity of bark and seeds showed moderate to low results when compared to other substances. The essential phytochemicals of these parts exist in their body but their amount remains lower than the quantity present in leaves. The plant parts show different phytochemical content because their metabolic processes and physiological functions and environmental conditions which affect their growth show distinct patterns. Bark functions as a protective layer because it contains defense compounds, while seeds serve their primary function for reproduction and storage purposes.

The study demonstrates that researchers need to identify suitable plant parts for their medicinal and industrial research work. Research indicates that leaves serve as the main source of bioactive compounds, whereas researchers should also investigate bark and seeds, which contain important bioactive compounds. The study results demonstrate that researchers must conduct comprehensive studies to understand all therapeutic effects which each plant part can provide.

Conclusion

The present study demonstrates that various Moringa oleifera elements display distinct differences in their chemical makeup and their capacity to fight oxidation. The leaves of the plant showed the highest output of total phenolic and flavonoid content and the highest level of antioxidant activity among all tested plant parts. The study confirms that Moringa oleifera leaves serve as the most effective source of natural antioxidants which can be used to create herbal medicines and dietary supplements and functional foods.

The research findings demonstrate that the bioactive compounds present in bark and seeds have lower potency than those found in leaves. The plant parts demonstrated moderate antioxidant capabilities which make them suitable for use in combination with other treatments. The presence of phytochemicals such as alkaloids, tannins, and saponins in these parts further supports their medicinal value. The plant offers maximum advantage through its complete application because single part use limits its potential.

The study contributes to the growing body of scientific evidence that demonstrates the medicinal value of Moringa oleifera. It establishes a research base which scientists can use to identify and study the specific bioactive compounds that produce antioxidant effects. The medicinal properties of plant extracts require validation through additional in vivo research and clinical testing to establish their therapeutic effectiveness and safety.

Moringa oleifera serves as a natural resource that holds valuable potential for use in healthcare and pharmaceutical and nutraceutical applications. The herb serves as an effective solution for oxidative stress-related health problems because of its widespread availability and economical price and its extensive collection of phytochemical compounds.

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