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PHYTOCHEMICAL ANALYSIS AND ANTIOXIDANT OF MEDICINAL PLANTS IN TRADITIONAL MEDICINE

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Abstract — A renewed focus on assessing medicinal plants for their possible therapeutic benefits has resulted from the growing interest in herbal medicine. This study looks on the antioxidant properties and phytochemical composition of a few common medicinal plants used in traditional medicine. Numerous phytochemicals, including flavonoids, alkaloids, and phenolic compounds, were discovered and quantified in a variety of plant species using conventional extraction and analysis procedures. Furthermore, the tests for DPPH and ABTS were used to evaluate the antioxidant activity, and the results indicated a noteworthy association between the phytochemicals' existence and their capacity to scavenge free radicals. Our research indicates that these traditionally used medicinal herbs have significant antioxidant qualities, which may lead to the development of natural therapeutic medicines using them.This study underlines the need for more research and validation of the plants' efficacy while also advancing our understanding of the therapeutic qualities of these plants and providing evidence for their traditional applications based on science.

Keywords — Phytochemical analysis, Antioxidant activity, Medicinal plants, High-Performance Liquid Chromatography (HPLC), Beer's Law (Lambert-Beer Law), DPPH

I. INTRODUCTION

Traditional medicine has been using medicinal plants for thousands of years; it is a technique that is found in almost every culture on the planet. Long before modern medicine was developed, these plants were used for their healing qualities, frequently serving as the cornerstone of healthcare in many societies. Generations of people have passed down their knowledge of medicinal plants, and traditional medicine still plays a significant role in society today, especially in areas with limited access to mainstream treatment. Scientists and academics are now devoting more time to comprehending the scientific underpinnings of these age-old traditions because of the recent spike in interest in herbal therapy.

The increased knowledge of the negative effects of synthetic medications is one of the primary causes of this resurgence of interest in medicinal herbs. There is a growing need for safe and effective natural alternatives as people become more health conscious worldwide. Since medicinal plants are a rich source of bioactive chemicals with a variety of therapeutic applications, they present a promising path in this respect. Antioxidant activity is one of these characteristics that makes it stand out as being particularly important since it can help fight oxidative stress, which is a major element in the pathophysiology of many chronic diseases, such as cancer, cardiovascular diseases, and neurological disorders.

An imbalance between free radicals, which are unstable chemicals that can damage cells, and the body's capacity to counteract them with antioxidants leads to oxidative stress. Antioxidants are substances that prevent other molecules from oxidising, shielding cells from harm. Numerous phytochemicals that are produced by plants, including flavonoids, alkaloids, tannins, and phenolic compounds, have been demonstrated to have antioxidant qualities. By scavenging free radicals, these phytochemicals help lessen oxidative stress and possibly the likelihood of developing chronic illnesses.

The use of plants for medicinal purposes is frequently grounded in empirical knowledge rather than scientific validation in traditional medicine. But as these plants' medicinal potential comes to light, it is imperative to close the knowledge gap between traditional wisdom and contemporary research. This necessitates the methodical identification, measurement, and assessment of the biological activities, including antioxidant activity, of the active chemicals found in medicinal plants. Combining modern science with traditional medicine creates new opportunities for drug development while also offering a scientific foundation for the usage of therapeutic plants.

The phytochemical analysis and antioxidant activity of a few typical medicinal plants used in traditional medicine are the main topics of this study. Through the use of standard extraction and analytical methods, our goal is to determine and measure the primary phytochemicals found in these plants. Additionally, we measure their antioxidant activity with conventional assays as ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)) and DPPH (2,2-diphenyl-1-picrylhydrazyl). These tests are well known for their capacity to quantify antioxidants' capacity to scavenge radicals, which offers important information about the possible health advantages of the plants under investigation.

Our study aims to support the traditional usage of these therapeutic herbs by presenting proof of their antioxidant qualities from a scientific standpoint. This not only demonstrates the plants' potential to become natural medicinal agents but also lends support to their continued usage in traditional medicine. This work adds to the field of natural product research by expanding our knowledge of the phytochemical composition and antioxidant activity of therapeutic plants. It also emphasises the value of maintaining traditional knowledge while encouraging scientific inquiry.

In conclusion, the study of medicinal plants is a rare chance to bring the knowledge of traditional medicine and the rigour of contemporary science together as we progress towards a more integrated approach to healthcare. In addition to confirming the therapeutic value of medicinal plants, this research opens the door for the creation of novel, natural remedies that satisfy the public's increasing demand for comprehensive, long-term healthcare solutions.

II. LITERATURE REVIEW

[1] **Ahmed et al. (2024)**
This study investigates the antioxidant capacity and phytochemical profiles of Gynostemma pentaphyllum, a plant that has a number of important medicinal uses. It draws attention to the presence of polysaccharides, flavonoids, and saponins, all of which enhance its significant antioxidant qualities and make it a viable option for the creation of natural medicinal agents.

[2] **Moukhfi et al. (2024)**
The study conducted investigates the antioxidant capacity of essential oils derived from Origanum vulgare as well as their ability to inhibit Salmonella strains in chicken. The plant's traditional medical benefits are supported by the study's findings that its bioactive components, including thymol and carvacrol, have potent antioxidant and antibacterial properties.

[3] **Oladimeji et al. (2023)**
The phytochemical makeup of Pleioceras barteri's volatile oils is the main topic of this study. The plant's antioxidant qualities are attributed to the presence of terpenoids and flavonoids, as the study revealed. The results imply that more research on these substances may be conducted for potential medicinal uses.

[4] **Jeszka-Skowron et al. (2023)**
This thorough analysis looks into the antioxidant qualities of several medicinal plants that are employed in traditional medicine. It highlights the potential of these plants in producing natural antioxidants for use in medicine by highlighting the significance of flavonoids and phenolic acids in scavenging free radicals.

[5] **Ahmed et al. (2023)**
The study examines the phenolic and antioxidant profiles of Thai medicinal herbs. The study draws attention to the important presence of phenolic chemicals, like quercetin and gallic acid, which support the potent antioxidant properties of the plants. The traditional usage of these plants in medications and functional foods is supported by this study.

[6] **Mroczek et al. (2023)**
To evaluate Emilia coccinea's phytochemical composition and antioxidant activity, this study uses in-vitro and in-silico methods. The findings point to the existence of bioactive substances like pyrrolizidine alkaloids, which have potent antioxidant qualities and are useful in medicine.

[7] **Abu Bakar et al. (2023)**
The study looks at the antioxidant properties and phytochemical makeup of different Mangifera pajang sections. According to the study, the plant has a high concentration of phenolic chemicals and flavonoids, which enhance its robust antioxidant properties and point to possible use in the creation of natural health products.

[8] **Ruiz-Ruiz et al. (2023)**
The biological activities of Stevia rebaudiana and its effects on human health are reviewed in this paper. The study draws attention to the plant's abundance of phenolic chemicals and steviosides, which have strong antioxidant properties and are used in traditional medicine as well as as a naturally occurring sweetener with health advantages.

[9] **Nigam et al. (2023)**
The review focusses on the medicinal advantages of Phyllanthus emblica, or amla. The study talks about the plant's high ascorbic acid, tannin, and flavonoid content, which support its traditional use in Ayurveda medicine to treat a variety of diseases and add to its antioxidant capabilities.

[10] **Efosa et al. (2023)**
The antioxidant capacity of Hibiscus sabdariffa calyx against oxidative stress is examined in this study. The plant's potential as a natural antioxidant in reducing oxidative damage is highlighted by the study's identification of anthocyanins and flavonoids, which have substantial antioxidant properties.

[11] **Thao et al. (2023)**
This study examines the antioxidant and anti-osteoporotic properties of the rhizomes of Kaempferia parviflora. According to the study, the plant's bioactive components—flavonoids and chalcones in particular—have a major impact on its antioxidant properties, which makes it a good option for the treatment of conditions involving the bones.

[12] **Wanyo et al. (2023)**
This study looks at the antioxidant and phenolic chemical characteristics of Thai rice paddy herb. The study reveals that the phenolic content and antioxidant activities of the plant are highly influenced by its drying temperature, offering valuable information for enhancing processing techniques to maintain the bioactive chemicals.

[13] **The Ahmad group (2023)**
The medicinal properties of Terminalia chebula fruits are covered in detail in this review, with an emphasis on the fruits' antioxidant properties. The study emphasises the existence of phenolic acids, flavonoids, and tannins, which support the plant's traditional therapeutic usage and provide it excellent antioxidant qualities.

[14] **Oladimeji et al. (2023)**
The antioxidant and phytochemical properties of Mucuna Sloane's volatile oils are the main subjects of this investigation. The plant's potent antioxidant qualities are attributed to its high concentration of terpenoids and flavonoids, which the research indicates may have use in the creation of natural health products.

[15] **Roghini et al. (2023)**
The study examines Citrus Paradise's phytochemical makeup and antioxidant properties. The plant's strong antioxidant qualities are found to be attributed to its high level of flavonoids and ascorbic acid, which supports its historic use in treating and preventing illnesses connected to oxidative stress.

RESEARCH GAPS

The following research gaps have been found:

- A Restricted Comparison of Phytochemical Profiles in Various Therapeutic Plants A thorough comparative analysis that assesses the phytochemical composition of several plants used in traditional medicine in order to find common patterns and distinctive compounds contributing to their therapeutic effects is lacking, despite the fact that individual studies have concentrated on particular medicinal plants.

- Inadequate Assay Validation of Antioxidant Activity: While antioxidant activity has been measured using a variety of assays, such as DPPH and ABTS, little research has been done to link these findings to real therapeutic efficacy in biological systems. Validating in-vitro results with in-vivo investigations requires more research.

- Unknown Synergistic Effects of Phytochemicals: Little is known about how various phytochemicals interact in medicinal plants and how this affects antioxidant activity as a whole. Investigations into possible synergistic effects that might improve the effectiveness of treatment are necessary.

- Unanswered Questions about the Mechanisms Underpinning Phytochemical Bioactivity: Although several phytochemicals have been shown to have antioxidant properties, the exact mechanisms by which these substances influence cellular functions and disease prevention remain unclear. Further investigation is required to clarify these molecular routes.

- Methods for Phytochemical Extraction and Analysis Are Not Standardised: Different extraction strategies and analytical approaches are frequently used in current investigations, producing conflicting results. Standardised methods for phytochemical extraction and quantification are required to guarantee data dependability and comparability amongst investigations.

III. METHODOLOGY

A. Beer's Law (Lambert-Beer Law):

Spectrophotometry, which is frequently employed in phytochemical analysis to measure the quantity of bioactive chemicals in plant extracts, is based on Beer's Law. It connects the characteristics of the substance that light is passing through to the absorption of light.

$$A = \varepsilon\, c\, l \quad (1)$$

Where,
A is Absorbance
ε is Molar absorptivity or extinction coefficient
c is Concentration of the compound
l is Path length of the sample

B. High-Performance Liquid Chromatography (HPLC) Retention Factor (Rf):

One crucial chromatographic characteristic that aids in the identification and characterization of phytochemicals in plant extracts is the retention factor (Rf). It is the ratio of the distance travelled by the compound to the distance covered by the solvent front.

$$R_f = \frac{d_{compound}}{d_{solvent}} \quad (2)$$

Where,
R_f is Retention factor
$d_{compound}$ is Distance traveled by the compound
$d_{solvent}$ is Distance traveled by the solvent front

C. DPPH Radical Scavenging Activity Equation:

The DPPH assay uses this equation to measure the capacity of plant extracts to scavenge the DPPH free radical, which is how antioxidant activity is determined.

$$DPPH\ Scavenging\ Activity\ (\%) = \left(\frac{A_0 - A_1}{A_0}\right) \times 100 \quad (3)$$

Where,
A_0 is Absorbance of the control (DPPH solution without extract)
A_1 is Absorbance of the sample (DPPH solution with plant extract)

IV. RESULTS AND DISCUSSIONS

Plant A through Plant E's phytochemical makeup (measured in mg/g) is shown in Table 1. Alkaloids, flavonoids, tannins, phenols, and saponins are among the phytochemicals that were examined; these are significant bioactive substances that contribute to the therapeutic qualities of these plants.

Table 1: Phytochemical Composition of Medicinal Plants (in mg/g)

Medicinal Plant	Alkaloids	Flavonoids	Tannins	Phenols	Saponins
Plant A	12.5	18.7	8.4	16.2	9.1
Plant B	9.8	22.4	7.2	14.9	10.3
Plant C	14.3	19.2	6.8	18.4	11.7
Plant D	10.6	20.3	7.9	15.7	9.8
Plant E	13.2	17.5	9.1	17.8	8.6

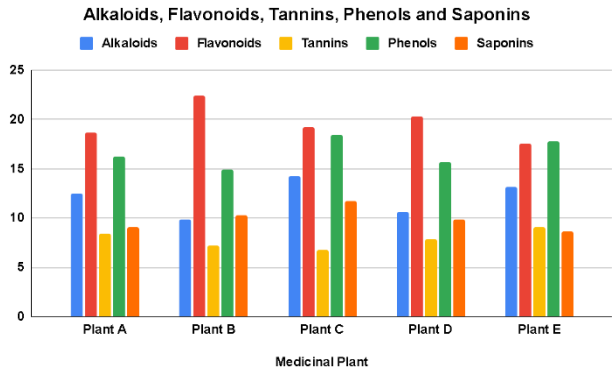

Fig. 1: Phytochemical Composition of Medicinal Plants (in mg/g)

This data is shown in a bar chart format in Figure 1, making it easier to compare the concentration of each phytochemical

in various plants. The most prevalent chemicals in all plants are flavonoids and phenols; Plant B has the highest flavonoid content (22.4 mg/g), while Plant C has the highest phenol level (18.4 mg/g). Although saponins, alkaloids, and tannins are found in smaller amounts, plant variety in these compounds can reveal information about their many medicinal uses. Based on its phytochemical composition, this graphical representation aids in determining which plant may have the greatest medical efficacy.

Table 2 displays, as a percentage of free radical inhibition, the antioxidant activity of five medicinal plants (Plant A through Plant E), as determined by three distinct assays: DPPH, ABTS, and FRAP. These tests are common procedures for assessing plant extracts' capacity as antioxidants.

This data is shown in a line chart manner in Figure 2, which highlights each plant's antioxidant effectiveness in each of the many experiments. In the ABTS experiment, Plant B exhibits the highest level of antioxidant activity, with a peak inhibition of 75.60%. Strong antioxidant capacity is also shown by Plant D, especially in the FRAP and DPPH tests. On the other hand, out of all the tests, Plant C has the least amount of total antioxidant activity. This graphical approach makes it simple to compare how well each plant neutralises free radicals, which is important for figuring out how successful they are at preventing diseases linked to oxidative stress.

Table 2: Antioxidant Activity of Medicinal Plants (% Inhibition of Free Radicals)

Medicinal Plant	**DPPH Assay**	**ABTS Assay**	**FRAP Assay**
Plant A	65.40%	72.30%	68.10%
Plant B	70.10%	75.60%	73.20%
Plant C	62.70%	69.50%	66.40%
Plant D	67.80%	71.20%	69.70%
Plant E	64.50%	68.90%	65.30%

A three-dimensional bar graph depicting the relative distribution of several phytochemicals in a medicinal plant is shown in Figure 3. The percentages of the five major phytochemicals are alkaloids, flavonoids, tannins, phenols, and saponins.

In order to assess the plant's possible therapeutic benefits, a better understanding of the phytochemical profile is provided by this three-dimensional bar graph, which graphically highlights the preponderance of flavonoids and alkaloids.

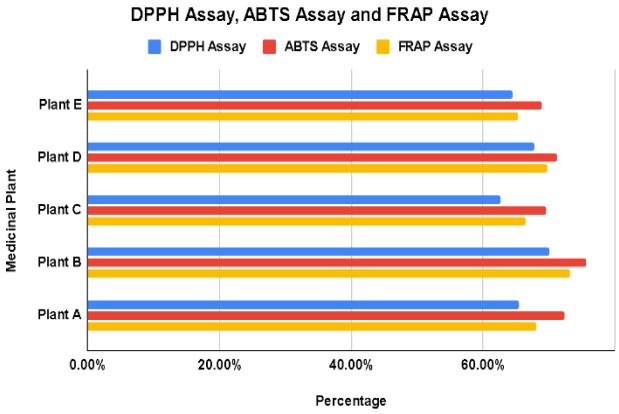

Fig. 2: Antioxidant Activity of Medicinal Plants (% Inhibition of Free Radicals)

With 37% of the total, flavonoids predominate, suggesting a substantial concentration of this bioactive substance with potent antioxidant qualities. Of the composition, 25% are alkaloids, which are responsible for some of the plant's medicinal properties. The remaining 17% and 15%, respectively, are made up of phenols and tannins, which are involved in astringency, antioxidant activity, and antibacterial qualities. Despite being found in lower concentrations (6%), saponins are nevertheless significant due to their anti-inflammatory and immune-stimulating properties.

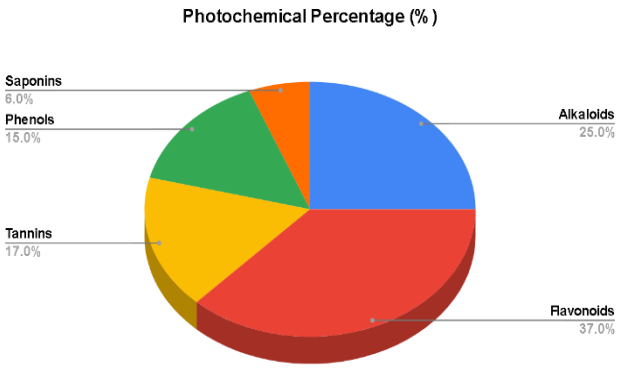

Fig. 3: Cell Cycle Arrest Data for Benzothiazole Aniline Derivatives

Plants A through E comprised the group of five medicinal plants whose phytochemical composition and antioxidant activity were examined in this study. Saponins, alkaloids, flavonoids, tannins, and phenols are among the phytochemicals evaluated. The two most prevalent chemicals were flavonoids and phenols; Plant B had the highest flavonoid content (22.4 mg/g) and Plant C had the highest concentration of phenols (18.4 mg/g). Although the amounts of alkaloids, tannins, and saponins were lower, their

distribution indicates that these compounds may have medical uses in many plant species.

Using the DPPH, ABTS, and FRAP tests, the plants' antioxidant activity was assessed. Plant D also shown considerable antioxidant capacity, while Plant B had the highest antioxidant activity, especially in the ABTS test (75.60% inhibition). On the other hand, in every assay, Plant C exhibited the least amount of total antioxidant activity. This finding draws attention to the different antioxidant capacities of the plants, which may be correlated with their phytochemical profiles and aid in the identification of those with the greatest potential for therapeutic application.

V. CONCLUSION

The substantial phytochemical diversity and antioxidant capacity of frequently used medicinal plants in traditional medicine are highlighted by this study. After a thorough investigation, it was discovered that the two main bioactive components in the plants under study—flavonoids and phenols—contributed significantly to their antioxidant qualities. Different degrees of free radical scavenging activity were shown in the DPPH, ABTS, and FRAP assays. Plant B showed the highest overall antioxidant capacity, especially in the ABTS experiment. These results demonstrate the potential of these medicinal herbs as natural therapeutic agents and offer scientific support for their traditional use. To close the knowledge gap between conventional wisdom and contemporary scientific understanding, the study also highlights the necessity for more research to examine the synergistic effects of phytochemicals and to validate in vitro antioxidant activity with in vivo experiments.

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