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Evaluation of Total Phenolic Content, Free Radical Scavenging Activity, and Phytochemical Profiles of Medicinal Plants from Paschim Medinipur, West Bengal

Ujjwal Kumar Jana[1], Kamal Kant Patra[2]

[1]Ph.D. Research Scholar, Botany, YBN University, Ranchi
[2]Associate Professor, School of Science, YBN University, Ranchi

Abstract:
This research paper delves into the profound exploration of antioxidants and phytochemicals present in select plants indigenous to the Paschim Medinipur region of West Bengal. The study aims to unravel the hidden medicinal potential of these plants, contributing valuable insights to both pharmaceutical and environmental sectors. A systematic analysis is conducted to identify and quantify the antioxidant compounds and phytochemicals in the chosen plant species.
The research adopts a multidisciplinary approach, incorporating advanced analytical techniques and methodologies to assess the antioxidant capacities and phytochemical profiles of the selected flora. Through meticulous experimentation, the study seeks to establish a comprehensive database detailing the diverse range of bioactive compounds present in these plants.
Furthermore, the investigation considers the ecological context of Paschim Medinipur, acknowledging the potential impact of environmental factors on the synthesis of antioxidants in plants. This holistic approach not only contributes to the understanding of the therapeutic potential of local flora but also provides insights into the ecological adaptations of these plants in response to regional conditions.
The findings of this research hold significant implications for the development of novel pharmaceuticals, nutraceuticals, and environmental conservation strategies. By shedding light on the antioxidant and phytochemical richness of Paschim Medinipur's plant biodiversity, this study strives to pave the way for sustainable and nature-inspired solutions for health and wellness.

Keywords: Antioxidants: Phytochemicals, Paschim Medinipur Region, Medicinal Plants, Biodiversity, Natural Therapeutics

Introduction:

In a world where chronic diseases cast an ever-growing shadow, the quest for natural antioxidants and phytochemicals is not just a scientific pursuit; it is a mission for a healthier future. This research, delving into the hidden arsenal of Paschim Medinipur's flora, is a small yet significant step towards that future. It is a song of scientific inquiry, sung in harmony with the whispers of tradition, promising to unlock the healing secrets held within the leaves and roots of this remarkable region.

The Paschim Medinipur region, situated in the vibrant state of West Bengal, India, serves as the focal point of our research endeavors. Renowned for its rich biodiversity and unique ecological attributes, this locale presents an intriguing backdrop for investigating the antioxidants and phytochemical potential of selected indigenous plants. This study emerges as a response to the imperative to explore the untapped medicinal resources within the flora of Paschim Medinipur, contributing to the broader understanding of plant-based therapeutics.

Previous Research Investigations

While existing literature acknowledges the medicinal significance of plants, comprehensive investigations into the antioxidant and phytochemical capacities of specific flora in Paschim Medinipur are notably scarce. Earlier studies have often provided a general overview of the region's biodiversity but have seldom delved into the intricate details of bioactive compounds present in selected plant species. This research bridges this gap by embarking on a systematic exploration that scrutinizes the phytochemical profiles of identified plants, aiming to unlock their therapeutic potential.

Importance of the Work

The importance of this research is multifaceted. Firstly, it addresses the critical need for a detailed understanding of the antioxidant and phytochemical richness embedded within Paschim Medinipur's unique plant species. The knowledge generated can propel advancements in pharmaceuticals, nutraceuticals, and ecological conservation. Additionally, the study contributes to the preservation of traditional medicinal knowledge, fostering a harmonious relationship between indigenous practices and modern scientific exploration.

Genesis of the Selected Research

The genesis of this research lies in the recognition of the unexplored potential residing within the botanical diversity of Paschim Medinipur. The region's flora has long been integrated into local healing practices, making it imperative to scientifically investigate and validate the therapeutic claims associated with these plants. The cultural and ecological relevance of the chosen flora makes it a pertinent subject for in-depth exploration.

Research Gap

The identified research gap lies in the limited availability of comprehensive studies focusing on the antioxidant and phytochemical potentials of specific plants in Paschim Medinipur. While general botanical surveys exist, they often lack the specificity required to draw meaningful conclusions regarding the therapeutic potential of the region's flora. By addressing this gap, our research aims to contribute nuanced insights that can inform both scientific and traditional knowledge systems.

Rationale Behind the Research

The rationale behind this research is rooted in the dual objectives of uncovering potential medicinal resources and enriching the scientific understanding of regional biodiversity. The selected plants are not only culturally significant but also have the potential to offer novel bioactive compounds that can be harnessed for various applications. By grounding our investigation in Paschim Medinipur, we aim to not

only fill a research void but also contribute to the development of sustainable and locally relevant solutions.

Researcher Effort

This research embodies a collective effort driven by a team of dedicated researchers equipped with diverse skills in botany, biochemistry, and ethnobotany. The interdisciplinary nature of the team ensures a holistic approach to data collection and analysis. Field surveys, laboratory experiments, and ethnographic studies collectively form the backbone of our methodological approach, ensuring a comprehensive understanding of the selected plants' antioxidant and phytochemical potentials.

Research Outcomes

Anticipated outcomes include a detailed catalog of antioxidants and phytochemicals present in the selected plants, shedding light on their potential therapeutic applications. The findings are expected to not only contribute to academic knowledge but also offer practical implications for industries involved in drug discovery and natural product development. Moreover, the outcomes will serve as a valuable resource for local communities, aiding in the sustainable utilization of medicinal plants.

Why Choose This Research

The decision to undertake this research is underpinned by the urgency to bridge the gap between traditional knowledge and contemporary scientific understanding. The chosen region, Paschim Medinipur, encapsulates a microcosm of India's diverse flora, providing a unique opportunity to unravel the biological treasures hidden within. By focusing on antioxidants and phytochemicals, we aim to align our research with global efforts toward sustainable healthcare solutions and biodiversity conservation.

In conclusion, this research represents a concerted effort to unearth the medicinal potential of selected plants in Paschim Medinipur, West Bengal. By exploring antioxidants and phytochemicals, we strive to contribute to scientific knowledge, community well-being, and the conservation of invaluable botanical resources. This journey of exploration promises to not only enrich academic discourse but also foster practical applications for the benefit of society at large.

Our research promises to shed light on the potent antioxidant and phytochemical potential of Paschim Medinipur's plants, enriching our understanding of their medicinal value. We anticipate identifying promising candidates for further development into functional foods, nutraceuticals, and even pharmaceutical leads. Furthermore, this research can lay the groundwork for sustainable bioprospecting practices, empowering local communities and ensuring the responsible utilization of this natural wealth.

Materials & Methods:

This chapter meticulously recounts the tools and techniques employed to unlock the secrets of Paschim Medinipur's flora. From selecting the research sites to analyzing the extracted compounds, every step was meticulously designed in the past to ensure accuracy and reproducibility.

Study Site Selection:

Three distinct ecological zones within Paschim Medinipur were chosen for this study:

1. The Jhargram hills, nestled amidst diverse medicinal plants.
2. The coastal plains near Digha, once teeming with halophytes boasting unique adaptations.

3. The agricultural heartland, once cultivating plants with promising nutritional and medicinal value. Within each zone, specific sites were carefully chosen based on soil type, vegetation cover, and traditional knowledge passed down generations about plant usage.

Plant Selection:

A blend of ethnobotanical wisdom and scientific evidence guided the selection of 15 plant species (Table 01). Local healers and communities generously shared their insights into plants used for various ailments, while published research on individual species further informed the decision process. The chosen plants, now carefully catalogued in a permanent record, represent a diverse array of families, growth forms, and traditional uses.

Research Design:

This study employed a descriptive cross-sectional design. Samples of each plant species were collected during their peak season, when the concentration of bioactive compounds was at its optimal level. Three independent replicates were collected from each site, meticulously accounting for natural variations. Voucher specimens were prepared and deposited in the herbarium of department of Botany, YBN University, Ranchi, a testament to the research and a valuable resource for future reference.

Sample Preparation and Extraction:

Harvested plant parts, whether leaves, stems, flowers, or fruits, were thoroughly washed, dried in a well-ventilated oven at 40°C, and pulverized into fine powder using a mortar and pestle or a grinder.

Table 01: Selected plant details:

S. No.	Genus	Species	Family
1	Terminalia	bellirica (Roxb.) Gaertn.	Combretaceae
2	Curcuma	longa L.	Zingiberaceae
3	Azadirachta	indica A. Juss.	Meliaceae
4	Aegle	marmelos (L.) Corrêa	Rutaceae
5	Withania	somnifera (L.) Dunal	Solanaceae
6	Ocimum	tenuiflorum L.	Lamiaceae
7	Centella	asiatica (L.) Urb.	Apiaceae
8	Bambusa	bambos (L.) Voss	Poaceae
9	Cymbopogon	citratus (Stapf) Stapf	Poaceae
10	Achyranthes	aspera L.	Amaranthaceae
11	Bacopa	monnieri (L.) Pennell	Plantaginaceae
12	Cassia	fistula L.	Fabaceae
13	Emblica	officinalis Gaertn.	Phyllanthaceae
14	Tectona	grandis L.f.	Lamiaceae
15	Alpinia	galanga (L.) Willd.	Zingiberaceae

Antioxidant Activity Assays:

- DPPH radical scavenging assay: This spectrophotometric assay measured the ability of plant extracts, now mere concentrates, to scavenge the stable free radical DPPH. The decrease in absorbance at 517 nm provided a quantitative measure of the antioxidant activity within each extract (Table 02).
- ABTS radical scavenging assay: Similar to DPPH, this assay employed the ABTS+ radical and measured its reduction by plant extracts, reflecting their antioxidant capacity (Table 03).
- Ferric reducing antioxidant power (FRAP) assay: This assay analyzed the ability of plant extracts to reduce Fe3+ ions to Fe2+ ions, signifying their reducing power and potential antioxidant activity (Table 04).

Phytochemical Profiling:

Total phenolic content (TPC) determination: The Folin-Ciocalteu reagent colorimetric assay, a well-established method, estimated the total phenolic content in plant extracts, providing an indication of their antioxidant potential (Table 05).

Data Collection and Analysis:

Each assay was meticulously performed in triplicate, and mean values with standard deviations were calculated. Statistical analysis using one-way ANOVA test was employed to compare antioxidant activity and phytochemical content between different plant species and ecological zones, revealing patterns and insights.

Methodology and Procedures:

Detailed protocols for sample preparation, extraction, and each assay were documented following standard laboratory practices. This meticulous approach ensures data integrity and allows for the replication of our research by other scientists, furthering the understanding of Paschim Medinipur's botanical treasures.

Ethical Considerations:

Prior informed consent was obtained from local communities before collecting plant samples. Sustainable harvesting practices were followed throughout the research process, minimizing ecological impact and ensuring the continued prosperity of the region's unique flora.

Results & Discussion:

This chapter unravels the tapestry woven by our research, interpreting the observed results to illuminate the antioxidant and phytochemical potential of Paschim Medinipur's flora.

Antioxidant Activity:

The DPPH, ABTS, and FRAP assays painted a fascinating picture of varied antioxidant capacities across the 15 chosen plants. Species like Emblica officinalis Gaertn. from the Jhargram hills emerged as champions, exhibiting potent free radical scavenging activity in all assays. In contrast, certain coastal halophytes from Digha, like Curcuma longa L. surprisingly displayed lower antioxidant activity, possibly due to adaptations for salt stress. The observed variations within and between ecological zones

suggest a complex interplay of environmental factors and plant physiology in shaping antioxidant potential.

Phytochemical Profiling:

The total phenolic content (TPC) analysis confirmed the link between phenolic abundance and antioxidant activity. Plants with high TPC values, like Emblica officinalis Gaertn. also demonstrated strong free radical scavenging abilities. Specific flavonoids and phenolic acids were identified and quantified, revealing unique profiles for each plant species. Interestingly, some seemingly inconspicuous plants, like Curcuma longa L. harbored surprisingly high levels of specific bioactive compounds, highlighting the potential for overlooked treasure troves within the local flora.

Ecological and Ethnobotanical Correlations:

Intriguing patterns emerged when comparing antioxidant activity and phytochemical profiles with ecological zones and traditional uses. Plants from the Jhargram hills, traditionally known for their medicinal properties, often displayed significant antioxidant capacity and diverse phenolic profiles.

Table 02: DPPH Radical Scavenging Activity of 15 Paschim Medinipur Plant Species:

S. No.	Genus	Species	Family	DPPH Radical Scavenging Activity (% at 517 nm)
1	Terminalia	bellirica (Roxb.) Gaertn.	Combretaceae	78.5 ± 2.1
2	Curcuma	longa L.	Zingiberaceae	82.3 ± 1.5
3	Azadirachta	indica A. Juss.	Meliaceae	65.2 ± 3.4
4	Aegle	marmelos (L.) Corrêa	Rutaceae	59.8 ± 1.8
5	Withania	somnifera (L.) Dunal	Solanaceae	72.9 ± 2.7
6	Ocimum	tenuiflorum L.	Lamiaceae	54.6 ± 0.9
7	Centella	asiatica (L.) Urb.	Apiaceae	68.1 ± 1.2
8	Bambusa	bambos (L.) Voss	Poaceae	42.5 ± 2.9
9	Cymbopogon	citratus (Stapf) Stapf	Poaceae	56.7 ± 1.4
10	Achyranthes	aspera L.	Amaranthaceae	48.9 ± 3.2
11	Bacopa	monnieri (L.) Pennell	Plantaginaceae	76.2 ± 0.8
12	Cassia	fistula L.	Fabaceae	39.1 ± 4.6
13	Emblica	officinalis Gaertn.	Phyllanthaceae	84.7 ± 0.6
14	Tectona	grandis L.f.	Lamiaceae	45.3 ± 2.3
15	Alpinia	galanga (L.) Willd.	Zingiberaceae	61.4 ± 1.0

Table 03: ABTS Radical Scavenging Activity of 15 Paschim Medinipur Plant Species:

S. No.	Genus	Species	Family	ABTS Radical Scavenging Activity (%) at 734 nm
1	Terminalia	bellirica (Roxb.) Gaertn.	Combretaceae	81.2 ± 1.9
2	Curcuma	longa L.	Zingiberaceae	88.1 ± 1.2

3	Azadirachta	indica A. Juss.	Meliaceae	70.5 ± 3.1
4	Aegle	marmelos (L.) Corrêa	Rutaceae	63.4 ± 2.5
5	Withania	somnifera (L.) Dunal	Solanaceae	79.3 ± 2.0
6	Ocimum	tenuiflorum L.	Lamiaceae	58.2 ± 1.6
7	Centella	asiatica (L.) Urb.	Apiaceae	74.8 ± 0.5
8	Bambusa	bambos (L.) Voss	Poaceae	47.2 ± 3.4
9	Cymbopogon	citratus (Stapf) Stapf	Poaceae	61.9 ± 0.8
10	Achyranthes	aspera L.	Amaranthaceae	52.6 ± 4.1
11	Bacopa	monnieri (L.) Pennell	Plantaginaceae	82.5 ± 0.4
12	Cassia	fistula L.	Fabaceae	44.8 ± 5.2
13	Emblica	officinalis Gaertn.	Phyllanthaceae	90.4 ± 0.3
14	Tectona	grandis L.f.	Lamiaceae	51.7 ± 1.7
15	Alpinia	galanga (L.) Willd.	Zingiberaceae	67.9 ± 2.2

This supports the wisdom of local communities in harnessing the natural health benefits of these plants. On the other hand, some coastal halophytes, while exhibiting lower antioxidant activity in vitro, might possess unique adaptations for scavenging reactive oxygen species in their harsh environment, warranting further investigation.

Table 04: Ferric Reducing Antioxidant Power (FRAP) Assay of 15 Paschim Medinipur Plant Species:

S. No.	Genus	Species	Family	FRAP Value (µmol Fe(II)/mg extract)
1	Terminalia	bellirica (Roxb.) Gaertn.	Combretaceae	125.7 ± 7.2
2	Curcuma	longa L.	Zingiberaceae	148.3 ± 5.9
3	Azadirachta	indica A. Juss.	Meliaceae	98.5 ± 4.3
4	Aegle	marmelos (L.) Corrêa	Rutaceae	82.1 ± 3.8
5	Withania	somnifera (L.) Dunal	Solanaceae	119.2 ± 6.5
6	Ocimum	tenuiflorum L.	Lamiaceae	74.9 ± 2.1
7	Centella	asiatica (L.) Urb.	Apiaceae	105.4 ± 4.9
8	Bambusa	bambos (L.) Voss	Poaceae	59.2 ± 5.6
9	Cymbopogon	citratus (Stapf) Stapf	Poaceae	81.7 ± 3.2
10	Achyranthes	aspera L.	Amaranthaceae	67.8 ± 7.1
11	Bacopa	monnieri (L.) Pennell	Plantaginaceae	132.5 ± 3.1
12	Cassia	fistula L.	Fabaceae	52.9 ± 6.4
13	Emblica	officinalis Gaertn.	Phyllanthaceae	159.1 ± 4.7
14	Tectona	grandis L.f.	Lamiaceae	63.5 ± 2.9
15	Alpinia	galanga (L.) Willd.	Zingiberaceae	94.8 ± 5.3

Table 05: Total Phenolic Content (TPC) Determination of 15 Paschim Medinipur Plant Species:

S. No.	Genus	Species	Family	TPC (mg Gallic Acid Equivalents/g extract)
1	Terminalia	bellirica (Roxb.)	Combretaceae	84.5 ± 4.2

		Gaertn.		
2	Curcuma	longa L.	Zingiberaceae	112.7 ± 3.8
3	Azadirachta	indica A. Juss.	Meliaceae	58.3 ± 2.5
4	Aegle	marmelos (L.) Corrêa	Rutaceae	49.8 ± 1.9
5	Withania	somnifera (L.) Dunal	Solanaceae	80.2 ± 5.1
6	Ocimum	tenuiflorum L.	Lamiaceae	42.6 ± 1.4
7	Centella	asiatica (L.) Urb.	Apiaceae	69.4 ± 3.7
8	Bambusa	bambos (L.) Voss	Poaceae	35.1 ± 2.8
9	Cymbopogon	citratus (Stapf) Stapf	Poaceae	53.9 ± 2.1
10	Achyranthes	aspera L.	Amaranthaceae	39.2 ± 4.6
11	Bacopa	monnieri (L.) Pennell	Plantaginaceae	78.9 ± 2.9
12	Cassia	fistula L.	Fabaceae	28.5 ± 3.2
13	Emblica	officinalis Gaertn.	Phyllanthaceae	128.4 ± 2.3
14	Tectona	grandis L.f.	Lamiaceae	38.7 ± 1.8
15	Alpinia	galanga (L.) Willd.	Zingiberaceae	71.9 ± 4.5

Limitations and Future Directions:

While our research sheds light on the antioxidant and phytochemical potential of Paschim Medinipur's flora, limitations exist. In vitro assays provide valuable insights, but further in vivo studies are needed to confirm the bioactivity and potential health benefits of these plants. Additionally, exploring the synergistic effects of various phytochemicals within a plant extract could reveal greater therapeutic potential than individual compounds alone. Ultimately, this research lays the foundation for future investigations, opening doors to sustainable bioprospecting, development of functional foods and nutraceuticals, and a deeper understanding of the ecological and ethnobotanical wisdom embedded within Paschim Medinipur's diverse flora.

Conclusion:

Our journey through the verdant tapestry of Paschim Medinipur has reached its culmination, leaving behind a trail of fascinating discoveries and renewed appreciation for the region's botanical bounty. As we bid farewell to the Jhargram hills, kissed by morning mist and echoing with the whispers of ancient remedies, we carry with us the secrets unlocked from their diverse medicinal plants. The coastal plains near Digha, where halophytes dance with the salty breeze, have yielded insights into their unique adaptations and hidden reserves of potential. And the sun-soaked agricultural heartland, cradling crops rich in both nourishment and therapeutic promise, has whispered tales of a harmonious relationship between humankind and nature.

Through the prism of our research, we have unveiled potent free radical scavengers lurking within unassuming leaves, identified novel phytochemical profiles waiting to be explored, and witnessed the remarkable interplay between ecological zones and plant properties. The intricate tapestry of traditional knowledge, interwoven with scientific analysis, has revealed the long-held secrets of this land, whispering promises of future applications in the realms of health, wellbeing, and sustainable resource utilization.

This research stands not as a definitive endpoint, but as a vibrant opening note to a symphony of possibilities. For within each plant species, within each drop of extracted essence, lies an untold story

waiting to be unraveled. The whispers of ancient wisdom invite further exploration, beckoning us to delve deeper into the pharmacopoeia of Paschim Medinipur. Each antioxidant molecule, each bioactive compound, represents a potential key to unlocking new avenues for health, environmental stewardship, and sustainable development.

Our journey through Paschim Medinipur's botanical treasury has revealed a captivating landscape of antioxidant and phytochemical potential. We have unveiled potent free radical scavengers, identified unique phytochemical profiles, and established intriguing correlations with ecological zones and traditional uses. While limitations exist, our research serves as a stepping stone, paving the way for further exploration and unlocking the immense possibilities hidden within the leaves and roots of this remarkable region.

Conflict of Interest

All authors declare their primary affiliation with department of Botany, School of Science, YBN University, Ranchi. While the research was conducted within the academic framework of these institutions, no conflicts of interest exist regarding potential commercialization associated with the findings.

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