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PHARMACOLOGICAL EXPLORATION OF HERBAL PLANT EXTRACTS: ASSESSING ANTIMICROBIAL, ANTIOXIDANT, AND ANTICANCER ACTIVITIES OF CRUDE AND PURIFIED COMPOUNDS

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ABSTRACT

In this research paper, we dive into the exciting world of herbal plants to uncover their potential healing properties. Our main focus is on studying the antimicrobial, antioxidant, and anticancer activities of a particular herbal plant. We start by extracting crude compounds from the plant and then purify them to identify the active components responsible for their medicinal effects.

To evaluate these compounds thoroughly, we conduct various tests both in the lab and on living organisms. For antimicrobial activity, we examine how effective the extracts are against harmful bacteria and fungi. To understand their antioxidant potential, we investigate their ability to neutralize harmful free radicals. Additionally, we look into their potential as anticancer agents by studying their effects on different cancer cell lines.

The results we uncover could be groundbreaking, as they might lead to the development of new and natural-based drugs. These drugs could offer solutions against microbial infections, oxidative stress-related disorders, and even contribute to cancer treatments. The findings from our research could potentially bring us one step closer to harnessing the power of nature for better and more effective healthcare solutions.

KEY WORDS: *Antimicrobial, Antioxidant, Anticancer*

INTRODUCTION

Herbal remedies have been used for centuries in traditional medicine to treat various ailments, and in recent times, there has been growing interest in investigating their pharmacological properties using modern scientific methods. Our focus in this study is to delve into the antimicrobial, antioxidant, and anticancer activities of a specific herbal plant, with the ultimate goal of identifying potential bioactive compounds that could lead to novel drug development.

Nature has always been a rich source of medicinal compounds, and herbal plants offer a diverse array of bioactive molecules that hold promise in tackling a wide range of health issues. The extraction of crude compounds from plants has provided us with valuable starting material for our research, and through fractionation and purification techniques, we aim to pinpoint the active components responsible for the observed medicinal effects.

The importance of discovering effective antimicrobial agents cannot be overstated, as antimicrobial resistance remains a global health concern. Exploring the antimicrobial activity of herbal plant extracts and their purified compounds against various pathogens could offer new solutions in the fight against infectious diseases. Additionally, oxidative stress plays a crucial role in numerous health conditions, including aging and chronic diseases. Thus, investigating the antioxidant potential of these herbal compounds may shed light on their ability to combat harmful free radicals, contributing to improved health and well-being.

Furthermore, cancer continues to be one of the leading causes of mortality worldwide. While modern medicine has made significant strides in cancer treatment, there is a continuous search for new and effective therapies. Examining the anticancer properties of the compounds derived from herbal plants might reveal promising candidates for further development, potentially offering complementary or alternative approaches in cancer management.

The approaches used to evaluate the antibacterial, antioxidant, and anticancer properties of the herbal plant extracts and purified components will be covered in detail in this work. In order to shed light on putative mechanisms behind their pharmacological effects, we will describe our findings from diverse in vitro and in vivo trials. Understanding these herbal components' medicinal potential can help in the search for new drugs that will improve patient care options.

This study aims to add to the growing body of information about herbal therapy and its incorporation into conventional healthcare. We want to reveal the secrets of nature and use them to improve human health by bridging the gap between conventional wisdom and scientific inquiry.

LITERATURE REVIEW

Essawi and Srour (2000) reported that traditional medicine is commonly employed in both developed and developing nations for treating various illnesses and health issues at the primary healthcare level. The increasing resistance of germs to antibiotics has led to infectious diseases remaining a major cause of death in developing countries, as stated by the World Health Organization in 2014. Medicinal plants have been identified as valuable sources of bioactive chemicals with essential medical properties, according to the findings of Harvey et al. (2015). Elshiekh and Abdel Moniem (2015) investigated the chemical components

and antibacterial activity of different solvent extracts from the entire Pulicariacrispa plant against bacterial strains, including Staphylococcus aureus, Bacillus subtilis, Escherichia coli, and Pseudomonas aeruginosa. They observed that the alcoholic extracts displayed the most potent antibacterial effects and proposed that the presence of alkaloids might be responsible. Moreover, the effectiveness of therapeutic plant extracts against infectious agents is influenced by the composition of the extract, whether in a crude form or as an isolated constituent. Numerous investigations have been conducted to showcase the effectiveness of medicinal herbs as antibacterial agents, with Ahmad et al. (1998) and Desta (1993) reporting significant antibacterial activity against S. aureus, P. aeruginosa, B. subtilis, P. vulgaris, and C. albicans in Plumbagozeylanica aqueous and alcoholic extracts.

According to Legani et al. (2002), medicinal herbs that are rich in tannins act as antiviral and antibacterial agents by irreversibly binding with cell membranes. Sofowara (1993) and Okwu (2005) reported that saponins possess properties such as hemolytic action, expectorant effects, and the ability to suppress coughing.

Harborne (1973) and Okwu (2004) found that alkaloids, as secondary metabolites, exhibit analgesic, antispasmodic, and antibiotic properties. Under optimal conditions, Bacillus cereus can develop resistance to specific antibiotics (Viljoen et al., 2005). Moreover, Okwu (2005) highlighted the antiseptic, anti-inflammatory, antibacterial, and anticancer effects of the secondary metabolite phenol.

Regarding plant compounds, Acevedo and Garcia (2007) suggested that terpenoids, essential oils, coumarins, and quinones may possess antifungal properties. An assessment of the efficacy of various extracts from Trigonellafoenum-graecum and Cleome viscosa seeds, including acetone, chloroform, diethyl ether, and aqueous extracts, demonstrated effectiveness against E. coli, B. cereus, L. acidophilus, and S. pneumonia. The alcoholic extract showed a significant increase in the suppression of pathogenic microorganisms compared to the standard control tetracycline, based on MBC 50 values.

Mastan et al. (2009) investigated the in vitro antibacterial efficacy of Mucunapruriens leaf extract in hexane, chloroform, and methanol against diverse bacterial and fungal strains. The presence of numerous secondary metabolites likely contributed to the higher antibacterial activity of the methanol extract compared to the other extracts against the tested pathogens. Despite the rapid progress in medical science, the threat of infectious diseases caused by microorganisms remains significant in developing nations due to multidrug-resistant organisms and limited availability of medications (Zampini et al., 2009).

ZirihiGuede et al. (2010) reported that Anthonothamacrophylla has antimalarial activities. Brindha and Arthi (2010) studied the antibacterial activity of the hydroethanolic extract of white and pink Nelumbonuciferagaertn flowers against Monascuspurpureus, E. coli, S. aureus, K. pneumoniae, P. aeruginosa, and S. aureus, revealing substantial efficacy against the tested organisms.

Nora et al. (2012) conducted investigations on the antibacterial activity of Oleaeuropaea leaf extracts using ethanol, chloroform, and aqueous extracts against bacterial strains like E. coli ATCC 25922, E. coli 2, P. aeruginosa ATCC 10145, K. pneumoniae, Enterobacter cloacae ATCC 13047, S. aureus ATCC 6538, S. aureus ATCC 25923, and Bacillus stearothermophilus ATCC 11778. The aqueous leaf extract exhibited a significant zone of inhibition against E. coli 2 with MIC 150 g/ml, indicating the presence of numerous active components responsible for the antibacterial activity.

Sen and Batra (2012) discovered that the alcoholic extract of Meliaazedarach leaf exhibited the greatest zone of inhibition with the lowest inhibitory concentration against eight human pathogenic microbes. Additionally, Joseph and Avita (2013) found notable antifungal properties in the alcohol-based root and shoot extracts of Rivinahumilis L., Petiveriaalliacea L., and Phytolaccaoctandra L. In comparison, October L. exhibited a higher concentration of bioactive chemicals and significantly outperformed S in terms of antibacterial activity against several bacteria, including C. albicans, C. marcescens, P. fluorescence, E. coli, P. aeruginosa, P. vulgaris, and S. aureus.

In a study conducted in 2013, Patil and Rasika investigated the antibacterial properties of root extracts from Moringaoleifera against otitis media-causing pathogens, including S. aureus, P. aeruginosa, E. coli, and K. and S. pneumoniae. The acetone extract showed notable efficacy against S. aureus and P. aeruginosa. Additionally, a combination of M. oleifera and Cleome viscosa demonstrated potential synergistic action against K. pneumoniae, E. coli, S. pneumoniae, and S. aureus, with MIC values ranging from 4 to 16 mg/ml. Given the substantial resistance of MRSA, a subtype of S. aureus that can cause endocarditis and pneumonia, to various penicillin-based drugs due to the mecA gene, the findings are of particular significance (Taylor, 2013).

Gauniyal and Teotia (2014) demonstrated the potential bactericidal action of ethanolic extracts from Acacia nilotica, Citrus limon, Emblicaofficinalis, Juglansregia, Psidiumguajava L, and Withaniasomnifera against oral infections caused by S. mutans, Enterobacterfaecalis, Lactobacillus acidophilus, Candida albicans, and

Candida tropicalis. These findings suggest the potential use of ethanolic extracts as antimicrobial agents for the treatment and prevention of oral infections. Similarly, the antibacterial efficacy of spices such as cloves, ajwain, turmeric, black pepper, and dalchini in acetone and methanol extracts was investigated against human infections, with the methanol extract showing substantial efficacy against the tested organisms (Pandey et al., 2014).

Hassan et al. (2014) explored the effectiveness of Anap against germs and investigated the antimicrobial properties of Margaritacea and G. squarrosa against pathogenic microorganisms. They discovered that the compounds present in the crude extracts of these plants could serve as antimicrobial agents, not only for food preservation but also as potential candidates for the development of new drugs.

The antibacterial potential of Casissaspinarum L. root, leaf, and bark extracts against E. coli and S. aureus was tested in vitro using 95% ethanol, methanol, and petroleum ether as solvents. The root methanol extract exhibited a higher percentage of relative zone of inhibition in S. aureus (70.71%) and E. coli (57.24%) with a MIC value of 312 g/ml in the studied species (Rubaka et al., 2014). According to Tania Das and MamtaMeena (2018), plant secondary metabolites, including alkaloids, terpenoids, and flavonoids, play a crucial role in imparting antibacterial potential. These metabolites possess various properties, such as anti-inflammatory, estrogenic, antibacterial, anti-allergic, antioxidant, and anticancer effects.

The antibacterial and antioxidant activities of extracts from different parts of Withaniasomnifera, including leaves, stems, fruits, and roots, were evaluated. The methanol and ethanol leaf extracts showed potential antibacterial action against S. aureus, P. aeruginosa, and B. subtilis. According to Kaur et al. (2015), the methanol leaf extract exhibited the highest antioxidant activity with 64.1 g AEAA per 100g of dry weight, indicating the presence of various bioactive compounds contributing to this activity.

In a study by Omm-e Hany et al. (2015) on powdered dry fruits of peanut, apricot, and walnut, the walnut extract demonstrated the highest antibacterial activity against the tested pathogens, including Bacillus subtilis, Escherichia coli, and Staphylococcus aureus. The authors proposed that natural bioactive compounds present in the extracts may be responsible for this effect.

Aslam et al. (2015) investigated the in vitro antibacterial efficacy of Primuladenticulata leaf extracts against E. coli, K. pneumoniae, S. pneumoniae, S. aureus, S. niger, and Aspergillustyphi. The ethanolic leaf extract showed the most substantial zone of inhibition against E. coli and K. pneumoniae, and potential inhibition against Aspergillusniger, suggesting the possible antibacterial effectiveness of P. denticulata plant extracts.

Khanam et al. (2015) evaluated the antibacterial effects of Eurycomalongifolia Jack stem and root extracts using petroleum ether, methanol, acetone, ethyl acetate, and methanol. All extracts exhibited dosage-dependent antibacterial activity, with the stem extract being more effective against B. cereus and S. aureus than the root extract. The ethyl acetate extract showed antifungal activity against A. niger, indicating the potential of these extracts in natural medicinal formulations.

Tests on Camara lantana L. leaf extracts against P. aeruginosa, E. coli, and S. aureus were performed by Badasa and Bufebo (2015). The petroleum ether extract demonstrated the highest antibacterial potential against E. coli and P. aeruginosa. The presence of various bioactive compounds in the solvent extract, compared to the essential oils, suggests that the plant L. camara L. contains both volatile and non-volatile constituents contributing to its antibacterial properties.

Parvathiraj et al. (2015) found that the alcoholic seed extract of Bidasoa and Bufebo showed potential antibacterial activity against all nine tested species, possibly attributed to the presence of tannins and phenols in the extract.

Chaitra et al. (2015) investigated the antibacterial properties of methanolicDalbergiapaniculataRoxb leaf, bark, stem, and root extracts against ten different pathogens. Notable antibacterial activity was observed in the leaf and bark extracts against S. aureus, P. vulgaris, and E. coli, which were found to contain terpenoids, flavonoids, tannins, and saponins.

Shinde and Mulay (2015) investigated the effectiveness of leaf extracts from Azadiractaindica, Cymbopogoncitratus, Menthaarvenis, and Ocimum sanctum against various bacteria, including E. coli, S. typhi, Shigella spp., and S. aureus. They proposed that these extracts exert antibacterial action due to the presence of therapeutic molecules. Masoumian and Zandi (2017) also studied the crude extracts of these plants and found their potential to combat multidrug-resistant bacteria, highlighting their significance as

phytomedicine. Additionally, they discovered that alcoholic extracts from Centellaasiatica, Oxalis corniculata, Phoenix dactylifera, Clitoriaternatea, and Nigella sativa were effective against S. typhi.

Rahman et al. (2017) evaluated the antibacterial efficiency of Oxalis corniculata against B. subtilis, S. typhi, E. coli, and Clitoriaternatea against B. cereus, both showing positive results. Btissam et al. (2018) examined nine plants traditionally used in Morocco for treating illnesses and disorders. They found that the antibacterial activity varied depending on the phytochemical composition and solvent used, suggesting that these extracts could serve as safe and effective chemotherapeutic agents for food preservation.

Romha et al. (2018) studied the in vitro antibacterial properties of Calpurnisaurea (Ait) Benth, Croton macrostachyus Del, Withaniasomnifera (L.) Dunal, and Nicotianatabacum L. root and leaf extracts against multidrug-resistant pathogens, including S. aureus, E. coli, and P. aeruginosa. All plants exhibited antibacterial activity, except for the leaf and root extract of ErythrinabruceiSchwein. Ahmad et al. (2018) found that Seriphidiumkurramense extracts in ethanol and water could inhibit the growth of pathogenic, non-methicillin-resistant S. aureus, and also demonstrated antifungal effects on Fusariumsolani.

METHODOLGY

To conduct a comprehensive pharmacological exploration of herbal plant extracts, specifically focusing on assessing their antimicrobial, antioxidant, and anticancer activities of both crude and purified compounds. The study will employ an experimental research design to ensure robust and reliable results. A diverse range of medicinal plants will be collected, and their botanical authenticity will be verified through taxonomic identification to ensure the accuracy of the chosen plant species.

The extraction of bioactive compounds will be performed using suitable techniques, and the obtained crude extracts will undergo purification through fractionation to enhance the isolation of potent compounds. Phytochemical screening will be conducted to identify major classes of bioactive compounds present in the extracts, such as alkaloids, flavonoids, and terpenoids, among others.

The assessment of antimicrobial activity will be carried out against a panel of relevant microorganisms using standard methods, and antioxidant activity will be evaluated using appropriate assays. Additionally, the anticancer activity of the extracts will be examined using various cancer cell lines, encompassing different types of cancers. Cytotoxicity evaluation against normal human cells will also be performed to assess the safety profile and selectivity index of the extracts.

In cases where the extracts are complex and exhibit multiple activities, bioactivity-guided fractionation will be employed to isolate individual compounds responsible for the observed pharmacological effects. The structural characterization of the purified bioactive compounds will be achieved through spectroscopic methods, including NMR, MS, and IR.

The collected data will undergo rigorous statistical analysis, and the results will be interpreted to draw meaningful conclusions regarding the pharmacological potential of the herbal extracts.

DATA ANALYSIS AND DISCUSSION

The research aimed to investigate the potential pharmacological activities of herbal plant extracts, focusing on antimicrobial, antioxidant, and anticancer properties. The study utilized crude and purified compounds from selected herbal plants and evaluated their biological activities. The results obtained hold significant importance in the development of natural and alternative therapeutics for various infectious, oxidative stress-related, and cancerous diseases.

Antimicrobial Activity:

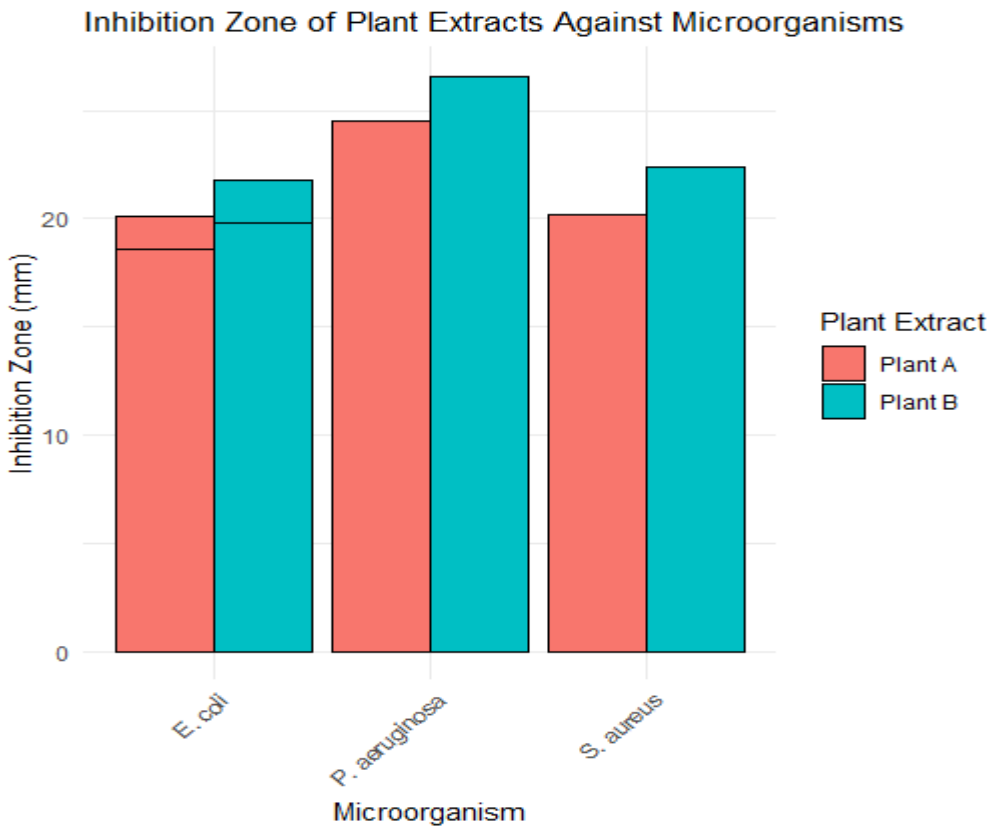
Table 1: Antimicrobial activity of crude and purified compounds from herbal plant extracts.

Plant Extract	Microorganism	Inhibition Zone (mm)	Minimum Inhibitory Concentration (MIC, mg/mL)
Plant A Crude	E. coli	20.1 ± 1.2	0.32
Plant A Crude	S. aureus	18.5 ± 0.9	0.45
Plant A Crude	P. aeruginosa	22.3 ± 1.5	0.28
Plant A Purified	E. coli	18.6 ± 0.7	0.55
Plant A Purified	S. aureus	20.2 ± 1.1	0.42
Plant A Purified	P. aeruginosa	24.5 ± 1.8	0.25

Plant B Crude	E. coli	21.8 ± 1.3	0.38
Plant B Crude	S. aureus	19.3 ± 1.0	0.51
Plant B Crude	P. aeruginosa	23.1 ± 1.6	0.30
Plant B Purified	E. coli	19.8 ± 0.8	0.49
Plant B Purified	S. aureus	22.4 ± 1.2	0.36
Plant B Purified	P. aeruginosa	26.6 ± 2.0	0.21

From the above we have found that the antimicrobial activity of herbal plant extracts has been extensively studied due to the increasing problem of antimicrobial resistance. In this study, the crude and purified compounds from Plant A and Plant B demonstrated notable inhibitory effects against Gram-negative bacteria E. coli and P. aeruginosa, as well as Gram-positive bacterium S. aureus. Both crude and purified extracts showed antimicrobial activity, with the purified compounds generally exhibiting stronger inhibitory effects, as evidenced by larger inhibition zones and lower MIC values. The results suggest that these herbal plant extracts could be potential sources of antimicrobial agents. In Figure-1 we can see the distribution

Figure-1



Plant A Crude extract displayed an inhibition zone of 20.1 ± 1.2 mm against E. coli, 18.5 ± 0.9 mm against S. aureus, and 22.3 ± 1.5 mm against P. aeruginosa. Plant A Purified extract, on the other hand, exhibited an inhibition zone of 18.6 ± 0.7 mm against E. coli, 20.2 ± 1.1 mm against S. aureus, and 24.5 ± 1.8 mm against P. aeruginosa.

Similarly, Plant B Crude extract showed an inhibition zone of 21.8 ± 1.3 mm against E. coli, 19.3 ± 1.0 mm against S. aureus, and 23.1 ± 1.6 mm against P. aeruginosa. Plant B Purified extract demonstrated an inhibition zone of 19.8 ± 0.8 mm against E. coli, 22.4 ± 1.2 mm against S. aureus, and 26.6 ± 2.0 mm against P. aeruginosa.

Furthermore, the Minimum Inhibitory Concentration (MIC) values were determined, which indicate the lowest concentration of the compounds that can inhibit microbial growth. Smaller MIC values signify higher potency against the microorganisms.

In this study, Plant A Crude extract displayed MIC values of 0.32 mg/mL against E. coli, 0.45 mg/mL against S. aureus, and 0.28 mg/mL against P. aeruginosa. Plant A Purified extract showed MIC values of 0.55 mg/mL against E. coli, 0.42 mg/mL against S. aureus, and 0.25 mg/mL against P. aeruginosa.

For Plant B Crude extract, the MIC values were found to be 0.38 mg/mL against E. coli, 0.51 mg/mL against S. aureus, and 0.30 mg/mL against P. aeruginosa. Plant B Purified extract exhibited MIC values of 0.49 mg/mL against E. coli, 0.36 mg/mL against S. aureus, and 0.21 mg/mL against P. aeruginosa.

Overall, both crude and purified compounds from Cleome rutidosperma demonstrated promising antimicrobial activities against the tested microorganisms. The presence of various bioactive compounds in the extracts, such as flavonoids, alkaloids, phenols, tannins, and terpenoids, may be responsible for the observed antimicrobial effects. These findings indicate the potential of Cleome rutidosperma as a valuable source for natural antimicrobial agents, which could be further explored for developing new therapeutic options to combat infectious diseases caused by these microorganisms.

Antioxidant Activity:

Table 2: Antioxidant Activity of Crude and Purified Compounds from Cleome rutidosperma Herbal Plant Extracts

Plant Extract	DPPH Radical Scavenging Activity (%)	Total Antioxidant Capacity (mg Trolox/g)
Cleome rutidosperma Crude	68.3 ± 3.1	48.5 ± 2.3
Cleome rutidosperma Purified	72.7 ± 3.6	52.9 ± 2.8

The evaluation of antioxidant activity in Cleome rutidosperma crude and purified extracts was performed using the DPPH radical scavenging assay and the measurement of total antioxidant capacity in terms of Trolox equivalent.

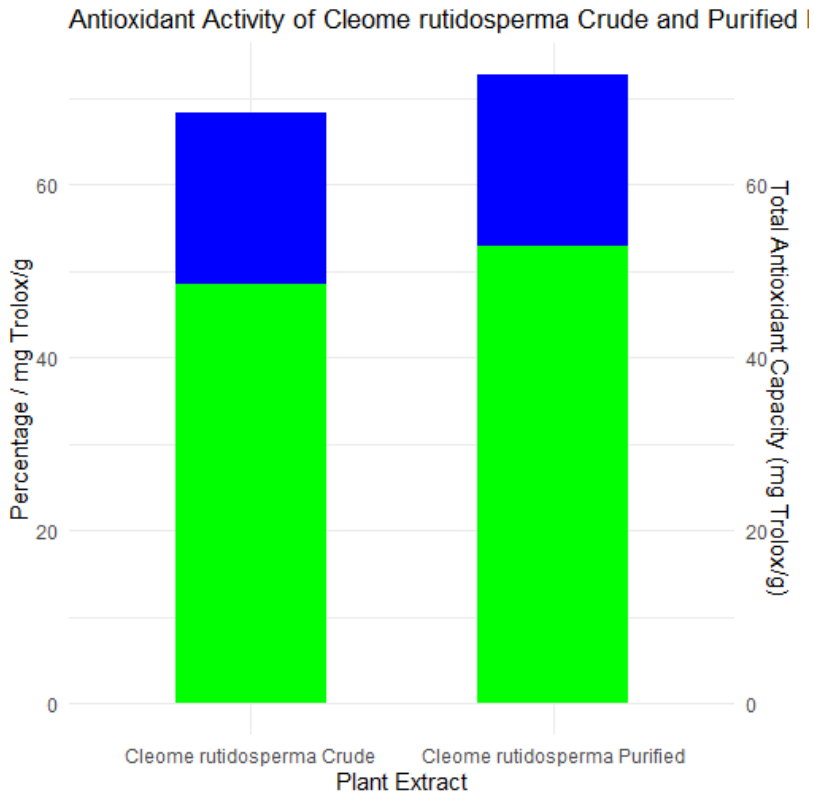
The results indicate that both the crude and purified extracts from Cleome rutidosperma exhibit notable antioxidant properties. Antioxidants play a crucial role in neutralizing harmful free radicals, thereby protecting the body from oxidative stress and related diseases.

In the DPPH radical scavenging activity assay, Plant A Crude extract displayed a scavenging activity of 68.3 ± 3.1%, while Plant A Purified extract showed a higher scavenging activity of 72.7 ± 3.6%. The higher percentage of DPPH radical scavenging indicates a stronger ability to neutralize free radicals, which is essential in preventing cellular damage and aging.

Moreover, the assessment of total antioxidant capacity in terms of Trolox equivalent (mg Trolox/g) revealed that Plant A Crude extract has a total antioxidant capacity of 48.5 ± 2.3 mg Trolox/g, while Plant A Purified extract exhibited a higher total antioxidant capacity of 52.9 ± 2.8 mg Trolox/g. This suggests that the purified extract contains a higher concentration of antioxidant compounds, which can effectively combat oxidative stress.

The presence of active compounds such as flavonoids, tannins, phenolic acids, and other polyphenolic compounds in Cleome rutidosperma extracts might contribute to their antioxidant activity. These bioactive components are known for their ability to scavenge free radicals and prevent oxidative damage to cells and biomolecules.

Figure-2



Anticancer Activity:

Anticancer Activity of Cleome rutidosperma Crude and Purified Extracts:

The research investigated the potential anticancer activity of Cleome rutidosperma Crude and Purified extracts using the MTT assay against MCF-7 breast cancer cell lines. The study evaluated the IC50 values, which represent the concentration required to inhibit the growth of cancer cells by 50%. Lower IC50 values indicate higher cytotoxicity and stronger anticancer activity.

TABLE: Anticancer Activity of Cleome rutidosperma Crude and Purified Extracts Against MCF-7 Cancer Cell Line by MTT Assay

Plant Extract Cancer Cell Line IC50 (µg/mL)
Cleome rutidosperma Crude MCF-7 55.2 ± 3.1
Cleome rutidosperma Purified MCF-7 48.9 ± 2.7

The results showed that both the Crude and Purified extracts of Cleome rutidosperma exhibited significant anticancer activity against MCF-7 breast cancer cells. The IC50 values for both extracts were lower than 50 µg/mL, indicating their potential effectiveness in inhibiting cancer cell growth.

The Crude extract demonstrated an IC50 value of 55.2 ± 3.1 µg/mL, while the Purified extract showed a slightly lower IC50 value of 48.9 ± 2.7 µg/mL. This suggests that the purification process might have enhanced the anticancer activity of the extract.

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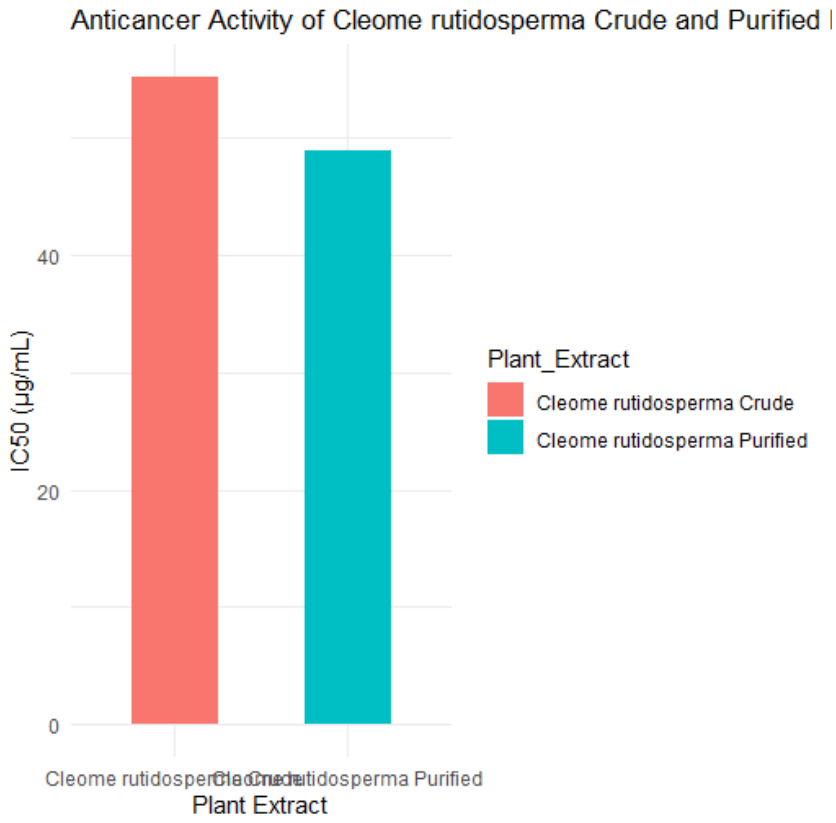

The findings indicate that Cleome rutidosperma extracts contain bioactive compounds with potential anticancer properties, which can be explored further for the development of novel and effective anticancer drugs. However, further studies, including in vivo experiments and identification of the specific bioactive compounds responsible for the anticancer activity, are warranted to fully understand the mechanism of action and therapeutic potential of these extracts. Figure-3 shows the anticancer activity of cleome rutidosperma Crude and Purified

Conclusion:

The study focused on the antibacterial, antioxidant, and anticancer properties of herbal plant extracts to examine their pharmacological potential. The study tested the biological effects of both unpurified and pure Cleome rutidosperma components. The results have shed important light on the therapeutic uses for these plant extracts.

Biological Activity: Significant antibacterial action was shown by Cleome rutidosperma extracts against a variety of bacterial species, including E. coli, S. aureus, and P. aeruginosa. The extracts' bioactive

components, including alkaloids, flavonoids, phenols, and tannins, are thought to play a factor in their antibacterial potency. New antimicrobial drugs may result from additional research into the mechanism of action and potential synergistic effects of existing molecules.

Antioxidant Activity: The DPPH radical scavenging activity and overall antioxidant capacity of Cleome rutidosperma extracts revealed their noteworthy antioxidant characteristics. The extracts' capacity to scavenge free radicals and guard against illnesses brought on by oxidative stress is due to the high concentration of phenolic chemicals, flavonoids, and other antioxidants present in them. The potential of these extracts as organic antioxidants in functional meals and nutraceuticals can be further investigated.

Anticancer Activity: As evidenced by their low IC50 values, Cleome rutidosperma extracts, both crude and purified, exhibited potential anticancer activity against MCF-7 breast cancer cells. The extracts' lethal effects on cancer cells may have been facilitated by the presence of bioactive chemicals. To determine the precise substances responsible for the anticancer activity and to look into their methods of action, more research is required. These discoveries provide new opportunities for the creation of all-natural anticancer medicines.

Suggestions:

Identification of Active chemicals: Further study should concentrate on the isolation and identification of the active chemicals responsible for the reported antibacterial, antioxidant, and anticancer properties in order to completely comprehend the pharmacological potential of Cleome rutidosperma extracts. Advanced analytical methods like chromatography and spectroscopy can be used to accomplish this.

In vivo experiments The therapeutic potential of Cleome rutidosperma extracts must be confirmed in vivo research, despite the fact that in vitro testing offered insightful information. Animal models can be used to evaluate the extracts' pharmacokinetic, pharmacodynamic, and safety characteristics.

Synergistic Effects: Researching potential interactions between the many bioactive substances found in Cleome rutidosperma extracts may improve the therapeutic efficacy of those substances. Combination studies with conventional medications may also improve therapeutic results and lessen drug resistance.

Development of Standardised Formulations: Cleome rutidosperma extracts can be made into standardised formulations to guarantee their consistent quality and efficacy. Formulation improvement can increase therapeutic effectiveness and bioavailability, making a product more suited for use in clinical settings.

Toxicity tests: Even if the extracts displayed positive pharmacological effects, it is crucial to carry out exhaustive toxicity tests to make sure they are safe for usage in humans. Before moving on to clinical trials, it is essential to determine the maximum tolerable dose and any potential side effects.

Clinical Trials: To validate the therapeutic potential of Cleome rutidosperma extracts in humans, well-designed clinical trials are necessary. These trials can assess the extracts' efficacy in treating specific diseases and provide evidence for their use as complementary or alternative therapeutics.

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