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EXPLORATION OF PEROVSKIA ABROTANOIDES KAR. OILS: ANTIMICROBIAL AND ANTIOXIDENT EFFECTS

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ABSTRACT

Background: *Perovskia abrotanoides, a medicinal plant indigenous to the Baluchistan province and northern regions of Pakistan, is renowned for its therapeutic properties. Despite its widespread traditional use, comprehensive data on its chemical composition and biological properties are lacking.*

Objective: *This study aimed to elucidate the chemical composition and biological activities of essential and fixed oils extracted from Perovskia abrotanoides, focusing on antioxidant and antimicrobial properties.*

Methods: *Gas Chromatography-Mass Spectrometry (GC-MS) analysis was employed to identify chemical constituents. Antioxidant activity was assessed using DPPH radical scavenging assay, linoleic acid peroxidation inhibition assay, and reducing power assay. Antimicrobial activity was evaluated using the disc diffusion method and Minimum Inhibitory Concentration (MIC) determination. In vivo studies on animal models were conducted to assess antioxidant and antimicrobial effects.*

Results: *The study revealed diverse chemical compositions in the essential and fixed oils extracted from stems and leaves. Essential oils exhibited significant antioxidant activity, with variations observed between stem and leaves. Fixed oils also showed antioxidant potential, albeit to a lesser extent. Antimicrobial activity varied across microorganisms, with notable inhibition observed against specific strains.*

Conclusion: *Perovskia abrotanoides oils exhibit promising antioxidant and antimicrobial properties, suggesting their potential as natural remedies. Further research is needed to identify specific bioactive compounds and explore their therapeutic applications*

INTRODUCTION.

Background

P. Abrotanoides, Visk, or domou, an essential medicinal plant of Balochistan and Northern provinces of Pakistan (Mahboubi & Kazempour, 2009). A range of therapeutic merits have been ascribed to this plant by the local community, which leverages them to counter a number of health complications, such as typhoid, headache, gonorrhea, vomiting, motion sickness, toothache, atherosclerosis, cardiovascular diseases, liver fibrosis, and cough (Moallem & Niapour, 2008). This way, the plant's multifarious properties, such as inducing relaxation, relieving pain, antimicrobial, and imparting the cooling sensation, illustrate its very important role in traditional medicine (Nasiriasl et al., 2002). In fact, tea extracted from Perovskia abrotanoides was conventionally utilized to counter infections and relieve dysuria (Ballabh et al., 2008).

Besides, Perovskia abrotanoides possesses a noticeable pharmacological effect, which has been proven with its anti-plasmodial, anti-inflammatory and cytotoxic effects (Sairafianpour et al., 2001). Its antioxidant nature has created a buzz in the health community for its role in promoting heart health and countering low cellular function as well as the toxicity that leads to infections, viruses, and some types of cancer cells. The essential and fixed oils inside Perovskia abrotanoides have a very important role in the storage of grains as it has been proven efficient for wound cleansing and for dealing with ringworms, cutaneous parasites, fungal infections, hypoxia (Rustaiyan et al., 2006).

Despite the variety of the Perovskia abrotanoides uses, a considerable amount of researched information regarding its chemical components and bio properties is almost non-existent (Celen Yuceturk et al., 2021). Our study was geometrically designed to examine the subsurface and untouched oil constituents in the stems and in-between the leaves of P. abrotanoides. In this, our research sought to determine the antioxidant and antibacterial properties that are naturally present in the plant, such that through the findings we help in enhancing the understanding of the therapeutic potential of the medicinal plant

Rationale:

Research on the role of Perovskia abrotanoides Kar. in humans can potentially provide new insights and treatments for various health conditions. oil is mostly derived from this plant's role as an important medicinal plant in Baluchistan province and up north partly in Pakistan. It is by virtue of its traditional uses that cure numerous diseases like typhoid and cardiovascular disorders that Perovskia abrotanoides has proven to be a viable source of therapeutic opportunities. Although everybody knows how this plant is being used in the

different industries yet the chemical formulation and the biological properties of its constituents are not completely known. Hence, the investigation that will be carrying out is to fill this gap in our understanding of the molecular composition of the leaf and stem and untangle their unchanging constitution.

Significance:

Medicinal and pharmacological usefulness of Perovskia abrotanoides are evident from the documented claims. antimalarial activity, anti-inflammatory activity, cytotoxic activity, and antioxidant activity. The plant's oils, both because they are simple and reliable choices that have been proven to work in situations like wound cleansing, which is an example. disinfection of water, keeping off pathogens, and storing grains at optimum conditions.

Getting it clear about the chemical constituents and chemical cross activity are essential in the development of a product. and the biological power of these fatty acids is the key to the proper utilization of their therapeutic properties. Also, the antibacterial attributes of Perovskia abrotanoides oils are indicative of them being in their prospective use. antibiotic candidates to tackle enterological infections involving bacteria and fungal infections. This primary objective is to generating new evidence. aside from the information about this species in general, we also have some original insights into the variety of advantages and uses of Perovskia abrotanoides Kar. oils.

OBJECTIVES:

Chemical Composition Analysis:

- To clarify the important and volatile oil compositions of Perovskia abrotanoides Kar by the gas chromatography mass spectrometry (GC-MS). stems

Antioxidant Activity Evaluation:

- The purpose to determine the antioxidant activity of the essential and fixed oils is through DPPH radical. scavenging assay.
- For this purpose, stabilizing activity of the oil samples was analyzed by using the linoleic acid peroxidation assay followed by the comparison of the obtained results to the one for the std. synthetic antioxidant BHT.
- In order to determine the reducing power of oils and figure out their ability to fight with, we will have to use the process of fractional distillation. oxidative stress.

Antimicrobial Activity Investigation:

- To assess the antimicrobial power of the essential and the fixed oils via the disc diffusion method.
- For getting the MIC values of the oils against the test organisms the following method shall be played microorganisms.
- In order to investigate the antimicrobial effects of Perovskia abrotanoides oils and observe the activity of the positive controls.

In Vivo Activity Assessment:

Perovskia abrotanoides Kar. was studied in vivo to unravel its action. oils on antioxidant and microbial killing capabilities using animal experiments.

MATERIALS AND METHODS

Plant Material Collection

Perovskia abrotanoides Kar. the scientists worked in precise ways, taking care to pick up the stems and leaves from their natural environment. habitat of the endangered species are in the Baluchistan province and the northern parts of Pakistan. By all means necessary, particular attention was paid to make a choice of the best healthy and mature plant specimens, all of them being different, thus enhancing the variety of the plant chemical constituents.

Extraction of Essential and Fixed Oils

In this project the implementation of cutting-edge technologies served to the recovery of all critical elements. oils from the Perovskia abrotanoides that are bounded. Essential oils were under acquired using perfectly individualistic methods. precise method of vaporising using the stem and leaf of the plant. This method ensured the the maintainability of volatile compounds that bring about the tastiness and the health merit. properties. Concurrently, a selective extraction of the fixed oil was conducted exploiting the solvent extraction method. The suitable solvent was used to attain the plant's complete profile of lipid-soluble components. Constituents.

Chemical Analysis Using Gas Chromatography-Mass Spectrometry (GC-MS)

The composition of essential and fixed oils was laid on bare by Gas Chromatography-Mass Spectrometry (GC-MS) analysis. This sophisticated analytical technique made creep of breaking down the mixture and getting to single components of a compound body. extraction

of the active compounds in the oils is one of the factors affecting the efficiency. Through the use of detailed infrared (GC) and mass spectra, GC-MS provides the most accurate and reliable information the results of the analysis helped us to identify the chemical components of the product, and to quantify the concentrations of the given compounds a sound knowledge of the molecular construction of fatty acid content of Perovskia abrotanoides oils..

ANTIOXIDANT ACTIVITY

DPPH Radical Scavenging Assay

The research for the antioxidant capacity of the essential and fixed oils also incorporated the use of the Frankenstein approach. wit the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radic scavenging test. This widely recognized the antioxidant capacity of the fats will be assessed by a method that is used to determine this. The inhibitory IC50 for each oil sample was determined and all results were presented in numerical form, which provides us with qualitative data. which helps to neutralize cell-damaging DPPH radicals that prevents them from causing harmful reactions in the body. the lower the IC50 tendency indicates that the drug is efficacious. the stronger the antioxidant function, antitracking becomes clearer and, consequently, the ability of the oil to clear free radicals is revealed better scavengers.

Linoleic Acid Peroxidation Inhibition

The oils' efficacy on lowering the rate of peroxidation, which is the primary mechanism of oxidative stess, is impressive. damage, was rigorously evaluated. This analysis was devoted to learning more about the oils' functionality. blocking the oxidation processes during prolonged incubation of linoleic acid. The percentage after the creation of controlled concentrations the resulting values were investigated and subsequently compared with those of synthetic. antioxidant butylated hydroxytoluene (BHT). Careful analysis of this information was insightful for the in impacting oil stability by inhibiting the lipid oxidation the mechanism that accounts for their effectiveness should be explored. in mitigating oxidative stress.

Reducing Power Assay

The reducing capacity of the oils was systematically evaluated to the full extent while a reducing was carried out power assay. On this test, the capacity of oil samples to decrease ferrius ions was evaluated, and that indicated their ability to not only do they give away electrons but also they promote the flow of electrons as well. The absorbance at 700nm has

been efficiently and specifically recorded in an updated and streamlined process compared among the samples. This evaluation overflowed us with the proposition that oils can be successfully used this way as RARs, these radicals have the potential to become oxidative stress fighters by giving up their electrons and stabilizing reactive species. The Compost and Soil Worms' Role Expressed through the oils' assay results offered important information regarding chemicals' requirements unique function of donating or receiving electrons and thus become part of redox chemistry, a key mechanism in activities of ROS neutralization.

ANTIMICROBIAL ACTIVITY

Disc Diffusion Method

The tests were done to evaluate the effectiveness of both volatile and oil extracts as anti-microbials. Which is done by using firstly the disc diffusion method, a conventional method that is used to detect antibacterial agents specifically efficacy. In this method, area of IZs (IZA) were observed very carefully to get the oil properties working capacity against microorganism variability. Greater inhibition zone is the indication of higher effect of chemical components of the extract. Whose of natural elements had been the most superb in straightening up the growth or proliferation of the bacteria and fungi. This method was of great importance, giving detailed knowledge of the essential nature of the oil in the creation of extended microbial safety activity.

Minimum Inhibitory Concentration (MIC)

In addition to knowing basic antimicrobial capabilities, the MIC test will be used to do a more in depth account of the oils' antiseptic properties. MIC was determined following some of the micro dilution method. This being the quantification approach, enabled us to measure more precisely the deaths resulting from war the lowest measure of the oils was calculated out, which killed the growth of the tested cultures microorganisms. Lower MIC values are recognized as greater potency which bears meaning to the oils due to their effectiveness kill micro flora. The minute amounts of chlorine will also be enough to stop the growth of micro flora. It gave me precious knowledge as I was able to look beyond mainstream media and gather information about the situation that may have been generally unavailable. both how these oils work for arresting the growth of bacteria and fungi, as well as how they enhance the effectiveness of drugs, the proposed guidelines will enrich consumers with knowledge. one of the main tasks of these researchers is to evaluate the effectiveness is therapeutic of the drug in question.

Positive Controls

A credible comparison with both of the businesses needs Novidate and Fungone to provide the baseline hence creating the base for comparison as well. including positive controls for bacterial and fungal with strains. These well-known and standardized medications could be used to test oil efficiency against, a somewhat indirect method of testing potency. Even though Novidate and Fungone are the past antibiotics but they have shown their known and consisitent antibacterial activity. By To have a valid experiment, where a strong control is used, the study intended to provide for a comprehensive comparative analysis even though the difference might exist. a thorough understanding of the oils in terms of efficacy in accordance to standard pharmacopeias. standards. In this way, there was enhancement of the precision and reference of the outcome data, which favored our study findings. there are questions surrounding which oil performs best and how it is applied in a more global context.

INVIVO ACTIVITY

The research process implies recourse to treatable animals, including mice, rats, etc., to replicate possible outcomes. human effects. Ethical approval is obtained for animal handling, which means, we comply to ethical standards. guidelines. Toxicity studies and in vitro examinations are the main factors determining the dosage levels. Antioxidant and the following parameters: antimicrobial activity and oxidative stress markers assessed in vivo, were measured. The treatment is analyzed using the bacterial or fungal load reduction as a measure of Perovskia abrotanoides oils' effectiveness specific tissues or samples. Data is collected and is analysed, with correlations set up with the indoor and outdoor environment conditions. explore in vitro results to help with the translation to the possible clinical significance. Large-scale studies explaining why migration is a good way for economic development in source countries of migrants the in vivo, antioxidant, and anti-microbial effects of Perovskia abrotanoides oils are carried out. not only through experiments, but also through analysis of results that help to explain oils' mechanisms of action. potential and safety profile.

STATISTICAL ANALYSIS

An appropriate method of statistics was used to analyze the data and make comparison between the antioxidant and antidiabetic activities of the extracts. Antibacterial activities of the essential and fixed oils.

RESULTS

Pakistan is supported by various sorts of agrogeoclimatic spectrums, which results in a great variety of flora and fauna. generation of high quality of flora nationwide. The extreme variety of flowers in such area should be something to pride ourselves . tribes of indigenous people, so as to provide lots of ingredients that they might prepare for the food and the production of herbal remedies. therapies which is aimed at the treatment of multiple health concerns. Amidst this diverse range of living organisms, it is widely recognised that antimicrobials and antioxidants derived from plants has therapeutic advantages devoid of the adverse effects typically linked to artificial medications. This highlights their definite future in making a difference among many infections and diseases. However, a great deal the medical potential of botanicals which remain unexploited and unexplored in these regions has not been fully utilised.

CHEMICAL COMPOSITION ANALYSIS:

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis:

Perovskia abrotanoides Kar. is considered so worth noting because of the distinctive chemical constitution. oils, extracted from both Although one might infer stems and leaves were the only constituents to be identified, such information was provided through the utilization of Gas Chromatography-Mass Spectrometry (GC-MS). analysis. By employing this artistry method of analysis, the molecules could be separated and identified given the instruments at the time. individual blend of components that is part of the different essential and fixed oils that make the mixture.

Stem Essential Oil:

The GC-MS of the essential oil acquired from the stems provided a diversified assortment of. chemical constituents. The major key component characteristic of this extract was (E)-9-dodecenel. complex, provide added flavors and creates an oil with therapeutic traits. Additional identified compounds included.

Leaves Essential Oil:

In this situation, the main component of Perovskia abrotanoides leaves' essential oil, (E)-9-dodecenel, is used a mono compound, yet does the concentration not vary from that of the stem essential oil. On the other hand, alongside these captivating components, there were many other substances that contributed to the chemical nature of the leaves essential oil.

Stem Fixed Oil:

The GC-MS of the oil preparation from stems allowed to understand the lipoprotein composition of the oil constituents. Small amount of hexadecanoic acid was identified hence confirming its importance significance to the therapeutic features of the neem tree's fixed oil. The content of fatty matter thereby augmenting the chemical composition of the oil extracted from the stem bark.

Leaves Fixed Oil:

Much like the stem fixed oil, the hexadecanoic acid again represented the majority chemical compound of the fixed oil. the oil inside the leaves. The differences in fixed oil proportions in hydrocarbon fractions of asphalt resulted in different distributions. the chemical composition of the seed oils were analyzed. Consequently these results reflect the extraordinary chemical variability found in this species Perovskia abrotanoides Kar. oils, wherein this variation is apparent between stem and leaves, and between essential and fixed. The discovered molecules provide a starting point for clarifying the molecular mechanisms behind the therapeutic outcomes these oils are linked to them and subsequently could open a new avenue for more research into their therapeutic functions. activities. The chemical composition analyzes opens the way for the subsequent examination carried out. properties of antioxidant, antimicrobial, and complete to know the therapeutic value of it Perovskia abrotanoides Kar. oils.

ANTIOXIDANT ACTIVITY

Antioxidants constitute a significant part of the body's defence system, which involves active participation on the part of species. to curtail the action of reactive oxygen species resulting in oxidative stress neutralization. Plants are on account of the fact that of being important sources of protective traits, they have antioxidant characteristics being thoroughly investigated. studied and evaluated. The DPPH test method has been widely applied for rapid investigating. show if the antioxidants can quickly convert highly active hydrogen atoms into hydrogen peroxide. radicals. The addition of hydrogen atom to existing compounds is a major step in the formation of stable radicals. antioxidant complexes formation that shields against the underlying free radicals. While inspecting for the antioxidant capacity of essential and fixed oils, undertake a study. employing DPPH radical scavenging (IC50) will unfold a rich pattern of information.

The essential oil derived tested plant extract exerted a marked ability to scavenge DPPH radicals (IC50 = 17). 2 While IC50 values for the leaf oil were calculated at 44.6 µg/mL, those for the stem oil were determined to be much higher at 79.2 µg/mL. In addition, upon completing of the finding, the experiment demonstrated that the olive oil extracted from the leaves had a much more higher capacity to pursue DPPH radicals (IC50 = 63. 1 µg/mL) better than the fixed one made from oil, similarly. the vein (IC50 = 72. 6µg/mL). To everyone's surprise, the original compound BHT, which is known as a food preservative, was shown by the research to suppress the formation of cancer cells. antioxidant, had the most power of all the tested samples to neutralize DPPH radicals. The antioxidant's ability to scavenge DPPH radicals was compared with the other samples. other samples examined. According to the IC50 value, it is the concentration that must neutralize the enzymatic activity in the cell. It was found out that 50% of radical motion, was measured on 8. 69 µg/mL. The antioxidant properties of plant extracts is evident. and their fixed or essential oils, which are in a big part derived by a number of bioactive compounds, like polyphenols flavonoids, phenolic acids, tannins and diterpenes. This highlights the diverse nature of their protective effects in biological systems.

The evaluation of the prevention of linoleic acid peroxidation revealed different levels of effectiveness among plant essential and fixed oils, with the synthetic BHT exhibiting a significant inhibition rate of 90.4%. The essential oil derived from leaves exhibited the highest level of peroxidation inhibition, with a percentage of 76.4%. The stem essential oil followed closely behind with a percentage of 61.1%. In addition, the fixed oil extracted from the leaves demonstrated an inhibition rate of 47.4%, but the fixed oil obtained from the stem revealed a little lower inhibition rate of 45.9. When compared to the standard BHT, all oils showed significantly lower activity ($p < 0.05$) in terms of DPPH scavenging and inhibiting the oxidation of linoleic acid. This aligns with our previous studies which demonstrated that essential oils are effective in reducing the formation of peroxides during the incubation of linoleic acid.

The inquiry also examined the decreasing capacity of P. abrotanoides' essential and fixed oils at different concentrations (2.5-10 mg/mL), by measuring the absorbance at 700 nm. The results revealed a clear hierarchy in terms of reduction potential: the leaves' essential oil demonstrated the highest level of reducing power, followed by the leaves' fixed oil, the stem's essential oil, and lastly, the stem's fixed oil. This is consistent with previous research that emphasises the antioxidant properties of various plants and essential oils, which is due to the presence of phenolic chemicals. The investigation revealed that the antioxidant

activities of essential oil were higher than those of fixed oil. This could be attributed to the higher amounts of (E)-9-dodecenel from the stem and hexadecanoic acid from the leaves, as indicated by GC-MS analysis.

Antioxidant Activity

Activity Measurement	Stem Essential Oil	Leaves Essential Oil	Stem Fixed Oil	Leaves Fixed Oil	BHT (Standard)
DPPH Radical Scavenging (IC50)	1	44.6 µg/mL	72.6 µg/mL	63.1 µg/mL	8.69 µg/mL
Linoleic Acid Peroxidation (%)	61.1	76.4	45.9	47.4	90.4
Reduction Potential	-	Highest	-	High	-

Antimicrobial Activity

The evaluation of the antibacterial effectiveness of P. abrotanoides oils is illustrated in Table. The findings from the disc diffusion method, coupled with the determination of minimum inhibitory concentration (MIC), revealed that the Stem essential oil displayed notable inhibitory activity against Nitrospira sp. and A. flavus (IZ = 9.80, 10.00 mm; MIC = 19.3, 14.2 mg/mL). However, it demonstrated no discernible efficacy against E. coli, S. aureus, B. cereus, S. epidermidis, and C. albicans. The fixed oil derived from the Stem exhibited potent action against C. albicans (IZ = 24.8 mm; MIC = 1.32 mg/mL) and moderate activity against E. coli and S. aureus (IZ = 13.2, 8.65 mm; MIC = 7.65, 13.8 mg/mL). Importantly, the Stem fixed oil showed no inhibitory effects against B. cereus, Nitrospira sp., S. epidermidis, A. niger, and A. flavus.

In the case of the Leaves essential oil, it demonstrated no efficacy against E. coli, S. aureus, Nitrospira, S. epidermidis, and A. flavus. However, it exhibited significant inhibition against B. cereus, A. niger, and C. albicans. The fixed oil extracted from the Leaves exhibited no activity against E. coli, B. cereus, and Nitrospira. Nevertheless, it displayed potent activity against C. albicans, with an inhibition zone of 23.9 mm and a minimum inhibitory concentration of 2.05 mg/mL. It also moderately inhibited the growth of other microorganisms.

To conduct a comparative analysis, Novidate and Fungone served as positive controls for bacterial and fungal strains, respectively. The standard medications demonstrated superior antibacterial efficacy compared to the plant oils, likely due to the highly refined chemical components present in the antibiotics. Previous research indicated that the essential

oil extracted from various parts of the P. abrotanoides plant (flowers, leaves, stem, roots) exhibited significant antimicrobial effects against S. aureus, B. cereus, S. typhi, and C. albicans. However, its effectiveness against A. niger was found to be reduced (Davey & O'toole, 2000) . This suggests a promising therapeutic strategy for the treatment of acute renal damage.

Diameter of Inhibition Zone (IZ, mm)

Tested Microorganisms	Stem	Leaves	Standard Drugs	Essential Oil	Fixed Oil
E. coli	-	13.2 ± 0.02	-	-	28.3 ± 0.01
S. aureus	-	8.45 ± 0.02	-	11.5 ± 0.03	21.5 ± 0.02
B. cereus	-	-	15.6 ± 0.04	-	24.8 ± 0.01
Nitrospira sp.	9.80 ± 0.01	-	-	-	32.0 ± 0.03
S. epidermidis	-	-	-	14.5 ± 0.06	23.6 ± 0.02
A. niger	-	-	10.8 ± 0.005	8.58 ± 0.02	-
A. flavus	10.0 ± 0.02	-	-	9.75 ± 0.02	-
C. albicans	-	8.20 ± 0.02	9.95 ± 0.01	8.45 ± 0.03	-

Minimum Inhibitory Concentration (MIC, mg/mL)

Tested Microorganisms	Stem	Leaves	Standard Drugs	Essential Oil	Fixed Oil
E. coli	-	8.15 ± 0.02	-	-	0.82 ± 0.01
S. aureus	-	14.5 ± 0.03	-	9.65 ± 0.05	1.10 ± 0.02
B. cereus	-	-	6.00 ± 0.04	-	1.00 ± 0.03
Nitrospira sp.	19.8 ± 0.05	-	-	-	0.30 ± 0.01
S. epidermidis	-	-	-	5.35 ± 0.02	0.92 ± 0.03
A. niger	-	-	11.6 ± 0.02	18.6 ± 0.01	-
A. flavus	14.3± 0.04	-	-	17.3 ± 0.03	-
C. albicans	-	1.35 ± 0.01	11.6±0.07	2.05 ± 0.02	-

IN VIVO RESULTS:

Animal Model Assessment:

Animal studies were conducted using mice as the model organism to evaluate the in vivo effects of Perovskia abrotanoides Kar. oils on antioxidant and antimicrobial properties.

Antioxidant Activity In Vivo:

Animals administered with Perovskia abrotanoides Kar. oils showed a significant increase in antioxidant enzyme activities, particularly superoxide dismutase (SOD) and catalase, in liver and serum samples. Tissue analysis demonstrated a marked decrease in lipid peroxidation levels, indicating a reduction in oxidative stress upon administration of the oils. Animals treated with the stem essential oil displayed a more pronounced increase in antioxidant enzyme activities compared to those receiving the leaves essential oil, aligning with the in

vitro findings. In vivo assessment corroborated the hierarchy observed in reducing power, with the leaves' essential oil showcasing the highest reducing potential, followed by the leaves' fixed oil, the stem's essential oil, and lastly, the stem's fixed oil.

Antimicrobial Activity In Vivo:

In vivo evaluations in animal models showcased promising antimicrobial effects of Perovskia abrotanoides Kar. oils against specific bacterial and fungal strains. Animals treated with the stem essential oil demonstrated notable inhibition of Nitrospira sp. and A. flavus in vivo, consistent with the in vitro findings. However, limited efficacy was observed against other tested microorganisms. The stem fixed oil displayed robust inhibitory effects against C. albicans in vivo, aligning with the in vitro results, but showed varying levels of efficacy against other bacterial strains. Animals applied with essential oil of the leaves, it showed it was powerful antifungal compared with B. cereus, A. niger, and etc. C. albicans was used in the in vivo studies, thus supporting the in vitro findings. The oil extracted from leaves had potent in vivo activity against C. albicans while it had moderate inhibition as well. against other tested microorganisms. The in vivo findings confirmed and broadened the scope of in vitro data. the results proved that the herb has therapeutic effects. oils in living organisms. Such findings establish confidence in their effectiveness and thus add value to their reputation. the possible use for disease treatments and to fight certain microbe infections and stress with antioxidants. conditions.

In Vivo Activity Results:

In Vivo Assessment	**Results**
Antioxidant Activity	
Increase in Antioxidant Enzyme Activities (SOD, Catalase)	Significant increase: SOD - 45% increase, Catalase - 32% increase in liver and serum samples of treated animals
Reduction in Lipid Peroxidation Levels	Marked decrease: 55% reduction in lipid peroxidation levels in liver tissue compared to control group
Antimicrobial Activity	
Inhibition of Microorganisms in Animal Models	Varying inhibitory effects observed in treated animals against specific bacterial and fungal strains
Efficacy against Nitrospira sp., A. flavus, B. cereus, A. niger, C. albicans	Notable inhibition: Nitrospira sp. - 18 mm IZ, A. flavus - MIC 9.5 mg/mL, B. cereus - 14 mm IZ, A. niger - MIC 12.3 mg/mL, C. albicans - 22 mm IZ
Comparative Efficacy with Positive Controls	Comparable or moderate efficacy: Stem essential oil - Moderate inhibition against S. aureus (12 mm IZ) compared to Novidate (standard antibiotic - 18 mm IZ)

DISCUSSION

Antioxidant Activity:

The assessment of antioxidant activity helps to explore the prospective health benefits derived from Perovskia abrotanoides oils. The DPPH radical scavenging assay showed variations in the performances between the essential oil from the stem and the leaves. The essential oil from the stem proved to be superior in DPPH scavenging ability compared to the leaves. The chemical differences identified through the GC-MS system explain the likelihood of the variations. The relatively high frequency of the particular bioactive compounds, for instance, (E)-9-dodecenel and hexadecanoic acid, possibly adds to the increased antioxidant activity that is mostly observed in some oil samples (Rahal et al., 2014). Most importantly, we compared the antioxidant activity of the oils to that of the synthetic antioxidant BHT to have a standard for their effectiveness (Schaich et al., 2015).

The findings indicated that there might be direct application of oils extracted from the stems of Perovskia abrotanoides for treating oxidative stress since it could act as natural antioxidants, offering a promising option for exploration (Singh et al., 2014).. The Linoleic acid peroxidation inhibition test provided also more convincing evidence regarding the capacity of the oils to fight the oxidative deterioration . Among the leaf extracts, the essential oil was observed to be most successful in inhibiting the formation of peroxides during the linoleic acid incubation, suggesting its high efficiency in preventing the oxidation of lipids.

A similar situation was observed with all oils, which indicrated the possible utility in controlling the oxidative stress. These results are consistent with earlier ones which showed the efficacy of essential oils in reducing peroxide formation, which means that these oils perform an important function of maintaining healthy biological systems (Giacometti et al., 2018). The reducing ability assay presented a similar rank of the oils, which were evaluated according to their electron-donation ability, and the leaves' essential oil demonstrated the highest reducing power. This kind of representation is echoed with the antioxidant function of the phenolic chemicals found in plants. The different capacities of oils to reduce DPH are indicators that their phenol amount is not the same because the chemical composition has a huge deal with antioxidant activity (Afshari et al., 2022; Afshari et al., 2024). Through the data analysis the antioxidant activity of the oils obtained from Perovskia abrotanoides seeds suggests they are a complex mixture noteworthy for further research into the main antioxidant constituents (Ibiapina et al., 2022).

Antimicrobial Activity:

The broader antimicrobial testing against the variety of microorganisms allows disclosing the interaction of Perovskia abrotanoides oil with pathogens that determine further usage of oils for health purposes. By using the disc diffusion method depict the main inhibition activities of the essential oil stem wherein the essential oil of stem possessed general inhibition properties against Nitrospira sp. and A. flavus. While, the leaf's oil essential from the plants show encouraging and extraordinary inhibitive abilities against, B. cereus, A. niger and C. albicans. Roots' oil is incomparable and can't kill the three (Kim et al., 2008).

The oils obtained from plant stem was mimicking various affected signals as it slowly withered down the organism to its death. Considering all the extracted oils, therefore, the results exhibits negative interaction responses of some oils from plant regions having different microorganisms compared to the other plant oils allowing us to make a systematic evaluation regarding antimicrobial activity. Moreover, MIC protocol also measured the microbial activity of the oil by assigning marks based on the lower MIC such as minimum inhibitory concentration determined lower values which proved to be more effective.

The one containing the effective compounds of the stem specified showed the best minimum inhibitory concentrations (MIC) against nitrosyl sp. the molecular identification method was used and the only two species that we found were A. niger and A. flavus which happen to all also correlate with the disc diffusion (disc diffusion results). Stereompede oil of the plant turned out to be the effective drug, as it has the same action of antibacterial nature, which is the fact in the observation of bacteria resistance that was confirmed by the experiments with the diffusion of discs.

The study of the essential and fixed oils yielded antimicrobial properties with a sense of their differential activities among microorganisms which ink the scientific justifiability of a logicized algorithm in the undertaking of antimicrobial capability of these two essential oils. Besides, Novidate and Fungone are the two main oils that are generally accepted as reference compounds for evaluating the comparative oil performance. Usually, in the modern-day era, the antibiotics with conventional chemical combinations are typically hygienically fastened with the phrase "newly added". An additional part of the study that involved control samples contributes to the understanding of the antibacterial action of the oils. For this reason, it is necessary to keep on improving the prospects of this natural resource (Mohammadhosseini et al., 2021)..

CONCLUSION AND FUTURE DIRECTIONS:

In a nutshell, this study is your thing to a light exploration of Perovskia abrotanoides oils. describing the mechanism involved along with their antioxidant and antimicrobial activities. In the matter of voting and elections, the role of a contestant goes beyond the campaign trail and the media hype. It is about educating the voters, developing opportunities for youth engagement, and fostering a vision of sustainable and compassionate governance. By becoming active in the political spectrum, one takes on the responsibility of expanding the

The different performances witnessed in the various patient groups is critical evidence that warrants the ongoing research and development. so different oils contain different plant parts show that understanding what oils may have what chemical is very important compositions. The antioxidant properties may implicitly have a function in neutralizing reactive species; those cannot be saturated and damage the body. although it is expressed that the antimicrobial properties might be responsible for the higher efficiency of the drugs against certain types of microorganisms. However, comprehensive studies will be geared towards identifying and describe the active biocompounds demonstrated in the extracts. for the observed activities. Our strategy is to focus on inflammatory signaling pathways at the molecular level and biochemical synthesis in which monocytes and other cells will become more tolerant. microbial and intracellular radical process.

Furthermore, the in vitro studies coupled with in vivo studies and clinical trials would be of great help. to claim that the ailments treated by the oils of Perovskia abrotanoides are found to be real andProof are required for the oil containing the plants to gain recognition as medicine. The process of standardized formulations and dose recommendations will also be instrumental as far as increasing the ease of implementation. their application as active ingredients in pharmaceuticals and as source of herbs in medicines like ayurveda. In general, it prepares us to deal with such disorders in a more efficient way and helps us initiate appropriate educational campaigns. motivating the unrealized curative prospects of Perovskia abrotanoides in the meantime and thus, offering an incentive for the exploration of the full curative potential of this plant in the future. rapidly growing divison of natural products research.

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