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The Role of Plants Having Antimicrobial Properties in the Management of Mental Health Disorders: A Review

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Millions worldwide suffer from mental health disorders such as depression, anxiety, and schizophrenia, underscoring the need for effective, accessible treatments. While conventional therapies have made strides in managing these conditions, challenges such as side effects and

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high costs persist. This review explores the therapeutic potential of medicinal plants with antimicrobial properties in addressing mental health disorders as there is an established body of knowledge on the link between the gut and the brain (GBA). The impact of the microbes in the gut on the hormones, neurotransmitters, and immune system to name a few has been seen to interfere with the development of mental illness and alleviation of symptoms. The relevant articles were retrieved for analysis through a comprehensive review of current literature using databases like Google Scholar, Web of Science, PubMed, and keywords like 'Medicinal plants' 'Mental health' 'Bioactive compounds', and the appropriate Boolean operators. The inclusion criteria were relevant to common mental health disorders like depression, anxiety, and schizophrenia, while the exclusion criteria included duplicates, lack of full-text availability, and non-English publications. The bioactive compounds in these plants—such as alkaloids, flavonoids, and terpenoids—were analyzed for their interactions with neurotransmitter systems and contributions to mental well-being. Key medicinal plants with antimicrobial properties, including St. John's wort, ashwagandha, and turmeric, were examined for their impact on mental health. The review also highlights the difficulties in translating traditional knowledge into clinical applications, calling for standardization and ethical considerations. Finally, the potential for drug development using biotechnology to enhance the therapeutic value of these medicinal plants is discussed, offering a promising avenue for future mental health treatments.

Keywords: Antimicrobials; mental illnesses; neuroprotective properties; phytochemicals; botanicals.

1. INTRODUCTION

Mental health disorders are a growing global concern, affecting millions of individuals across various age groups and demographics [1]. Mental health is a condition of well-being in which an individual recognizes his or her abilities, can cope with the usual demands of life, can work productively, and can contribute to his or her community [2].

A deviation from this, constituting a significant disturbance in thinking, emotional regulation, or behavior results in mental disorders [3].

These disorders, including depression, anxiety, bipolar disorder, and schizophrenia, significantly impact individuals' quality of life and overall well-being [4]. Certain neurotransmitters have been postulated to play a significant part in the development of mental illness, and modulating them can help alleviate symptoms in those suffering from mental disorders. There is a considerable body of evidence suggesting serotonin deficiency in people with depression. Selective modulation of serotonin neurotransmission has remained a viable treatment strategy for mood and anxiety disorders [5].

Conventional treatments for mental health disorders primarily involve pharmacotherapy and psychotherapy [6]. Psychotropics, drugs that affect behavior, mood, thoughts, or perception, target neurotransmitter transporters and are the drug of choice in mental disorders [7]. However, they often come with side effects, limited efficacy, and high costs, leading to the need for alternative therapeutic approaches. The search for new, effective, and affordable treatments is crucial in addressing the global burden of mental health disorders [8].

1.1 The Relevance of Medicinal Plants in Traditional Medicine

Medicinal plants have been an integral part of traditional medicine systems worldwide for centuries [9, 10]. These plants are often used for their therapeutic properties, and many have been scientifically validated for their efficacy in treating various ailments [11]. In the context of mental health, certain medicinal plants have been recognized for their potential to alleviate symptoms of mental disorders [12,13]. The bioactive compounds present in these plants may interact with neurotransmitter systems, offering a natural alternative to synthetic drugs [12]. The evaluation of medicinal plants as a source of new treatments for mental health disorders is particularly relevant in regions where access to conventional healthcare is limited [13].

1.2 Importance of Exploring Antimicrobial Activity in the Context of Mental Health

Recent study has highlighted the potential link between microbial infections and mental health disorders [14]. The gut-brain axis, a bidirectional

communication network between the gastrointestinal system and the brain, plays a significant role in mental health [15-17]. Dysbiosis, or a state of gut-microbiota imbalance, has been associated with various mental health disorders, including but not limited to depression, schizophrenia, and anxiety [18-21]. This has led to an increased interest in the antimicrobial properties of medicinal plants, as they may help restore microbial balance and alleviate mental health symptoms [22]. Exploring the antimicrobial activity of medicinal plants used in traditional medicine could provide valuable insights into their therapeutic potential for mental health disorders [11].

Reactive Oxygen Species (ROS), also known as free radicals, are unstable molecules that react with other cellular molecules in the body and can cause damage to DNA, RNA, and proteins. Elevated levels of harmful ROS have been noted to underlie both the development and progression of several mental health disorders including depression, anxiety, and schizophrenia [23-25]. The body's antioxidant defense mechanism that is required to clear up ROS gets overwhelmed, leading to several outcomes like inflammation and neurodegeneration. This imbalance between antioxidants and ROS is indicative of increased oxidative stress which has been noted to be one of the pathophysiologic processes seen in mental illnesses. Antimicrobials have been shown to have antioxidant properties, which is proposed to be one of the ways they exert their therapeutic effect to improve mental health.

Research has shown that individuals with schizophrenia, including non-medicated, medicated, first-episode, and chronic patients, exhibit decreased levels of total antioxidants. Additionally, they have reduced antioxidant enzyme levels such as catalase, glutathione, and, superoxide dismutase and lower serum levels of brain-derived neurotrophic factor (BDNF) in their brain tissue [23].

This implies that bolstering the antioxidant defense mechanism in patients with mental illness can not only slow down the progression of the disease but also delay and probably prevent the onset of the disorder. This in turn underscores the reason for exploring the possibilities that lie in employing antimicrobial agents in the management of mental disorders.

Furthermore, the gut contains microbes that are beneficial to maintaining body hemostasis, and metabolites of the gut microbiota play a role in exerting anti-inflammatory and pro-inflammatory effects [26,27]. The presence of certain bacteria is associated with inflammatory molecules that may bring about inflammation in various body tissues [28]. Alternatively, the stress-related shift in the gut microbiota endangers the tight junction of the gut barrier causing bacteria and bacteria products to move from the gut to the bloodstream, lymph nodes, and other organs, ultimately inducing systemic inflammatory responses. This heightened inflammation has been seen to underscore the development of mental health disorders like depression [29].

Pro-inflammatory cytokines are also important stimulators of the hypothalamic-pituitary-adrenal (HPA) axis which is a pivotal pathway in the regulation of mental health. In individuals with depression, for example, the HPA axis as hyperactive has been noted [27]. This provides another basis for a need to explore the effects of antimicrobials.

2. HISTORICAL AND CULTURAL CONTEXT

2.1 Traditional Use of Medicinal Plants in Treating Mental Health Disorders

For centuries, various cultures have relied on medicinal plants to treat mental health disorders [30-32]. Indigenous communities and traditional healers have utilized a range of plant species to address symptoms of anxiety, depression, and other mental ailments [33]. These plants are often administered in the form of teas, infusions, or powders, with the belief that their natural properties can restore balance to the mind and body [30]. The traditional use of medicinal plants in mental health is deeply rooted in the understanding of the human body as a holistic entity, where physical, mental, and spiritual health are interconnected [34,35].

2.2 Ethnobotanical Practices and Indigenous Knowledge

Ethnobotany, the study of the connection between people and plants, offers valuable insights into the use of medicinal plants for mental health treatment [36]. Indigenous knowledge, passed down through generations, encompasses a wealth of information on the preparation, dosage, and application of these plants [37,38]. This knowledge is often intertwined with cultural practices and spiritual

beliefs, making it a rich source of alternative treatment methods [36]. Ethnobotanical studies have revealed that many plants traditionally used for mental health disorders possess bioactive compounds with pharmacological effects, validating their therapeutic potential [39,40].

2.3 Cultural Beliefs Surrounding Mental Health and Plant-Based Remedies

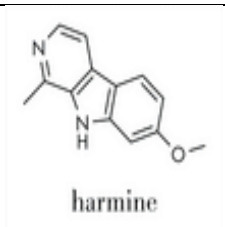
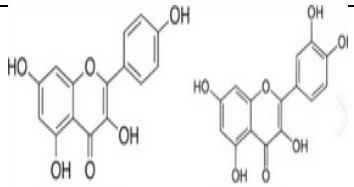
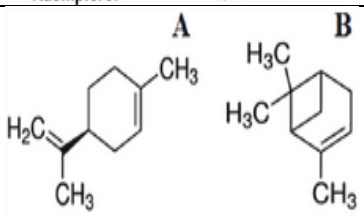
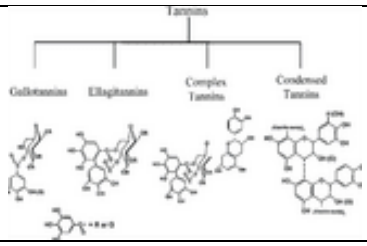
Cultural beliefs play a significant role in the perception and treatment of mental health disorders [41, 42]. In many cultures, mental health is not solely viewed as a medical issue but as a manifestation of spiritual or supernatural forces [43]. This perspective influences the use of plant-based remedies, as certain plants are believed to possess spiritual or protective properties that can ward off evil spirits or negative energies associated with mental illness [41]. The cultural context in which medicinal plants are used is crucial to understanding their role in mental health treatment [44]. In some communities, the use of these plants is accompanied by rituals, prayers, or other spiritual practices, emphasizing the holistic approach to healing [37]. These practices have brought to light various plant based interventions used for mentally ill persons thus giving a basis for scientific evaluation of these plants, even though some of them are under reported.

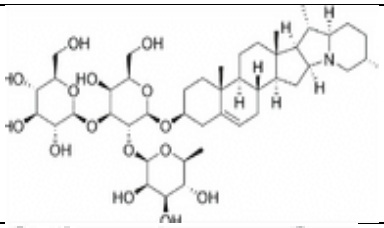
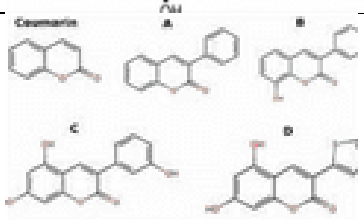
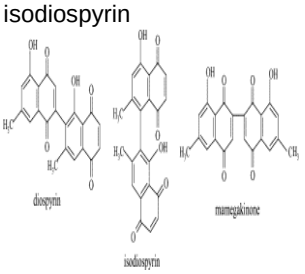
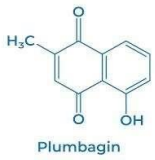
3. PHYTOCHEMICAL CONSTITUENTS OF MEDICINAL PLANTS

3.1 Overview of the Active Compounds Responsible for Antimicrobial and Neuroprotective Effects

Medicinal plants contain a wide array of phytochemicals that contribute to their therapeutic effects [45]. Among these, alkaloids, flavonoids, terpenoids, phenolics, and glycosides are prominent in exerting antimicrobial and neuroprotective activities [46]. The list of these phytochemicals and their pharmacological indications are presented in Table 1.

Table 1. List of plant phytochemicals and their pharmacological indications

S/N	Phytochemical	Chemical Structure	Pharmacological Indication	References
1	Alkaloids	 harmine	Broad-spectrum antimicrobial activity; Neuroprotective effect	[148] [166]
2	Flavonoids	 Kaempferol Quercetin	Antioxidant properties; Modulate oxidative stress and inflammation in the brain; Modulate protein expression and ameliorate cognitive dysfunction; modulate neurotransmitters like serotonin, and dopamine.	[167] [168]
3	Terpenoids		Antimicrobial properties; Anxiolytic and antidepressant effects; Anti-schizophrenic activity.	[23] [169]
4	Tannins:		Protects against microbial infections; Exerts antidepressant effects.	[55] [170]

S/N	Phytochemical	Chemical Structure	Pharmacological Indication	References
5	Saponins		Both antimicrobial and neuroprotective activities; Modulate the immune system and protect neurons from oxidative stress.	[160] [161]
6	Coumarins		Antimicrobial activity, and also acts on the central nervous system to alleviate anxiety and depression.	[162] [163]
7	Naphthoquinones	Plumbagin, diospyrin, isodiospyrin   Plumbagin	Antimicrobial activity, Neuroprotective against Alzheimer's Disease, Depression-like Behavior and Memory Deficits	[77] [80,164] [165]

4. SYNERGISTIC EFFECTS OF PHYTOCHEMICALS ON MENTAL HEALTH AND MICROBIAL INFECTIONS

The phytochemicals in medicinal plants often work synergistically, enhancing each other's effects on mental health and microbial infections [47,48]. For example, the combination of flavonoids and alkaloids in a plant extract may result in enhanced neuroprotective and antimicrobial activities compared to the isolated compounds [49]. This synergy is crucial in traditional medicine, where whole plant extracts are often used rather than isolated compounds, providing a broad spectrum of therapeutic effects [50].

5. MECHANISMS OF ACTION

5.1 Anti-Inflammatory

Mental health disorders, particularly those with an inflammatory component, may be influenced by microbial infections [51]. The antimicrobial properties of certain plants can reduce the microbial load and, consequently, the inflammation that contributes to mental health issues [52]. For example, antimicrobial activity against gut pathogens can lead to a reduction in systemic inflammation, which has been linked to depression and anxiety [51]. Antimicrobials like *Diospyros mespiliformis* play a significant role as an anxiolytic by reducing the inflammatory process [53].

Antimicrobial phytochemicals like resveratrol and curcumin not only inhibit microbial growth but also protect neurons from damage caused by oxidative stress and inflammation [54,55]. This dual action is particularly relevant in conditions like depression, where both microbial imbalances and neuro-inflammation are contributing factors [53].

5.2 Antioxidant

They also exhibit their effects on improving mental health through their antioxidant activity,

thereby reducing free radicals that potentially damage neurons. Examples of such antimicrobials are *Allium cepa* L. [56], *Chrysanthellum americanum* L, a plant in west Africa [57,58]. *Cnestis ferruginea* Vahl ex DC (Connaraceae) exerts its antioxidant activity by enhancing superoxide dismutase [59].

5.3 Modulation of Neurotransmitters

Neurotransmitters are chemical messengers in the brain abnormal levels of which can lead to mental disorders, for example, dopamine, serotonin, and norepinephrine amongst others [60]. They are often a target in managing these disorders.

One of the ways antimicrobials exert their effect on mental health is by enhancing neurotransmitters like serotonin, thus giving an anxiolytic and antidepressant outcome. For example, *Cnestis ferruginea* Vahl ex DC (Connaraceae) [59]. Evidence exists for the link of depression with reduced dopamine levels [61] and *Allium cepa* L., has been shown to exert its antidepressant effect by reducing the metabolism of dopamine [62]. Red onion husk demonstrates a counteractive effect on ketamine-induced oxidative stress and neuronal hyperactivity highlighting its potential as a complementary therapeutic strategy for managing manic episodes in bipolar disorder [63].

A biologically active compound derived from *Celastrus paniculatus* Willd. (black oil plant), known as 3-(3,4-dimethoxy phenyl)-1- (4-methoxyphenyl) prop-2-en-1-one (DPMPP), appears to be a valuable therapeutic target for schizophrenia and other associated neuropsychiatric conditions by restoring neurotransmitters like dopamine, norepinephrine, serotonin, and monoamine oxidase (MAO) to normal activity. This outcome is similar to clozapine, a medication used in treatment-resistant schizophrenia [64,65].

Ficus platyphylla Delile has been proposed to have an anti-depressant effect by modulating the dopaminergic pathway. The plant is used in Nigeria's traditional medicine to cure a wide range of mental diseases such as insomnia, psychotic symptoms, depression, epilepsy, pain, and inflammation [66].

5.4 Effect on Hypothalamic-Pituitary-Adrenal (HPA) Axis

Apocynum venetum L. has shown anti-depressant-like effects equivalent to fluoxetine (an anti-depressant drug by reducing the activity of the HPA axis [67]. Anti-depressant and anxiolytic effects are also achieved by the normalization of neuroendocrine systems (HPA-axis) by *Cnestis ferruginea* Vahl ex DC (Connaraceae) [59].

5.5 Specific Medicinal Plants with Known Antimicrobial and Mental Health Benefits

St. John's Wort (*Hypericum perforatum*): Widely used for its antidepressant effects, St. John's Wort also possesses antimicrobial properties against various bacteria and viruses [69]. Its active compounds, hypericin and hyperforin, modulate neurotransmitter levels and reduce oxidative stress, making it a valuable plant in the treatment of depression and anxiety [70].

Ashwagandha (*Withania somnifera*): This adaptogenic herb is known for its ability to reduce stress and anxiety [71]. It also exhibits antimicrobial properties, particularly against certain strains of bacteria and fungi. The neuroprotective effects of ashwagandha are attributed to its withanolides, which modulate neurotransmitter levels and reduce neuroinflammation [72]. A systematic review reveals that it reduces psychopathologies in psychosis [73].

Turmeric (*Curcuma longa*): Curcumin, the active compound in turmeric, is well-known for its anti-inflammatory and antimicrobial properties [74,75]. It also has neuroprotective effects, making it beneficial in the treatment of depression and anxiety. Curcumin's ability to cross the blood-brain barrier allows it to exert direct effects on brain function [76]. The list of some medicinal plants with antimicrobial properties used in the management of mental health is presented in Table 2.

6. CASE STUDIES OR DOCUMENTED USES IN DIFFERENT REGIONS OR COMMUNITIES

Africa: In various African communities, plants like *Zanthoxylum chalybeum* and *Moringa oleifera* are used for both their antimicrobial properties and their ability to treat mental health conditions such as anxiety and depression [113]. Traditional healers often use these plants in combination to enhance their therapeutic effects [48].

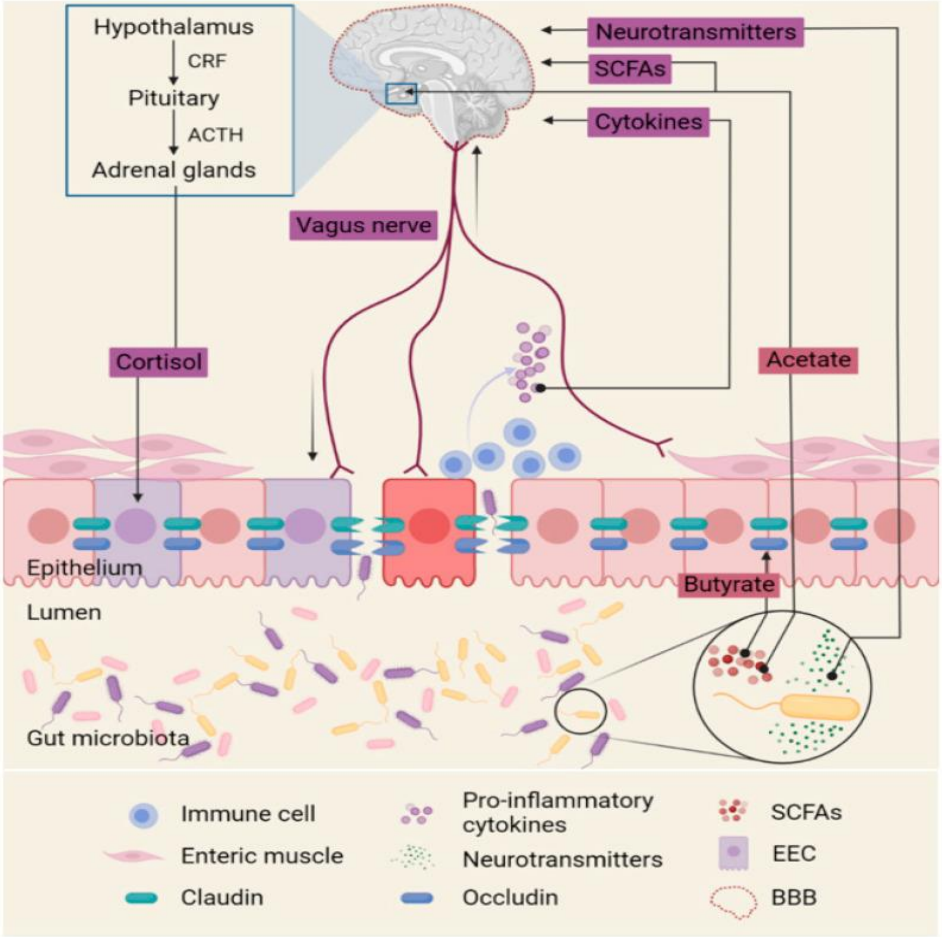


Fig. 1. Mechanisms of bidirectional communication between gut microbiota and the brain. SCFA-short chain fatty acid, EEC- entero-epithelial cells, BBB- blood brain barrier [68]

Table 2. Some antimicrobial plants with anxiolytic, antidepressant and antipsychotic properties

S/N	Plants	Family	Pharmacological Indications	References
1	*Diospyros piscatorial*(Gurke)	Ebenaceae	Antibacterial activity.	[77]
2	*Diospyros mespiliformis*	Ebenaceae	Analgesic and antipyretic; Antihelminthic; Dermatomycosis Anxiolytic activity Antipsychotic properties	[53,78,79,80,81]
3	*Allium cepa* L	Liliaceae	Antimicrobial & anxiolytic, antidepressant properties	[56,59,82,83,84]
4	*Allium ascalonicum* Linn.	Liliaceae	Antimicrobial & Anxiolytic properties	[85,86,87]
5	*Jatropha curcas* L.	Euphorbiaceae	Antimicrobial Anti-depressant and Anxiolytic and Antipsychotic properties	[88,89,90]
6	*Musa sapientum* L.	Musaceae	Antimicrobial and Antidepressant properties	[89,91,92]
7	*Allium sativum* Linn.	Liliaceae	Antimicrobial, Analgesia. Anxiolytic and Antidepressant properties	[93,94,95,96]

S/N	Plants	Family	Pharmacological Indications	References
8	*Azadirachta indica* A. Juss	Meliaceae	Analgesia; Anxiolytic; For the treatment of Alzheimer's disease	[97,98]
9	*Eucalyptus* sp	Myrtaceae	Antimicrobial, Antioxidant; Antipsychotic, Antidepressant properties	[23,99,100,101,102,103]
10	*Talinum triangulare* (Jacq.) Willd.	Portulaceae	Neuroprotection; Antiviral; Antibacterial and anticancer properties	[104]
11	*Olax subscorpioidea* Oliv.	Olacaceae	Antimicrobial, Prevention of oxido-inflammatory damage and modulation of cholinergic transmission. Antidepressant property	[105,106,107]
12	*Rinorea dentata* Kuntze	Violaceae	Used to manage Alzheimer's disease (AD),	[108]
13	*Spondias mombin* L.	Anacardiaceae	Antidepressant and Anxiolytic properties	[109]
14	*Elaeis guineensis* Jacq.	Arecaceae	Antimicrobial, Antidepressant and Anxiolytic properties	[110,111]
15	*Diospyros melanox ylon*		Antimicrobial, Antidepressant	[112]

Vernonia Amygdalina (Asteraceae) which contains flavonoids, saponins, terpenes, phenolic acids, amongst others, possesses antioxidant, antimicrobial, and anxiolytic properties, as well as antidepressant-like potentials [114-118]. *Spondias mombin* L. (Anacardiaceae) is traditionally used for its anxiolytic and antidepressant proprties [119], as well as its antimicrobial effects [120].

Asia: In traditional Chinese medicine, plants like *Bupleurum* species are used for both mental health disorders and microbial infections [121]. These plants are often included in formulas designed to balance the mind and body, reflecting the holistic approach of traditional medicine [37]. *Urena lobate* (Malvaceae), commonly known as Caesarweed or Congo jute In India, has some beneficiary activities for medicinal and non-medicinal purposes such as antioxidant, inflammatory, antimicrobial, antidiarrheal, antidiabetic, antihyperlipidemic and anxiolytic-*like* effect [111,122-124].

Europe: The use of St. John's Wort (*Hypericum perforatum*) dates back to ancient times, and it is among the most researched herbal medicines for mental health. It is a first-line treatment for depression in several European countries [125].

7. COMPARISON OF THE EFFECTIVENESS OF DIFFERENT PLANTS

Comparative studies have shown that while some plants like St. John's Wort are more effective in treating depression, others like ashwagandha may be better suited for anxiety due to their adaptogenic properties [72,126]. The antimicrobial activity of these plants also varies, with turmeric being particularly potent against a broad spectrum of pathogens [74].

8. CLINICAL AND PRECLINICAL STUDIES

8.1 Summary of Clinical Trials or Preclinical Studies Involving These Medicinal Plants

Several clinical and preclinical studies have investigated the efficacy of medicinal plants with antimicrobial and neuroprotective properties in treating mental health disorders:

St. John's Wort: Numerous clinical trials have confirmed its efficacy in treating mild to moderate depression, with some studies also highlighting its antimicrobial effects [126].

Ashwagandha: Clinical trials have shown that ashwagandha can reduce symptoms of anxiety and stress, with some studies also pointing to its antimicrobial properties [71].

Turmeric: Preclinical studies on turmeric have demonstrated its neuroprotective and antimicrobial effects, with ongoing clinical trials exploring its potential in treating depression and anxiety [76].

Allium cepa

Allium ascalonicum Linn.

Jatropha curcas L.

Musa sapientum

Allium sativum Linn.

Azadirachta indica A. Juss

Eucalyptus sp.

Talinum triangulare (Jacq.) Willd.

Olax subscorpioidea Oliv.

Rinorea dentata Kuntze

Spondias mombin L.

Elaeis guineensis Jacq

Ashwagandha (*Withania somnifera*)

Diospyros piscatoria (Gurke)

Eucalyptus globulus

Turmeric (*Curcuma longa)*

St. John's Wort (*Hypericum perforatum)*

Fig. 2. Pictorial representation of some antimicrobial plants with anxiolytic, anti-depressant and anti-psychotic properties

8.2 Evidence Supporting the Use of these Plants in Mental Health Treatments

The evidence supporting the use of these plants in mental health treatments is strong, particularly for conditions like depression and anxiety [69]. The combination of antimicrobial and neuroprotective effects makes these plants especially valuable in cases where infections or inflammation play a role in mental health disorders [72].

8.2.1 Clinical trials

Clinical trials have shown that *Gotu kola extract improves working memory in humans* [127]. *T*he following medicinal plants: lemon grass (*C. citratus*), lavender (*L. officinalis*)*,* lemon balm (*M. officinalis*), passion fruit (*P. incarnata*) and valerian (*V. officinalis*), were noted to have anxiolytic effect in pre-clinical and clinical studies. Chamomile (*M. chamomilla*) presented clinical anxiolytic efficacy. In addition, antidepressant effects were reported for lavender and lemon balm in the pre-clinical studies, as well as for lemon balm and valerian in the clinical studies [128].

8.3 Challenges in Translating Traditional Knowledge into Clinical Practice

One of the major challenges in translating traditional knowledge into clinical practice is the standardization of plant extracts [129]. The variability in phytochemical content due to factors like growing conditions and extraction methods can lead to inconsistent results in clinical trials. Additionally, the complexity of plant extracts, with their multiple active compounds, poses challenges in understanding their mechanisms of action and potential interactions with conventional medications [130,131].

9. SAFETY, EFFICACY, AND TOXICITY

9.1 Assessment of the Safety and Efficacy of Medicinal Plants

The safety and efficacy of medicinal plants used for treating mental health disorders are paramount, especially when considering their dual role in providing antimicrobial and neuroprotective benefits [132]. Traditionally, these plants have been used for centuries, often without documented adverse effects, suggesting a level of safety [133]. However, modern scientific evaluation is essential to confirm these findings.

Safety: The safety of medicinal plants varies based on factors such as species, dosage, preparation method, and individual patient characteristics [11]. For example, St. John's Wort, while generally considered safe, can cause photosensitivity in some individuals [70]. Ashwagandha is another plant widely regarded as safe, but it may cause gastrointestinal upset in some people [71].

Efficacy: The efficacy of these plants is supported by both traditional use and modern studies. For instance, St. John's Wort is well-documented for its antidepressant effects [70], while turmeric is recognized for its anti-inflammatory and neuroprotective properties [76]. However, the efficacy can be influenced by the quality of the plant material and the method of preparation [134].

9.2 Potential Side Effects and Toxicity Concerns

Despite their therapeutic benefits, some medicinal plants may have potential side effects or toxicity concerns that need to be addressed [10]:

Side Effects: Common side effects of medicinal plants include gastrointestinal discomfort, allergic reactions, and interactions with conventional medications. For instance, St. John's Wort can interact with antidepressants, leading to serotonin syndrome, a potentially life-threatening condition [31,70].

Toxicity Concerns: Some plants, particularly in high doses or with prolonged use, may be toxic [135]. For example, kava, used traditionally for its anxiolytic effects, has been associated with hepatotoxicity in some cases [136]. Additionally, the presence of heavy metals, pesticides, or adulterants in poorly regulated herbal products can pose significant health risks [137].

9.3 Safe Dosage Levels and Preparation Methods

Determining safe dosage levels is crucial in the use of medicinal plants [135]. Traditional knowledge often provides guidelines, but modern research is needed to validate these dosages and ensure safety:

Dosage Levels: Safe dosage levels can vary depending on the plant, its preparation, and the individual's health status [135]. For instance, the typical dose of St. John's Wort extract for depression is 300 mg, taken three times daily, standardized to 0.3% hypericin content [138].

Preparation Methods: The method of preparation can significantly influence both the safety and efficacy of medicinal plants [11]. Traditional methods include decoctions, infusions, and tinctures [139]. Modern techniques, such as standardized extracts, ensure consistency in the concentration of active compounds, which is vital for both safety and efficacy [140].

10. CHALLENGES AND LIMITATIONS

Challenges in Standardizing Plant-Based Treatments: One of the significant challenges in using medicinal plants is the lack of standardization [140].

Variability in phytochemical content due to factors such as geographical location, climate, soil conditions, and harvesting time can lead to inconsistencies in the therapeutic efficacy of these plants [141].

Standardization Issues: Unlike pharmaceutical drugs, which have a single active ingredient, medicinal plants contain a complex mixture of compounds [131]. Standardizing these mixtures to ensure consistent potency and safety is challenging but necessary for their integration into modern medicine [142].

Possible solutions to this include researchers familiarizing with the locals on the way these plant based substances are being administered, encouraging individuals to give their reviews about them by sending out language based questionnaires, and provision of funding by governmental bodies or non- governmental organizations

10.1 Limitations in Current Research and Knowledge Gaps

Despite the long history of using medicinal plants, there are still significant limitations in current research:

Limited Clinical Trials: Many medicinal plants have been studied primarily in preclinical settings, with a lack of robust clinical trials to confirm their efficacy and safety in humans [31]. This gap in research makes it difficult to fully endorse these plants for widespread clinical use [130]. There is also a small body of knowledge about the use of these plants in Nigeria, as they are under reported.

Knowledge Gaps: There is also a gap in understanding the precise mechanisms of action of many medicinal plants, particularly how their antimicrobial properties intersect with neuroprotective effects [143]. Additionally, there is limited research on potential interactions between these plants and conventional medications [144].

10.2 Ethical Considerations in the Use of Indigenous Knowledge

The use of indigenous knowledge in modern medicine raises important ethical considerations:

Intellectual Property: Indigenous communities have developed extensive knowledge of medicinal plants over centuries [33]. It is crucial to recognize and respect their intellectual property rights and ensure that they benefit from any commercialization of this knowledge [145].

Cultural Sensitivity: The integration of indigenous knowledge into modern medicine should be done with cultural sensitivity, ensuring that traditional practices are respected and preserved [146].

10.3 Potential for Drug Development

Medicinal plants hold tremendous potential as a source for new drugs, particularly in the context of antimicrobial resistance and mental health disorders:

New Drug Development: The diverse phytochemical profiles of medicinal plants offer a rich source for discovering new antimicrobial and psychoactive drugs [147]. For example, berberine, an alkaloid from *Berberis* species, is being explored for its potential to treat both infections and neurological disorders [148].

Antimicrobial Resistance: The growing problem of antimicrobial resistance makes the search for new antimicrobial agents urgent [149]. Plants like *Diospyros* spp.*, Eucalyptus sp..* garlic (*Allium sativum*), shallot (*Allium ascalonicum*), *Cola sp.* Schott *Funtumia elastica* (Preuss) Stapf. *Trichilia heudelotii* with its well-documented

antimicrobial properties, are being studied for its potential to develop new antibiotics [77,80,85,99, 150-155].

10.4 Opportunities for Integrating Traditional Knowledge with Modern Medicine

The integration of traditional knowledge with modern medicine offers several opportunities:

Complementary Therapies: Medicinal plants can be used as complementary therapies alongside conventional treatments, particularly in mental health [156]. For instance, turmeric supplements may be used to enhance the effects of antidepressants, given its anti-inflammatory properties [74,75].

Holistic Approaches: Traditional medicine often emphasizes a holistic approach to health, which can complement the more reductionist approach of modern medicine. Integrating this perspective can lead to more comprehensive and effective treatment strategies [37].

10.5 The Role of Biotechnology in Enhancing the Therapeutic Potential of These Plants

Biotechnology offers tools to enhance the therapeutic potential of medicinal plants:

Genetic Engineering: Advances in genetic engineering allow for the modification of plants to increase the yield of active compounds or to produce novel phytochemicals with enhanced therapeutic properties [157,158].

Tissue Culture: Tissue culture techniques can be used to produce large quantities of medicinal plants under controlled conditions, ensuring consistent quality and reducing the impact on wild populations [159].

11. CONCLUSION AND FUTURE DIRECTIONS

11.1 Summary of Key Findings and Their Implications for Mental Health Treatment

This review highlights the significant potential of medicinal plants with antimicrobial properties in exerting anxiolytic, antidepressant, and antipsychotic effects in the management of mental disorders. The dual action of these plants on both microbial infections and neurological pathways offers a promising approach to managing conditions like depression, anxiety, and neurodegenerative diseases.

11.2 Recommendations for Future Research and Clinical Studies

Clinical Trials: More clinical trials are needed to confirm the efficacy and safety of these plants in treating mental health disorders.

Mechanistic Studies: Research should focus on elucidating the mechanisms by which these plants exert their effects, particularly the interaction between their antimicrobial and neuroprotective activities.

Standardization: Efforts should be made to standardize the preparation and dosage of these plants to ensure consistency and safety in their use.

11.3 The Potential Impact of These Medicinal Plants on Global Mental Health Care

Medicinal plants with antimicrobial, antidepressant, anxiolytic, and antipsychotic properties have the potential to significantly impact global mental health care, particularly in regions where access to conventional medications is limited. By integrating traditional knowledge with modern scientific research, these plants could provide affordable, effective, and culturally acceptable treatments for mental health disorders on a global scale.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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