Journal of Scientific and Technology Research (TUBITTUM)
olume 4 Issue 4, 2025, pp: 159-174 **www. Tubittumjournal.com** ISSN: 2822-5295
https://tubittumjournal.com/article/1122

Impact of Herbal Compounds on Human Gut Microbiota: A Comprehensive Review

Mojtaba Valizadegan Arjomand [1], Maryam Madani Asl [2], Reza Faraji Meydani [3], Khadije Soltani langarani [4], Diako Ghazizadeh [5], Ali Piran [6], Mehran Rostam Zaman[7]

[1]*Doctorate in Naturopathic Medicine, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium ORCID: 0009-0002-6559-1107*

[234567] *Doctorate Student in Naturopathic Medicine, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium*

Received 07/01/2026 **Accepted** 10/02/2026
DOI:10.64209/tubittum.v5i1.1122

Abstract

Background and Objective: The human gastrointestinal tract harbors a complex and dynamic community of microorganisms collectively known as the intestinal microbiota, which plays a crucial role in maintaining metabolic, immunological, and physiological homeostasis. These microorganisms regulate essential bodily functions, including digestion, nutrient absorption, immune modulation, and protection against pathogenic organisms. Disruption of the intestinal microbial balance (dysbiosis) has been increasingly associated with a wide range of diseases, such as metabolic disorders, inflammatory conditions, autoimmune diseases, and gastrointestinal dysfunctions. In recent years, growing scientific interest has focused on the potential of medicinal plants and bioactive herbal compounds to modulate gut microbiota composition, enhance beneficial microbial populations, and restore intestinal homeostasis. Understanding the interaction between herbal compounds and gut microbiota may provide novel, safe, and complementary therapeutic strategies for the prevention and management of microbiota-related diseases.

Materials and Methods: Information related to this study was obtained from searching databases such as SID, Magiran, Google Scholar, and PubMed using the keywords medicinal plants, intestinal microbiota, dysbiosis, and microbiome.

Findings: In today's medical science, it is believed that the intestinal microbiota affects the central nervous system through the enteric nervous system, and this view is due to the similarity of the enteric nervous system to the central nervous system and its autonomy. These microorganisms affect energy generation, normal body function, the immune system, obesity, thinness, malnutrition, neurological disorders, mood and cancer in humans. On the other hand, there are many studies on the effect of medicinal plants and essential oils of medicinal plants in creating a balance in the intestinal microbial population, which can prevent the above diseases in the first stage and, in most cases, be effective in treating the aforementioned diseases.

Conclusion: The balance of the intestinal microbiota is an influential factor in the functioning of organs and the health of all body systems, including the nervous system, and in some cases even prevents the development and occurrence of various diseases. Today's medical science believes that the intestinal microbiota regulates the functioning of the central nervous system through the enteric nervous system, the production of metabolites, and the stimulation of the immune system. According to studies, utilizing the properties of some medicinal plants can help to restore the microbial balance of the intestinal flora.

Keywords: Microbiota, gut microbiome, medicinal plants, Iranian medicine

Introduction

The human gastrointestinal tract harbors a complex and dynamic ecosystem of microorganisms collectively referred to as the gut microbiota. These microorganisms coexist symbiotically with the host and play a pivotal role in maintaining physiological homeostasis, influencing metabolic regulation, immune function, neurodevelopment, and protection against pathogenic invasion [1–4]. The gut microbiota is not limited to the colon but extends throughout the entire digestive tract, exhibiting remarkable diversity, stability, and resilience under healthy conditions [2,3].

Accumulating evidence suggests that disruption of gut microbial composition—commonly termed dysbiosis—is associated with a wide range of chronic and inflammatory diseases, including metabolic disorders, neuropsychiatric conditions, autoimmune diseases, gastrointestinal syndromes, and malignancies [4–6]. Dysbiosis has been linked to impaired immune modulation, altered short-chain fatty acid (SCFA) production, increased intestinal permeability, and aberrant gut–brain axis signaling [5,7–11]. Importantly, the establishment and maturation of the gut microbiota begin early in life and are shaped by multiple environmental factors, including diet, lifestyle, stress exposure, and pharmacological interventions [8,10].

Among modifiable factors, dietary components and plant-derived bioactive compounds have gained increasing attention for their capacity to modulate gut microbial composition and function. Herbal compounds, essential oils, and phytochemicals possess antimicrobial, prebiotic, anti-inflammatory, and immunomodulatory properties that may selectively influence microbial diversity and metabolic activity [35–37,42]. Traditional medical systems, including Persian and herbal medicine, have long utilized plant-based remedies to restore gastrointestinal balance and treat systemic diseases, a concept that aligns with contemporary microbiome-centered therapeutic strategies [35].

Recent experimental and clinical studies indicate that herbal compounds can alter the abundance of key microbial taxa such as *Bifidobacterium*, *Lactobacillus*, and *Akkermansia muciniphila*, while suppressing pathogenic or pro-inflammatory species [29,32,34]. These microbiota-mediated effects have been implicated in improved metabolic profiles, attenuation of systemic inflammation, modulation of immune responses, and regulation of neurobehavioral outcomes through the gut–

brain axis [17–22]. Furthermore, plant-derived antimicrobials are being explored as potential alternatives or adjuncts to conventional antibiotics, particularly in the context of rising antimicrobial resistance [30,31,39].

Given the expanding body of evidence linking herbal compounds to gut microbiota modulation and human health outcomes, a comprehensive synthesis of current findings is warranted. Therefore, the aim of this review is to systematically evaluate the role of herbal and natural compounds in modulating the human gut microbiota and to examine their implications for health and disease. By integrating evidence from experimental, clinical, and mechanistic studies, this review seeks to provide a clearer understanding of microbiota-targeted herbal interventions and to highlight their potential as complementary strategies in preventive and therapeutic medicine.

Study Design

This study was conducted as a **narrative review** following the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020** guidelines to ensure transparency and methodological rigor in the identification, screening, and selection of relevant literature.

Data Sources and Search Strategy

A comprehensive literature search was performed using four major electronic databases: **PubMed, Google Scholar, Scientific Information Database (SID), and Magiran**. The search strategy aimed to retrieve studies investigating the effects of herbal and natural compounds on the human gut microbiota and their associations with health-related outcomes.

The search was conducted using combinations of the following keywords and Medical Subject Headings (MeSH) terms:

- *Medicinal plants*
- *Herbal compounds*
- *Gut microbiota*
- *Intestinal microbiome*
- *Dysbiosis*
- *Gut–brain axis*

No geographical limitations were applied. Articles published in English and Persian were considered eligible. Additionally, reference lists of relevant articles were manually screened to identify further potentially eligible studies.

Study Selection and Eligibility Criteria

Identification

The initial database search yielded **348 records**, and an additional **22 records** were identified through manual searching of reference lists and related literature.

Screening

After removal of duplicate records, **285 articles** remained and were screened based on their titles and abstracts. During this stage, **64 articles** were excluded due to irrelevance to the study topic or insufficient scientific quality.

Eligibility

A total of **98 full-text articles** were assessed for eligibility. Among these, **44 studies** were excluded for the following reasons:

- Insufficient or absent data regarding gut microbiota outcomes
- Lack of herbal or natural compound interventions
- Non-original research formats, including editorials, commentaries, and opinion-based articles

Inclusion

Ultimately, **54 studies** met all predefined inclusion criteria and were included in the final narrative synthesis.

Data Extraction

Data were systematically extracted from the included studies using a structured approach. Extracted variables included:

- Study design and population characteristics
- Type of herbal or natural compound investigated
- Targeted disease or health condition
- Gut microbiota-related outcomes (e.g., microbial diversity, specific taxa changes, SCFA production)
- Proposed biological and mechanistic effects

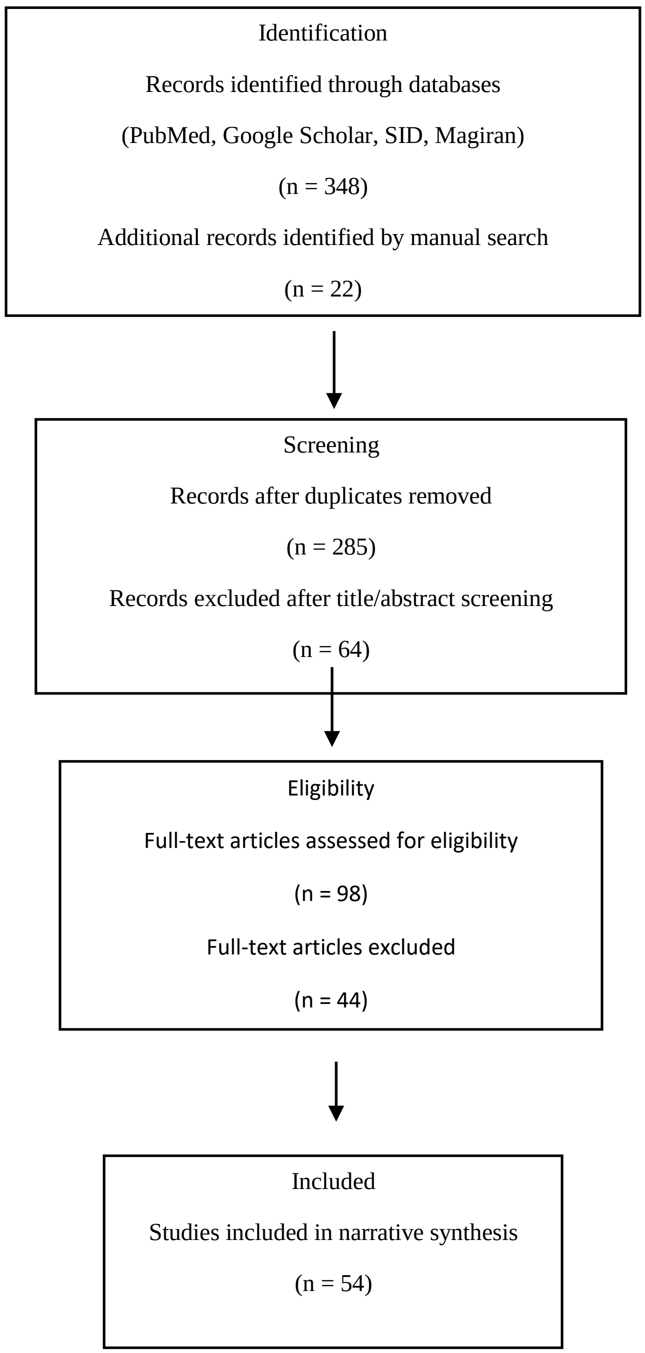
Data Synthesis

Due to substantial heterogeneity in study design, interventions, outcome measures, and experimental models (human, animal, and in-vitro studies), a quantitative meta-analysis was not feasible. Therefore, findings were synthesized **descriptively and thematically**, focusing on patterns of microbiota modulation, mechanistic pathways, and health-related implications.

PRISMA Flow Diagram

The study selection process is illustrated in **Figure 1**, which presents the PRISMA 2020 flow diagram outlining the identification, screening, eligibility, and inclusion stages of the reviewed literature.

Figure 1



Journal of Scientific and Technology Research (TUBITTUM)
olume 4 Issue 4, 2025, pp: 159-174 **www. Tubittumjournal.com** ISSN: 2822-5295
https://tubittumjournal.com/article/1122

Results

1. Effects of Herbal Compounds on Gut Microbiota Composition

The reviewed studies consistently demonstrate that medicinal plants and their bioactive constituents exert significant modulatory effects on the composition and diversity of the human gut microbiota. Multiple investigations reported that herbal compounds promote the growth of beneficial bacterial genera, including *Lactobacillus*, *Bifidobacterium*, and *Prevotella*, while suppressing pathogenic microorganisms such as *Escherichia coli*, *Staphylococcus aureus*, *Clostridium* spp., and opportunistic fungi (*Candida* spp.) (2–4,40,42).

Herbal interventions were particularly effective in restoring microbial balance in conditions associated with dysbiosis, including metabolic disorders, inflammatory diseases, stress-related conditions, and antibiotic-induced microbial disruption (5,6,34).

The major medicinal plants investigated for gut microbiota modulation and their reported microbial effects are summarized in Table 1.

Table 1. Effects of Major Medicinal Plants on Gut Microbiota

Medicinal Plant	**Key Bioactive Compounds**	**Effects on Beneficial Bacteria**	**Effects on Pathogenic Bacteria**	**Overall Impact on Gut Microbiota**
Ginger (*Zingiber officinale*)	Gingerols, shogaols	↑ *Lactobacillus* spp.	↓ *E. coli*, ↓ *S. aureus*	Improves microbial diversity; anti-inflammatory effects (36,37,42)
Cinnamon (*Cinnamomum zeylanicum*)	Cinnamaldehyde, eugenol	Mild ↑ SCFA-producing bacteria	Strong inhibition of Gram+ and Gram− pathogens	Potent antimicrobial activity; supports microbial balance (42–44)
Ajwain (*Trachyspermum ammi*)	Thymol, carvacrol	Supports growth of lactobacilli	↓ Gastrointestinal pathogens	Restores microbial balance; reduces bloating and dysbiosis (42,43)

Medicinal Plant	Key Bioactive Compounds	Effects on Beneficial Bacteria	Effects on Pathogenic Bacteria	Overall Impact on Gut Microbiota
Cumin (*Carum carvi*)	Terpenoids, carvone	Improves digestive microbiota	Moderate antimicrobial activity	Enhances digestion; stabilizes gut flora (35,42)
Ashwagandha (*Withania somnifera*)	Withanolides	↑ Beneficial microbes via stress reduction	Indirect reduction of inflammatory triggers	Supports gut–brain axis; mitigates stress-induced dysbiosis (45–49)
Amla (*Phyllanthus emblica*)	Vitamin C, polyphenols	↑ *Bifidobacterium* spp.	Antibacterial and antiviral effects	Strong antioxidant; improves mucosal immunity (50–54)

2. Impact on Microbial Diversity and Metabolic Activity

Several studies highlighted that plant-derived polyphenols, essential oils, and dietary fibers enhance overall microbial diversity and stimulate the production of short-chain fatty acids (SCFAs), such as acetate, propionate, and butyrate (2,21,24). Increased SCFA production was associated with improved intestinal barrier function, reduced systemic inflammation, and enhanced energy homeostasis (21,24).

In particular, ginger (*Zingiber officinale*) and cinnamon (*Cinnamomum zeylanicum*) demonstrated notable effects on microbial metabolism, contributing to reduced inflammatory markers and improved glucose and lipid metabolism (36,37,42,43).

3. Antimicrobial Effects of Essential Oils

Essential oils derived from medicinal plants exhibited strong antimicrobial activity against both Gram-positive and Gram-negative bacteria. Cinnamon, ginger, thyme, clove, and ajwain essential oils showed measurable inhibitory effects against common intestinal pathogens, without completely disrupting beneficial microbial populations (36,37,42–44).

Journal of Scientific and Technology Research (TUBITTUM)
olume 4 Issue 4, 2025, pp: 159-174 **www. Tubittumjournal.com** ISSN: 2822-5295
https://tubittumjournal.com/article/1122

These antimicrobial effects are mainly attributed to bioactive compounds such as terpenoids, phenylpropanoids, flavonoids, and phenolic acids, which disrupt bacterial cell membranes, inhibit enzyme activity, and interfere with microbial replication (30,31,42).

4. Modulation of the Gut–Brain Axis

A substantial proportion of the included studies emphasized the role of gut microbiota modulation in regulating the gut–brain axis. Alterations in microbial composition influenced neural signaling, stress responses, mood regulation, and cognitive function through mechanisms involving SCFA signaling, immune modulation, vagus nerve activation, and neurotransmitter synthesis (7,9–11,17–20,22).

Herbal compounds such as *Withania somnifera* (Ashwagandha) demonstrated indirect neuroprotective and anxiolytic effects by reducing stress-induced dysbiosis and modulating gut-derived inflammatory signals (45,48,49).

5. Effects on Neurological and Neurodevelopmental Disorders

Several studies reported altered gut microbiota profiles in neurological and neurodevelopmental disorders, including autism spectrum disorders, anxiety, depression, and neurodegenerative diseases (14,15,17–20,28,29). Herbal and probiotic-based interventions showed potential in partially restoring microbial balance and improving behavioral and neurological outcomes (14,15,32).

Notably, reduced abundance of *Akkermansia muciniphila* and *Bifidobacterium* spp. was frequently observed in children with autism, suggesting a possible therapeutic role for microbiota-targeted herbal strategies (14,29).

6. Immunomodulatory and Anti-inflammatory Outcomes

The reviewed literature indicates that gut microbiota modulation by medicinal plants significantly influences immune system function. Herbal compounds were shown to regulate cytokine production, enhance mucosal immunity, and reduce chronic low-grade inflammation associated with dysbiosis (5,27,33,41).

Plants such as *Phyllanthus emblica* (Amla) exhibited strong antioxidant and anti-inflammatory effects, contributing to improved microbial stability and immune tolerance (50–54).

7. Summary of Key Findings

Overall, the included studies provide strong evidence that medicinal plants:

- Enhance beneficial gut microbial populations
- Suppress pathogenic microorganisms

- Improve microbial metabolic activity and SCFA production
- Modulate immune responses and inflammatory pathways
- Influence gut–brain communication and neurological health

These findings support the therapeutic potential of herbal compounds as complementary or alternative strategies for maintaining gut microbiota balance and improving overall health outcomes (2–7,17,21,30–32).

Table 2 summarizes the major health outcomes associated with herbal-induced modulation of the gut microbiota, highlighting effects on metabolic, immune, gastrointestinal, and neurobehavioral parameters.

Table 2. Health Outcomes Associated with Herbal Modulation of Gut Microbiota

Health Area	**Microbiota-Related Mechanism**	**Herbal Evidence**	**Overall Effect**
Mental Health (Anxiety, Depression)	Gut–brain axis modulation; SCFA signaling; vagal pathways	*Ashwagandha*, stress-modulating herbs	Improved mood regulation and stress resilience (7,10,17,22,45–49)
Metabolic Health (Obesity, Appetite Regulation)	SCFA production; appetite control via hypothalamic signaling	Ginger, cinnamon	Reduced appetite; improved metabolic balance (21,32,36,37)
Immune Function	Cytokine modulation; enhanced mucosal immunity	*Amla*, *Ashwagandha*	Reduced inflammation; improved immune tolerance (5,27,50–52)
Gastrointestinal Health	Pathogen suppression; improved digestion	Ajwain, cumin	Relief from dysbiosis, bloating, IBS-like symptoms (34,35,42)
Antimicrobial Protection	Direct inhibition of pathogenic bacteria	Cinnamon, ginger, thyme	Reduced pathogenic load; microbial stability (30,31,42–44)

Discussion

1. Central Role of Gut Microbiota in Human Health

The findings of this comprehensive review reinforce the concept that the gut microbiota functions as a central regulator of human physiological homeostasis. A balanced microbial ecosystem is essential for digestion, immune regulation, metabolic control, and neural signaling. Disruption of this equilibrium, commonly referred to as dysbiosis, has been strongly associated with the pathogenesis of metabolic, inflammatory, neurological, and immune-mediated disorders (2–6,24).

Accumulating evidence indicates that gut microbiota influences host health not only locally within the gastrointestinal tract but also systemically through immune modulation, endocrine signaling, and neurochemical pathways (5,7,11,17). These observations highlight the microbiota as a critical therapeutic target in modern integrative medicine.

2. Medicinal Plants as Modulators of Microbial Homeostasis

The reviewed studies suggest that medicinal plants exert their beneficial effects on gut microbiota through multiple complementary mechanisms. Unlike broad-spectrum antibiotics, which often disrupt both pathogenic and beneficial bacteria, herbal compounds tend to exhibit selective antimicrobial activity, suppressing harmful microorganisms while preserving or even promoting beneficial species (30–32,42).

Polyphenols, terpenoids, flavonoids, and alkaloids present in medicinal plants can act as prebiotic-like substrates, enhancing microbial diversity and metabolic activity (21,30). This selective modulation contributes to increased microbial resilience and stability—key features of a healthy gut ecosystem (2).

3. Anti-inflammatory and Immunomodulatory Pathways

Chronic low-grade inflammation is a hallmark of many dysbiosis-associated diseases. The reviewed evidence indicates that herbal compounds modulate inflammatory pathways by influencing cytokine production, enhancing mucosal immunity, and improving intestinal barrier integrity (5,27,33,41).

For example, *Phyllanthus emblica* (Amla) demonstrates potent antioxidant and anti-inflammatory properties that may reduce oxidative stress and support immune tolerance within the gut environment (50–54). Such effects are particularly relevant in preventing immune-mediated disorders and reducing systemic inflammatory burden.

4. Herbal Influence on the Gut–Brain Axis

One of the most compelling findings of this review is the role of medicinal plants in modulating the gut–brain axis. Through microbial-derived metabolites such as short-chain fatty acids, neurotransmitter precursors, and immune mediators, gut microbes can directly affect central nervous system function (7,9–11,17–22).

Herbal compounds such as *Withania somnifera* (Ashwagandha) appear to mitigate stress-induced dysbiosis and normalize gut–brain communication pathways, leading to improvements in mood, stress resilience, and cognitive function (45,48,49). These findings support the emerging role of phytotherapy as a complementary approach in neuropsychiatric and stress-related disorders.

5. Relevance to Neurological and Neurodevelopmental Disorders

Altered gut microbiota profiles have been consistently reported in neurological and neurodevelopmental conditions, including autism spectrum disorders, anxiety, depression, and neurodegenerative diseases (14,15,17–20,28,29). The reviewed studies suggest that microbiota-targeted herbal interventions may partially restore microbial balance and positively influence behavioral and neurological outcomes (14,15,32).

Although current evidence is promising, most human studies remain preliminary. Nonetheless, these findings underscore the potential of medicinal plants as adjunctive therapies in managing complex brain-related disorders via the gut–brain axis.

6. Addressing Antibiotic Resistance through Herbal Alternatives

The global rise in antibiotic resistance has intensified the need for alternative antimicrobial strategies. Medicinal plants offer a promising solution due to their multi-target mechanisms of action and lower propensity for inducing resistance (30,31).

Essential oils and plant extracts demonstrate antibacterial activity through membrane disruption, enzyme inhibition, and interference with bacterial quorum sensing, which may reduce the likelihood of resistance development (30,42). This positions herbal compounds as valuable tools in both preventive and therapeutic contexts.

7. Limitations and Future Directions

Despite the growing body of evidence, several limitations must be acknowledged. Many studies included in this review were conducted in vitro or in animal models, limiting direct clinical applicability. Human clinical trials often vary in dosage, formulation, and duration of herbal interventions, making comparisons challenging.

Future research should focus on:

- Well-designed randomized controlled trials in humans
- Standardization of herbal preparations and dosages
- Long-term safety and efficacy assessments
- Integration of microbiome sequencing technologies to clarify mechanisms

Journal of Scientific and Technology Research (TUBITTUM)
olume 4 Issue 4, 2025, pp: 159-174 **www. Tubittumjournal.com** ISSN: 2822-5295
https://tubittumjournal.com/article/1122

Such efforts are essential to translate microbiota-based herbal interventions into evidence-based clinical practice.

8. Clinical Implications

The findings of this review suggest that medicinal plants can be effectively integrated into preventive and therapeutic strategies aimed at maintaining gut microbial balance. When used alone or in combination with probiotics and lifestyle interventions, herbal compounds may contribute to improved gastrointestinal, metabolic, immune, and neurological health.

Conclusion

The gut microbiota plays a fundamental role in maintaining human health by regulating metabolic, immune, neurological, and gastrointestinal functions. Disruption of microbial homeostasis (dysbiosis) is increasingly recognized as a contributing factor in the development of numerous chronic diseases, including metabolic disorders, inflammatory conditions, and neuropsychiatric abnormalities (2–6,17–20).

The findings of this comprehensive review demonstrate that medicinal plants and their bioactive compounds possess significant potential to modulate gut microbiota composition and restore microbial balance. Herbal agents rich in polyphenols, essential oils, terpenoids, and alkaloids exhibit selective antimicrobial, anti-inflammatory, antioxidant, and prebiotic-like effects that support beneficial microbial populations while suppressing pathogenic species (30–32,42).

Herbal interventions such as *Zingiber officinale*, *Cinnamomum zeylanicum*, *Trachyspermum ammi*, *Withania somnifera*, and *Phyllanthus emblica* were shown to improve microbial diversity, enhance immune tolerance, regulate metabolic pathways, and influence gut–brain axis signaling. These multifaceted actions suggest that phytotherapy may serve as an effective complementary approach for preventing and managing dysbiosis-related gastrointestinal, metabolic, immune, and neurological disorders (45–54).

Furthermore, in the context of increasing antibiotic resistance, medicinal plants represent a promising alternative or adjunctive strategy due to their multi-target mechanisms and lower likelihood of inducing microbial resistance (30,31). However, despite encouraging preclinical and early clinical evidence, limitations remain regarding heterogeneity in study design, dosage, formulation, and outcome measures.

Future research should prioritize large-scale, well-controlled human clinical trials with standardized herbal preparations and advanced microbiome profiling techniques to establish definitive therapeutic protocols. Integrating medicinal plants into microbiota-targeted interventions may ultimately offer a safe, cost-effective, and biologically harmonious strategy for promoting gut health and overall well-being.

Refrences:

1. Fariba Kohdani, Hanieh Al-Sadat Ejtahed, Kamelia Akhgarjand, Amir Bagheri, Ahmad Jaidi, Farideh Shirasab, Atiyeh Mirzababai, Seyyed Mohammad Mousavi. Microbiome and health book, Tehran, Naqsh Ivan, introduction, 2022.

2.Lozupone CA, Stombaugh JI, Gordon JI, Jansson JK, Knight R. Diversity, stability and resilience of the human gut microbiota. Nature. 2012; 489(7415): 220-30.

3. Thursby E, Juge N. Introduction to the human gut microbiota. Biochem J. 2017; 474(11): 1823-36.
4.Gerritsen J, Smidt H, Rijkers GT, de Vos WM. Intes tinal microbiota in human health and disease: the impact of probiotics. Genes Nutr. 2011; 6(3): 209-40.

5. Thaiss CA, Zmora N, Levy M, Elinav E. The microbiome and innate immunity. Nature. 2016; 535(7610): 65-74.

6. Fujimura KE, Slusher NA, Cabana MD, Lynch SV. Role of the gut microbiota in defining human health. Expert Rev Anti Infect Ther. 2010; 8(4): 435-54.

7. Borre YE, Moloney RD, Clarke G, Dinan TG, Cryan JF. The Impact of microbiota on brain and behavior: mechanisms & therapeutic potential. in: lyte m, cryan jf, editors. microbial endocrinology: the microbiotagut-brain axis in health and disease. New York, NY: Springer New York; 2014. p. 373-403.

8. Putignani L, Del Chierico F, Petrucca A, Vernocchi P, Dallapiccola B. The human gut microbiota: a dynamic interplay with the host from birth to senescence settled during childhood. Pediatr Res. 2014; 76(1): 2-10.

9. Neufeld KA, Fo s ter JA. Effects of gut microbiota on the brain: implications for psychiatry. J Psychiatry Neurosci. 2009; 34(3): 230-1.

10. Foster JA, Rinaman L, Cryan JF. Stress & the gut-brain axis: Regulation by the microbiome. Neurobiol Stress. 2017; 7: 124-36.

11. Carabotti M, Scirocco A, Maselli MA, Severi C. The gut-brain axis: interactions between enteric microbiota, central and enteric nervous systems. Ann Gastroenterol. 2015; 28(2): 203-9.

12. Xiao P. A Modeling Study in the Regulation of Stress on Neuronal Plasticity: The University of Texas at Arlington, 2015.

13.Mokhtari S, Jafari SM, Khomeiri M, Maghsudlou Y, Ghorbani M. The cell wall compound of Saccharomyces cerevisiae as a novel wall material for encapsulation of probiotics. Food Research International.2017;96:19-26.

14. Strati F, Cavalieri D, Albanese D, De Felice C, Donati C, Hayek J, et al. New evidences on the altered gut microbiota in autism spectrum disorders. Microbiome. 2017; 5(1): 24. doi: 10.1186/s40168-017 0242-1. 10

15. Li Q, Han Y, Dy ABC, Hagerman RJ. The gut microbiota and autism spectrum disorders. Front Cell Neurosci. 2017; 11: 120. doi: 10.3389/fncel.2017.00120.

16. Clark A, Mach N. Exercise-induced stress behavior, gut-microbiota-brain axis and diet: a systematic review for athletes. J Int Soc Sports Nutr. 2016; 13: 43. doi. org/10.1186/s12970-016-0155-6.

17. Cryan JF, Dinan TG. Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour. Nat Rev Neurosci. 2012; 13(10): 701-12.

18. Tillisch K, Labus J, Kilpatrick L, Jiang Z, Stains J, Ebrat B, et al. Consumption of fermented milk product with probiotic modulates brain activity. Gastroenterology. 2013; 144(7): 1394-401.

19. Sampson TR, Mazmanian SK. Control of brain development, function, and behavior by the microbiome. Cell Host Microbe. 2015; 17(5): 565-76.

20.Dinan TG, Cryan JF. Gut-brain axis in 2016: Brain-gut-microbiota axis - mood, metabolism and behaviour. Nat Rev Gastroenterol Hepatol. 2017; 14(2): 69-70.

21. Byrne CS, Chambers ES, Morrison DJ, Frost G. The role of short chain fatty acids in appetite regulation and energy homeostasis. Int J Obes (Lond). 2015; 39(9): 1331-8.

22. Vuong HE, Yano JM, Fung TC, Hsiao EY. The microbiome and host behavior. Annu Rev Neurosci. 2017; 40: 21-49.

23. Ressler KJ. Amygdala activity, fear, and anxiety: modulation by stress. Biol Psychiatry. 2010; 67(12): 1117-9.

24. Qin J, Li R, Raes J, Arumugam M, Burgdorf Ks, Manichanh C, et al. A human gut microbial gene catalogue established by metagenomic sequencing. Nature. 2010;464(7285):59-65.

25. Arevalo-Rodriguez I, Smailagic N, i Figuls MR, Clapooni A,Sanchez-Perez E, Giannakou A, et al. Mini Mental State Examination (MMSE) for the detection of Alzheimers disease and other dementias in people with mild cognitive impairment (MCI). Cochrane Database of Systematic Reviews. 2015(3).

26. Lanctot KL, Herrmann N, Mazzotta P, Khan LR, Ingber N, GABAergic function in Alzheimers disease: evidence for dysfunction and potential as a therapeutic target for the treatment of behavioural and psychological symptoms of dementia. The Canadian Journal of Psychiatry. 2004;49(7)439-53.

27. Alegre ML, Mannon RB, Mannon PJ. The microbiota, the immune system and the allograft. Am J Transplant. 2014; 14(6): 1236-48.

28. Klukowski M, Wasilewska J, Lebensztejn D. Sleep and gastrointestinal disturbances in autism spectrum disorder in children. Developmental period medicine. 2015;19(2):157-61.

29. Wang L, Christophersen CT, Sorich MJ, Gerber JP, Angley MT, Conlon MA, Low relative abundances of the mucolytic bacterium Akkermansia muciniphila and Bifidobacterium spp. In faces of children with autism. Applied and rnvironmental microbiology.2011;77(18):6718-21.

30. Guzman JD, Gupta A, Bucar F, Gibbons S, Bhakta S. Antimycobacterials from natural sources: ancient times, antibiotic era and novel scaffolds. Front Biosci 2012; 17(5): 1861 -1881 . 11

31. Campanini -Salinas J, Andrades -Lagos J, Mella -Raipan J, Vasquez -Velasquez D. Novel classes of antibacterial drugs in clinical development, a hope in a post -antibiotic era. Current Topics in Medicinal Chemistry 2018; 18(14): 1188 -1202.

32. Lee SJ, Bose S, Seo JG, Chung WS, Lim CY, Kim H. The effects of co -administration of probiotics with herbal medicine on obesity, metabolic endotoxemia and dysbiosis: a randomized double -blind controlled clinical trial. Clin Nutr 2014; 33(6): 973 -981 .

33. Eyvazi S, Vostakolaei MA, Dilmaghani A, Borumandi O, Hejazi MS, Kahroba H, et al. The oncogenic roles of bacterial infections in development of cancer. Microbial Pathogenesis 2020; 141(8): 104019 .

34. Simrén M. IBS with intestinal microbial dysbiosis: a new and clinically relevant subgroup Gut 2014; 63(11): 1685 -1686 .

35. Hamedi A, Zarshenas MM, Sohrabpour M, Zargaran A. Herbal medicinal oils in traditional Persian medicine. Pharmaceutical Biology 2013; 51(9): 1208 -1218 .

36. Abdullahi A, Khairulmazmi A, Yasmeen S, Ismail I, Norhayu A, Sulaiman M, et al. Phytochemical profiling and antimicrobial activity of ginger (Zingiber officinale) essential oils against important phytopathogens. Arabian Journal of Chemistry 2020; 13(11): 8012 -8025 .

37. Wang X, Shen Y, Thakur K, Han J, Zhang J - G, Hu F, et al. Antibacterial activity and mechanism of ginger essential oil against Escherichia coli and Staphylococcus aureus. Molecules 2020; 25(17): 3955 .

38. Mohammadzadeh F, Monirifar H, Saba J, Valizadeh M, Haghighi AR, Zanjani BM, et al. Genetic variation among Iranian alfalfa (Medicago sativa L.) populations based on RAPD markers. Bangladesh Journal of Plant Taxonomy 2011; 18(2): 93 -104 .

39. Azargun R, Gholizadeh P, Sadeghi V, Hosainzadegan H, Tarhriz V, Memar MY, et al. Molecular mechanisms associated with quinolone resistance in Enterobacteriaceae: review and update. Transactions of the Royal Society of Tropical Medicine and Hygiene 2020; 114(10): 770 -781.

40. Davis CP. Normal flora. Medical Microbiology 4 th ed . University of Texas Medical Branch at Galveston; 1996 .

41. Vaishnavi C. Translocation of gut flora and its role in sepsis. Indian J Med Microbiol 2013; 31(4): 334 342.

42. Nazzaro F, Fratianni F, De Martino L, Coppola R, De Feo V. Effect of essential oils on pathogenic bacteria. Pharmaceuticals 2013; 6(12): 1451 -1474 .

43. Graich H, Amouch F, et al. Antibacterial activity of essential oils extracts from cinnamon, thyme, clove and geranium against a gram negative and gram positive pathogenic bacteria. Journal of Diseases and Medicinal Plants 2017; 3(2 -1): 1 - 5 .

44. Soleimani N, Ebraze N. Evaluate anti - bacterial effects of cinnamomun verum and ferula gummosa essential oil on some pathogen gram positive and negative bacteria. New Cellular and Molecular Biotechnology Journal 2016; 6(23): 87 -94 (Persian) . 12

45. Shukla R, Pahal S, Gupta A, Choudhary P, Misra K, Singh S.J Modulation of GPCR receptors common to gut inflammatory diseases and neuronal disorders, Alzheimer's and Parkinson's diseases as druggable targets through Withania somnifera bioactives: an in silico study Biomol Struct Dyn. 2023 Jul;41(10):4485-4503.

46. Chatterjee SS, Kumar V. Quantitative systems pharmacology: Lessons from fumaric acid and herbal remedies. Drug Des. 2017;6:152.

47. Kumar V, Thakur AK, Verma S, Yadav V, Chatterjee SS. Potential of some traditionally used edible plants for prevention and cure of disability associated comorbidities. TANG [Hum Med] 2015;5:8.1–8.22.

48. Kumar V, Dey A, Chatterjee SS. Phytopharmacology of Ashwagandha as an anti-diabetic herb. In: Kaul S, Wadhwa R, editors. Science of Ashwagandha: Preventive and Therapeutic Potentials. Cham: Springer; 2017. pp. 37–68.

49. Dey A, Chatterjee SS, Kumar V. Analgesic activity of a Withania somnifera extract in stressed mice. Orient Pharm Exp Med. 2016;16:295–302.

50. Baliga, M.S.; Dsouza, J.J. Amla (Emblica officinalis Gaertn), a wonder berry in the treatment and prevention of cancer. Eur. J. Cancer Prev. 2011, 20, 225–239.

51. Wang, C.C.; Yuan, J.R.; Wang, C.F.; Yang, N.; Chen, J.; Liu, D.; Song, J.; Feng, L.; Tan, X.B.; Jia, X.B. Anti inflammatory effects of Phyllanthus emblica L. on benzopyrene-induced precancerous lung lesion by regulating the IL-1β/miR-101/Lin28B signaling pathway. Integr. Cancer Ther. 2017, 16, 505–515.

52. Saini, R.; Sharma, N.; Oladeji, O.S.; Sourirajan, A.; Dev, K.; Zengin, G.; El-Shazly, M.; Kumar, V. Traditional uses, bioactive composition, pharmacology, and toxicology of Phyllanthus emblica fruits: A comprehensive review. J. Ethnopharmacol. 2022, 282, 114570.

53. Khan, A.; Ahmed, T.; Rizwan, M.; Khan, N. Comparative therapeutic efficacy of Phyllanthus emblica (Amla) fruit extract and procaine penicillin in the treatment of subclinical mastitis in dairy buffaloes. Microb. Pathog. 2018, 115, 8–11.

54. Gunti, L.; Dass, R.S.; Kalagatur, N.K. Phytofabrication of selenium nanoparticles from Emblica officinalis fruit extract and exploring its biopotential applications: Antioxidant, antimicrobial, and biocompatibility. Front. Microbiol. 2019, 10, 931.