

The Role Of Fermented Foods In Regulating Gut Microbiota And Mental Health

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ABSTRACT

Background: Scientifically, fermentation is the process by which microorganisms convert sugar into alcohol and organic acids, which extends the shelf life of food. Today, the field of Nutritional Psychiatry has emerged to identify food components that are important for mental health, emphasizing that the complex interaction between nutrition and brain function highlights the need for a multidisciplinary approach. **Objective:** To explore the role of fermentation-based diets in regulating gut microbiota and their impact on mental health. **Methods:** The research method used was a literature review, with five journals reviewed. **Results:** Based on the five research journals reviewed, the main findings centered on the crucial and comprehensive relationship between gut microbiota, nutrition (diet), and mental health. The first journal introduced psychobiotics, specific live microorganisms that provide therapeutic benefits for mental disorders by increasing the production of important neurotransmitters such as dopamine and serotonin in the gut. The second and fourth journals explicitly show a strong correlation between a healthy diet and mental well-being. The third journal specifically discusses the role of fermented foods in Nutritional Psychiatry. The fifth journal also discusses lifestyle and nutritional neuroscience related to mental health. **Conclusion:** There is a close relationship between gut microbiota, diet, and mental health, which indicates the potential of nutritional and psychobiotic interventions in the prevention and treatment of mental disorders.

Keywords: Diet, Fermented Foods, Gut Microbiota, Mental Health

Introduction

Fermented foods have been a component of the human diet since ancient times. Among the earliest evidence for the deliberate use of fermentation has been found in pottery vessels discovered in China dating back to 7000 BC, which were used to ferment rice, honey, and fruit.¹ Fermentation is a process in which alcohol, carbon dioxide, and/or organic acids are produced by microorganisms, primarily from sugars and under mostly anaerobic conditions, for energy production.¹ The accumulation of alcohol and organic acids and the associated increase in the acidity of the food substrate inhibit the growth of other microorganisms and enzyme activity in the food system, thereby reducing the rate of decay and producing food with a longer shelf life.¹ Since the Paleolithic era, there have been many opportunities to consume food products (e.g., honey, fruits or berries, and their juices) that have unknowingly undergone natural microbial fermentation.² Without knowledge of microbes, our ancestors recognized, over time, the palatability, preservative, analgesic, and mental stimulation or calming qualities of fermented foods and beverages.

Information in popular media about the relationship between nutrition and mental health is increasingly invading our daily lives. Nutritional psychiatry has emerged to provide hope in identifying which food components are truly important for mental health, including in psychiatric disorders, as well as to whom, under what circumstances, and at what specific doses these nutritional interventions have preventive and therapeutic efficacy.³ The complex interactions between the food we eat and how our brains respond to nutrients highlight the connection between daily lifestyle habits and brain, mind, and body health. Understanding the relationship between food and its impact on mental/brain health, along with the reciprocal influence of mental/brain health on overall health, including gut health and daily lifestyle habits such as food choices, requires a transdisciplinary approach that combines the fields of psychiatry, psychology, neuroscience, nutrition, and lifestyle medicine. The objective of this review is to explore the role of fermentation-based diets in regulating gut microbiota and mental health.

Material and Methods

The research method used was a literature review with a comprehensive literature search conducted using the Google Scholar, PubMed, and Scopus databases. The inclusion criteria for journals in this study were journals published in the last 10 years, namely 2014-2024, focusing on the role of fermentation-based diets that have an influence on microbiota regulation and mental health. The exclusion criteria for journals in this study were those with too broad a scope and not focused on the relationship between gut health and mental health. The keywords used were “role of fermented diets,” “microbiota regulation,” “mental health,” and “nutrition.” A total of 8 journals were selected based on relevance. The number of articles that became the focus of this research review was 5 journals.

Result and Discussion

The following are the five journals that were the focus of this study:

Table 1. Journal Literature Review

No	Author & Year	Title	Methods	Result
1.	Naufal, et al. (2020)	The Role of Fermented Foods in Regulating Gut Microbiota and Mental Health	-	Psychobiotics provide therapeutic effects and positive outcomes for people with mental disorders, as seen in improved mood, reduced depression, and overall better mental health, making them a potential intervention for various mental disorders, in addition to pharmacological therapy. Psychobiotics (beneficial live microorganisms) have the ability to directly increase the production of key neurotransmitters in the gut. Neurotransmitters produced or influenced in the gut include: Approximately 90% of the body's serotonin is produced in the gut, partly mediated by microbes. Serotonin regulates mood, sleep, and appetite. Then there is dopamine, which is associated with pleasure, motivation, and reward. GABA (Gamma-Aminobutyric Acid) is the main inhibitory

				neurotransmitter that helps reduce anxiety. And norepinephrine, which is involved in stress responses and alertness.
2.	Putri, et al. (2024)	The Effect of Diet on Mental Health The Role of Nutrition in College Students	Quantitative with survey methodology	There is a significant correlation between nutritious food consumption and lower levels of stress and anxiety. The nutrients consumed (carbohydrates, essential fatty acids, proteins, vitamins, and minerals) serve as precursors (raw materials) for neurotransmitter synthesis in the brain. Protein is broken down into amino acids, such as tryptophan, which is the main precursor for the synthesis of serotonin (mood regulator). The amino acid tyrosine is a precursor for dopamine and norepinephrine.
3.	Selhub, et al. (2014)	Fermented Foods, Microbiota, And Mental Health: Ancient Practice Meets Nutritional Psychiatry	-	Well-controlled fermentation can often increase the nutritional content and specific phytochemicals in food, the ultimate value of which can be linked to mental health. Fermentation of fiber-rich components (such as rice bran or soybean sprouts) by lactic acid bacteria has been

				<p>shown to produce new bioactive compounds (such as phenolic metabolites) that did not previously exist. These new compounds have beneficial anti-inflammatory and immune effects. Given the strong correlation between systemic inflammation and mental disorders (such as depression and anxiety), the ability of fermented foods to reduce inflammation serves as a key mechanism for protecting mental health. The reduction in experimental stress and fatigue (as demonstrated by fermented rice bran extract) is a direct result of this decrease in inflammatory burden.</p>
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4.	Adan, et al. (2019)	Nutritional Psychiatry: Towards Improving Mental Health By What You Eat	Intervention Study	Dietary modifications (often combined with lifestyle changes) have potential in the prevention and treatment of mental health. SCFAs are key signaling molecules that connect the gut to other body systems, including the brain, through anti-inflammatory pathways. SCFAs circulate throughout the body and have anti-inflammatory effects. Chronic inflammation is known to be a major driving factor in the pathogenesis of depression and other mental disorders.
5.	Merlo, et al. (2024)	Gut Microbiota, Nutrition, & Mental Health	Intervention Study	Nutritional neuroscience and lifestyle emerge as powerful tools for improving patient outcomes, alleviating mental/brain health challenges, and enhancing the management and treatment of existing mental/brain health conditions by advocating for health-promoting diets, correcting nutritional deficiencies, and integrating nutrition-centered strategies into clinical care. Essential fatty acids (such as Omega-3)

				are key components of nerve cell membranes. Protein provides amino acids that are precursors to nearly all neurotransmitters (e.g., Tryptophan for Serotonin, Tyrosine for Dopamine).
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The first journal, titled “Psychobiotics: The Role of Gut Microbiota in Mental Health” by Naufal, et al. (2020), reveals that psychobiotics can provide therapeutic effects and positive outcomes for people with mental disorders, thus having the potential to be used as an intervention for various mental disorders, in addition to pharmacological therapy⁵. This journal explicitly positions the gut microbiota as a central regulator of physical health, with a particular focus on its new role in mental health. The key concept introduced is Psychobiotics, which are specific live microorganisms proven to provide therapeutic effects and positive outcomes for individuals with mental disorders⁵. This synthesis shows that psychobiotics not only act as supplements but also have great potential as alternative or adjuvant interventions alongside conventional pharmacological therapy in the treatment of various mental disorders⁵. This synthesis shows that psychobiotics not only act as supplements, but also have great potential. as alternative or adjuvant interventions alongside conventional pharmacological therapies in the treatment of various mental disorders⁵. The second point regarding the mechanism of psychobiotics lies in their ability to influence the Enteric Nervous System (ENS). Psychobiotics work by increasing the production of important neurotransmitters in the gut. The neurotransmitters affected include dopamine, serotonin, norepinephrine, and GABA. This increased production then modulates nerve signal transmission at nearby synapses, which directly affects nerve function and mental health⁵. This analysis also presents the gut microbiota not only as an entity related to the brain, but also as a vital component of basic human physiological functions. Basic functions include microbiota that maintain metabolism, nutrient absorption, and immunity. They also help the body fight pathogens.

The root of the problem here is dysbiosis⁶. When dysbiosis (an imbalance in the composition of the microbiota) occurs, overall health is disrupted, triggering various serious problems such as digestive disorders, autoimmune diseases and metabolic syndrome, as well as diseases related to the nervous system, blood circulation, and immunity⁶. It is also mentioned that abnormal microbiota composition and susceptibility to dysbiosis are influenced by a number of external and internal factors such as diet and lifestyle, which have a major impact, with antibiotic therapy specifically highlighted for its potential to reduce diversity and significantly alter microbiota composition.

This synthesis analysis emphasizes that mental health cannot be separated from gut health. This journal provides a scientific basis that by modulating the gut microbiota through psychobiotics, it is possible to improve neurotransmitter levels and provide new hope in nutritional psychiatry as a comprehensive intervention approach. The research gap in this journal is the lack of studies identifying specific microbiota biomarkers for mental disorders and testing the efficacy of personalized psychobiotic therapy based on patients' dysbiosis profiles. In line with the second journal by Putri, et al. (2024) entitled "The Effect of Dietary Pattern on Mental Health: The Role of Nutrition in Students," which focuses on the relationship between dietary patterns and mental health, with students as the specific subject. The main finding is a significant correlation showing that consumption of nutritious food is directly related to lower levels of stress and anxiety. The relationship between nutrition and psychology is described as a complex but direct process. Neurotransmitter regulation in the form of proper nutrition plays a crucial role in regulating brain neurotransmitters⁷. Meanwhile, the psychological function of these regulated neurotransmitters is to influence three main aspects, namely mood, cognitive function, and behavior. Therefore, a healthy diet is vital not only for emotional health but also for supporting optimal cognitive function (such as focus, memory, and learning ability), which is particularly relevant for the student population⁷. This analysis synthesizes that food is more than just a source of physical energy; it is the primary chemical regulator for the brain. The composition of the food a person consumes directly influences the chemical balance underlying mood and mental function. In other words, dietary intervention is an effective and proven pathway to mitigate common mental disorders such as stress and anxiety⁷. The gap in this journal research is the lack of studies that explicitly measure and link dietary changes in students to measurable cognitive and academic outcomes beyond just emotional well-being.

In the third journal, the discussion focused on fermented foods' ability to influence mental health from a study titled "Fermented Foods, Microbiota, and Mental Health: Ancient Practice Meets Nutritional Psychiatry" by Selhub, et al. (2014). This synthesis shows that traditional diets rich in antioxidant and anti-inflammatory foods are key to protecting against mental health disorders. Conversely, diets high in fat or sugar and low in nutritional value are significantly correlated with conditions such as depression, anxiety, and chronic stress, which can potentially trigger an inflammatory microbiome.²

Fermentation acts as a biochemical process that improves the nutritional quality and functionality of food. This mechanism can be seen from three main aspects. First, increased antioxidants in the form of fermentation, for example in fruit/herbal smoothies with *Lactobacillus plantarum*, maintain and increase polyphenolic compounds and vitamin C, thereby increasing free radical scavenging activity. Second, synergistic activity, in the form of more prominent antioxidant capacity in fermented soy milk, and its effects increase synergistically when using a

combination of lactic acid bacteria and bifidobacteria. Third, the creation of new bioactive compounds through the fermentation of fiber-rich components (such as soybean sprouts and rice bran) produces new bioactive compounds that have beneficial immune, glycemic, and anti-inflammatory activities². This analysis synthesizes that fermentation is not only a method of preservation, but a process that optimizes the functional content of food that is fundamentally beneficial to the brain. By increasing the availability of antioxidant/anti-inflammatory compounds, fermented foods actively combat chronic inflammatory conditions in the gut that contribute to mental disorders. This practice offers a powerful, food-based approach to supporting mental health through microbiota regulation and reduction of the body's inflammatory burden. The research gap in this journal is the lack of studies testing the efficacy of fermented foods as a complementary therapy in the treatment of more severe clinical mental disorders and measuring their impact on quality of life and psychiatric medication needs.

Similar to the first and second journals, the fourth journal also discusses dietary patterns that have the potential to prevent mental illness but focuses on diet. This journal is titled “Nutritional Psychiatry: Towards Improving Mental Health By What You Eat” by Adan, et al. (2019), which states that dietary modifications (often combined with lifestyle changes) have potential in the prevention and treatment of mental health. The main synthesis is that dietary modifications, especially when combined with lifestyle changes, can be an effective strategy for improving mental health, as well as metabolic health⁸. This journal explains the mechanisms by which a healthy diet works through the gut and its systemic effects. Microbiota diversity through long-term dietary patterns plays an important role in maintaining gut microbiota diversity⁸. The role of fiber here is specifically highlighted because a high-fiber diet can increase gut microbial diversity and short-chain fatty acid (SCFA) production. Meanwhile, systemic effects in the form of increased SCFA and microbial diversity have positive effects on metabolic health, including increased insulin sensitivity, reduced risk of obesity, and reduced inflammation in the body. These findings suggest that dietary interventions that promote gut health can simultaneously prevent and manage metabolic diseases, which often have comorbidities with mental disorders⁸. This analysis found a strong correlation between healthy eating patterns and mental well-being. A healthy diet is associated with better psychological outcomes. This journal synthesizes that diet is not merely a nutritional aspect, but a fundamental biological modification tool.

By promoting a high-fiber diet rich in fruits, vegetables, fish, and whole grains, individuals not only improve their metabolic system (through reduced inflammation and increased insulin sensitivity), but also directly increase the diversity of their gut microbiota, which ultimately lowers the risk of mental illness and improves psychological well-being. The research gap in this study is the lack of research focusing on implementation barriers and tailored intervention strategies to ensure long-term adherence to a healthy diet for people with mental disorders. The fifth journal also discusses lifestyle and nutritional neuroscience related to mental health.

This journal is titled “Gut Microbiota, Nutrition, & Mental Health” by Merlo, et al. (2024). It positions mental health in the context of the brain's extremely high energy and nutritional needs, and links it to lifestyle and nutritional neuroscience. The main finding emphasizes the brain's extreme metabolic needs. The brain consumes about 20–25% of the body's total energy consumption the largest amount compared to other human organs⁴.

This implicitly suggests that small fluctuations in energy or nutrient supply can have a major impact on cognitive and mental function. This analysis emphasizes that energy supply alone is not sufficient to achieve optimal brain health. The brain requires a diverse range of essential nutrients, including carbohydrates, essential fatty acids, proteins, and vitamins and minerals. This journal synthesizes that daily decisions (including diet and other factors such as sleep and physical activity) directly affect the quality of energy and nutrient supply to the brain. The field of nutritional neuroscience focuses on how specific nutrients affect the structure and function of the nervous system, and ultimately, behavior and mental health⁴. This journal serves as a foundation emphasizing that mental health is highly dependent on a stable and high-quality supply of fuel and raw materials to the brain. Therefore, lifestyle (especially nutritional choices) is a key determinant in ensuring that the brain's highest metabolic needs are met to maintain optimal cognitive and mental function. The research gap in this journal is the need to develop precision nutrition therapy guidelines based on the metabolic needs of the impaired brain and to test the effectiveness of specific nutritional interventions as part of clinical management.

Conclusion

The essence of several journals is that there is a close relationship between gut microbiota, diet, and mental health, which shows the potential of nutritional and psychobiotic interventions in the prevention and treatment of mental disorders. The gut microbiota, particularly living organisms called psychobiotics, are crucial because they influence the production of neurotransmitters such as dopamine and serotonin, which modulate nerve function; imbalances (dysbiosis) in the microbiota can trigger various health problems, including mental disorders. A healthy diet, rich in nutrients, antioxidants, and anti-inflammatories (such as fermented foods or a diet high in fruits and vegetables) has been shown to be associated with lower levels of stress and anxiety, while a diet high in sugar and fat correlates with a higher risk of mental health problems, confirming the crucial role of dietary and lifestyle modifications in supporting psychological well-being and optimal cognitive function.

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