



The Mind-Gut Connection: Nutraceutical and Probiotic Strategies for Psychological Resilience

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Abstract

The gut-brain axis, a two-way communication network connecting the brain's emotional and cognitive regions with the intestinal tract's function, has been clearly proven by emerging science. The groundbreaking role that psychobiotics-probiotics that have positive effects on mental health-and nutraceuticals play in regulating this relationship is examined in this article. We'll go into detail about how certain nutritional approaches, such as particular probiotic strains, anti-inflammatory botanicals, and neuro-supportive micronutrients, can have a positive impact on mood, stress response, and cognitive function. This provides an additional avenue for enhancing psychological resilience and mental health.

Keywords: Gut; Mind; Nutraceuticals; Probiotics; Psychological Resilience

Introduction

The psychobiotic revolution: How gut bacteria talk to the brain

For generations, the stomach was thought regarded be a purely functional organ that handled the routine functions of excretion and digestion. This perspective has been drastically altered by modern research, which now shows that the gut is a sophisticated, communicative, and intelligent organ that has a significant impact

on our mental and emotional states. This groundbreaking insight is embodied in the idea of the gut-brain axis, a complex, reciprocal communication network that closely links the brain's central nervous system (CNS) with the gut's enteric nervous system (ENS).

This relationship is a hardwired, physiological reality made up of immunological, endocrine, and neurological pathways rather than just a philosophical idea.

The trillions of microorganisms that constitute the gut microbiota act as the key translators in this conversation, producing a constant stream of signals that can alter brain function. Their influence is exerted through three primary mechanisms [1-4].

The vagus nerve: The neural information superhighway

The vagus nerve, the body’s longest cranial nerve, serves as the most direct conduit between the gut and the brain. It transports signals both ways, acting as a biological superhighway. We now know that an estimated 80% of its fibres are afferent, meaning they transmit information from the gut to the brain, despite the fact that historically it was believed that they predominantly carried signals from the brain to the organs (to regulate processes like heart rate and digestion).

The vagus nerve is actively stimulated by the gut bacteria. Beneficial bacteria create metabolites like short-chain fatty acids (like butyrate) when they break down food fibres.

These substances have the ability to interact with gut lining nerve endings, transmitting messages to brain areas including the limbic system and the hypothalamus—which are essential for controlling mood, emotion, and stress—up the vagus nerve. Whether the gut is calm or irritated, this neuronal route enables it to quickly and directly affect our emotional environment. The vagus nerve is the physical channel for gut sensations, and studies have shown that if it is severed, the anti-anxiety properties of some probiotics are totally eliminated [5-9].

Neurotransmitter production: The gut as a chemical factory

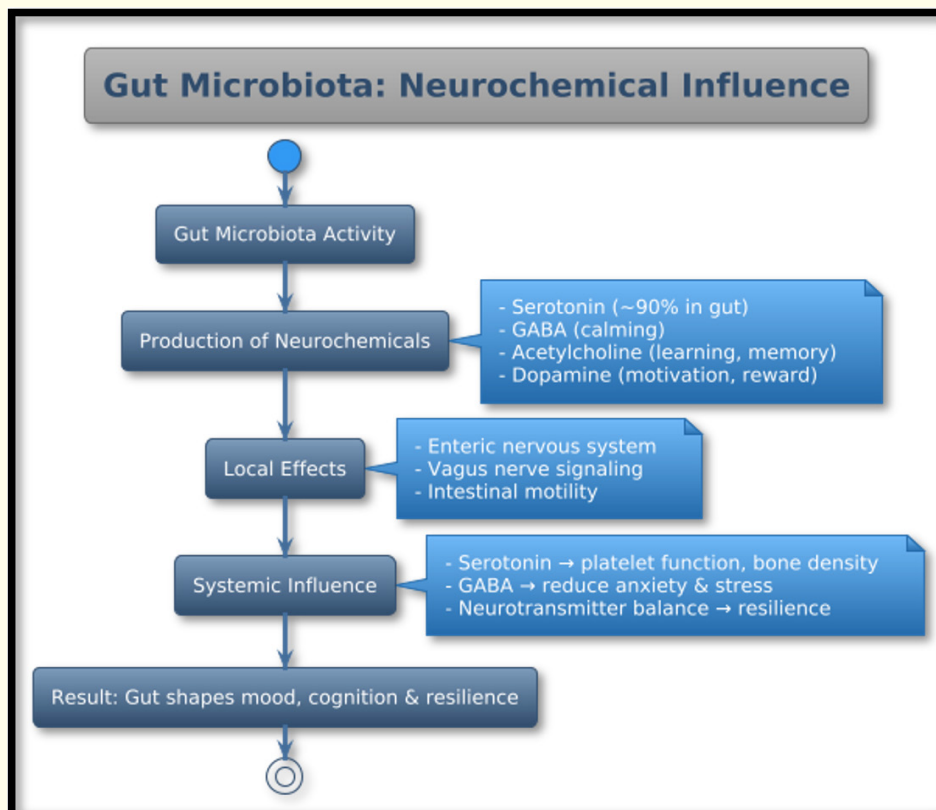


Figure 1: Neurochemical influence of gut microbiota.

The gut microbiota's involvement as a major location for the synthesis of neurochemicals that control our mental states is arguably its most astounding function. Although the blood-brain barrier may not be directly crossed by these microbially generated neurotransmitters, they have a strong local impact on the vagal afferents and enteric nervous system, and they can affect the body's total levels of these vital substances. Serotonin, a neurotransmitter strongly linked to emotions of happiness and well-being, is the most well-known example. About 90% of the serotonin in the body is thought to be created in the gut, mostly by enterochromaffin cells, the activity of which is greatly impacted by certain gut bacteria [7-11].

In addition to having a significant impact on intestinal motility, this gut-derived serotonin also reaches the bloodstream and affects bone density and platelet function. Through its precursors, it may also have an indirect impact on brain function. Additionally, gamma-aminobutyric acid (GABA), the main inhibitory neurotransmitter in the brain, is produced in large quantities by important species of the *Lactobacillus* and *Bifidobacterium* bacteria. As a calming agent, GABA lowers stress, anxiety, and terror by slowing down brain activity. Other bacteria are capable of producing dopamine, which is essential for motivation and reward, and acetylcholine, which is involved in learning and memory. The gut microbiota is a key regulator of psychological resilience because it controls the synthesis of these potent neuroactive chemicals, which effectively helps establish the baseline tone of our nervous system [9-12].

Systemic inflammation: The silent link to mental fog and mood disorders

Systemic inflammation, an immunological response that can have catastrophic effects on the brain when it persists, is the third main channel. One of the main causes of this low-grade, systemic inflammation is dysbiosis, or an unbalanced gut flora. When pathogenic bacterial strains predominate, the intestinal lining's integrity may be compromised, allowing bacterial particles such as lipopolysaccharide (LPS) to seep into the circulation. This condition is commonly known as "leaky gut." A strong inflammatory toxin is LPS. When it enters the bloodstream, it sets off a strong immunological

reaction that causes immune cells to release a plethora of pro-inflammatory cytokines, including TNF- α , IL-1, and IL-6. These cytokines can get past the blood-brain barrier and go throughout the body. Once in the brain, they activate the brain's resident immune cells (microglia), sparking neuroinflammation [13-15].

In addition to impairing neuronal growth and connectivity, this inflammation in the brain can also upset the delicate balance of neurotransmitters and negatively impact our core stress response system, the hypothalamic-pituitary-adrenal (HPA) axis. The pathophysiology of anxiety, sadness, and cognitive impairment including fogging and poor attention are all closely related to this series of events. As a result, an inflammatory condition that directly compromises emotional stability and mental clarity might be fuelled by a disturbed stomach.

In conclusion, the stomach actively participates in controlling the chemistry and function of the brain, making it much more than just a digestive organ. The condition of our gut microbiota is closely related to our mental health because of the vagus nerve's continuous neuronal activity, the synthesis of several neurochemicals, and the control of systemic inflammation. This close relationship serves as the basis for the use of probiotics and targeted nutraceuticals, sometimes referred to as psychobiotics, as a tactical tool to promote not only physical health but also strong psychological resilience [14-16].

Key nutraceuticals for neurotransmitter synthesis and mood support

Thought is not the only building block of the human brain's sophisticated design, which includes extensive networks of neurones and intricate chemistry. A consistent supply of particular nutritional building blocks is essential to its very structure and operation. Micronutrients serve as crucial cofactors, structural elements, and regulatory agents at the molecular level, which is where we must go when discussing mental health, cognition, and emotional resilience. Three nutrient groups—magnesium, B vitamins, and omega-3 fatty acids—stand out among the wide variety of nutrients for

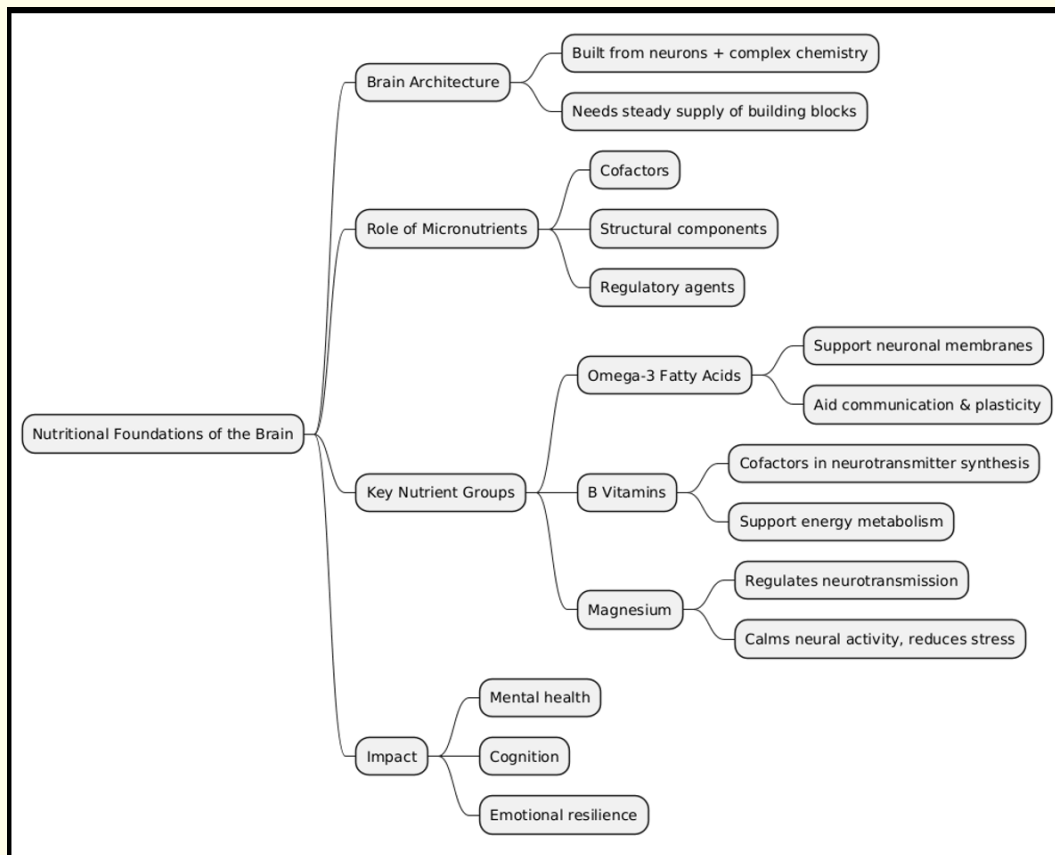


Figure 2: Nutritional foundation of brain and its connectivity.

their significant and well-established involvement in forming and preserving our mental landscape [15-19].

Omega-3 fatty acids: The architects of neural integrity and fluidity

The brain is nearly 60% fat, and the type of fat we consume directly influences its cellular integrity and signaling efficiency. The long-chain omega-3 fatty acids Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) are not merely beneficial; they are indispensable for brain health.

DHA is the predominant structural fat in the brain, particularly in the synapses-the crucial gaps where communication between neurons occurs. It is woven into the very fabric of neuronal cell membranes, where it enhances membrane fluidity. This fluidity is critical. It allows neurotransmitter receptors to move freely, facilitates the release of synaptic vesicles, and ensures that signals are transmitted quickly and efficiently. A membrane rich in DHA is like a well-oiled machine, enabling clear and rapid thought, learning, and memory recall.

Although it is likewise found in the brain, EPA has a distinct but no less important function as a potent mood and anti-inflammatory. The brain is particularly vulnerable to inflammation and oxidative stress, which can harm neurones and interfere with transmission. Strong anti-inflammatory compounds known as protectins and resolvins, which effectively reduce neuroinflammation, are derived from EPA. Clinical research continuously demonstrates that high-EPA formulations are especially successful in promoting mood because of this activity. EPA helps to establish a biochemical environment that promotes emotional stability and positivity by reducing inflammatory signals in the brain that can inhibit the synthesis and function of important neurotransmitters like dopamine and serotonin. Together, EPA and DHA work in concert: DHA builds and maintains the brain's hardware, while EPA protects it from the corrosive effects of inflammation [20-25].

B Vitamins: The master conductors of neurochemical synthesis

B vitamins, more especially B6 (pyridoxine), B9 (folate), and B12 (cobalamin), are the maestro conductors if the brain is an orchestra of neurochemicals. They are vital cofactors in the enzymatic processes that produce almost all of the main neurotransmitters that control our emotions and thoughts.

These vitamins are absolutely necessary for the production of serotonin from tryptophan, dopamine from tyrosine, or GABA from glutamate. For example, the enzyme that transforms 5-HTP into serotonin, the neurotransmitter of happiness and wellbeing, requires vitamin B6 as a cofactor. This conversion is ineffective in the absence of sufficient B6, which may result in a deficiency that has an adverse effect on mood.

They are involved in a crucial process known as methylation in addition to the synthesis of neurotransmitters. This metabolic cycle is in charge of maintaining the protective myelin sheath that surrounds neurones, controlling gene expression, and repairing DNA. B9 and B12 vitamins are essential for this procedure. When

either is lacking, homocysteine, an inflammatory amino acid that is harmful to neurones, builds up. A known risk factor for cognitive decline, brain vascular injury, and compromised neurotransmitter function is elevated homocysteine. Therefore, B vitamins do more than just help produce brain chemicals; they also make sure the brain's whole biochemical environment is ready for optimal, healthy performance, shielding it from the molecular trash that can impair mood and obscure thinking [24-26].

Magnesium: The natural guardian of neural calm

The brain's excitatory signals frequently run amok in today's world of continuous stimulus. Magnesium is a basic mineral that regulates excitation and shields the brain from the damaging effects of long-term stress. It functions as nature's natural cool pill.

It has two main methods to produce its relaxing effects. First, magnesium plays a key role in controlling the body's primary stress response system, the hypothalamic-pituitary-adrenal (HPA) axis. It aids in regulating the main stress hormone, cortisol, release. An overactive HPA axis is avoided by having enough magnesium levels, which protects the brain from the neurotoxic consequences of long-term, high cortisol, which can harm cells in the hippocampus, a part of the brain essential for memory and emotional control.

The second, and possibly more significant, function of magnesium is to guard the gate of the NMDA receptor, which is a receptor for glutamate, the primary excitatory neurotransmitter in the brain. The ion channel of the NMDA receptor is physically blocked by magnesium when it is present. By doing this, overactivation is avoided and signals are only sent when they are powerful and significant. This plug is removed in stressful or magnesium-deficient situations, making the NMDA receptor hyperactive. Excitotoxicity, which is linked to anxiety, migraines, and long-term cognitive damage, is the result of overstimulation that physically burns off neurones. Magnesium prevents the neurological "shouting matches" that cause overwhelm and damage by peacefully residing in the receptor and ensuring that brain exchanges are controlled and purposeful [19-22].

In conclusion, basic diet, rather than a sophisticated medication, is the first step towards psychological resilience and healthy brain function. Magnesium gives the brain the necessary calm that shields it from the rigours of contemporary life, B vitamins coordinate the symphony of neurochemicals and preserve its metabolic hygiene, and omega-3 fatty acids construct the physical structure of the brain and protect it from inflammation. When combined, these dietary neurosculptors offer the building blocks for creating a brain that is durable and functional.

Adaptogens and botanicals for stress resilience and HPA axis modulation

Fatigue, anxiety, and cognitive burnout can result from the body's natural homeostasis being readily upset by constant psychological and physical stress. Although this issue is brought about by contemporary life, nature may have a crucial remedy in the form of a special class of plants called adaptogens. These are non-toxic compounds that support the hypothalamic-pituitary-adrenal (HPA) axis, the body's primary stress response mechanism, and assist the body adapt to and withstand a variety of stressors, restoring physiological function. Of these natural therapies, ashwagandha, rhodiola rosea, and L-theanine are among the most respected and well researched; each provides a unique route to peace and mental clarity [21-23].

Ashwagandha: The cortisol modulator

Ashwagandha (*Withania somnifera*), a cornerstone of Ayurvedic medicine, stands as a premier adaptogen for its profound ability to temper the body's stress response. Its therapeutic power lies in its rich concentration of withanolides, steroid-like compounds that directly modulate the HPA axis.

Chronic stress keeps the HPA axis stuck in the "on" position, leading to persistently elevated levels of the stress hormone cortisol. While essential in acute situations, high cortisol over time is corrosive-disrupting sleep, impairing immune function, promoting anxiety, and even contributing to weight gain. Ashwagandha

intervenes by signaling the body to reduce the overproduction of cortisol. Clinical studies have consistently demonstrated that supplementation with a standardized root extract can significantly reduce cortisol levels, sometimes by substantial percentages. Human experience is immediately translated from this physiological effect: people report significant decreases in felt tension and anxiety, as well as increases in calmness and the quality of their sleep. In order to help the body return to a baseline of physiological calm, ashwagandha helps the body disengage from a condition of chronic hyper-arousal [24-26].

Rhodiola rosea: The mental fatigue fighter

Rhodiola Rosea is used to energise the worn-out system, while ashwagandha is used to relax the overloaded one. Students, athletes, and professionals all like this Arctic root because of its well-known capacity to prevent mental exhaustion and improve cognitive function under duress.

Rhodiola has two mechanisms. First, it is thought to increase the brain's neurotransmitter signalling efficiency. By blocking the enzyme that degrades catecholamines like dopamine, norepinephrine, and serotonin, it prolongs the time that these essential chemicals for motivation, concentration, and mood are active at the synapses. This results in better memory, increased focus, and a more upbeat attitude when faced with difficult activities.

Second, rhodiola promotes the metabolism of cellular energy. It promotes the synthesis of adenosine triphosphate (ATP), which is the main source of energy for cells, especially in the brain. This lessens the weariness and sense of mental burnout brought on by extended stress. Rhodiola Rosea prevents the cognitive deficiencies that frequently accompany chronic stress by promoting a state of sustained mental clarity and endurance by increasing both the chemical messengers of attention and the underlying cellular energy required for cognition [27-29].

L-Theanine: The Architect of Calm Alertness

A special amino acid called L-theanine, which is mostly present in green tea, has the seemingly counterintuitive benefit of promoting deep relaxation without making you feel sleepy. This “calm alertness” condition is what makes it such a useful tool for stress management and improving focus at the same time. The power of L-theanine stems from its direct effect on brain waves. According to research on electroencephalograms (EEGs), it encourages the production of alpha brain waves. These waves are linked to a wakeful relaxation state that is comparable to that attained during intense creativity or meditation. You are in this mental state when you are mentally sharp but anxiety-free, and you are also extremely calm and aware.

The regulation of important neurotransmitters by L-theanine is the basis for this effect. It easily penetrates the blood-brain barrier and raises GABA levels, which are the brain’s main inhibitory neurotransmitter that lowers excitability and encourages calm. It can also raise dopamine and serotonin levels at the same time, which can boost mood and overall wellbeing. Green tea, which contains both caffeine and L-theanine, may also help temper the stimulating effects of caffeine, which is why it gives you a smoother, more jitter-free energy boost than coffee alone. Instead of forcing relaxation, L-theanine softly guides the brain into a more balanced and effective state. In conclusion, these adaptogens provide supplementary methods for dealing with the pressures of contemporary living. L-theanine fosters a calm and concentrated state of mind, rhodiola rosea energises mental energy and attention to combat exhaustion, and ashwagandha offers profound, systemic assistance to reduce an overactive stress response. Collectively, they embody nature’s potent toolkit for not only enduring stress but flourishing despite it, laying the groundwork for genuine psychological resilience [24,26,27].

Strategic use of clinically-studied probiotic strains for mental health

Once a fringe theory, the idea that gut flora can affect mental health is now a key component of nutritional neuroscience. As a result, the term “psychobiotics” was coined, which refers to live

organisms that, when consumed in sufficient quantities, help patients with mental illnesses. Cutting-edge research is now identifying certain bacterial strains with known, quantifiable effects on psychological well-being, going beyond the overall advantages of probiotics. This precise method offers a new way to enhance mental health by enabling tailored nutritional therapies meant to modulate the gut-brain axis [28-31].

The Cerebiome® Combination: A Clinically-Validated Synergy for Stress and Mood

A particular combination of two strains, *Lactobacillus helveticus* R0052 and *Bifidobacterium longum* R0175, has some of the strongest human clinical evidence. Thorough double-blind, placebo-controlled trials—the gold standard of scientific research—have been conducted on this patented compound, which is frequently sold under the name Cerebiome®.

The outcomes are noteworthy. Supplementing with this combination for 30 days resulted in a substantial decrease in psychological distress, including symptoms of anxiety and depression, as compared to the placebo group in a trial including healthy people who self-reported stress and anxiety. Importantly, these subjective evaluations were supported by biological indicators: participants’ reduced cortisol levels, a stress hormone, gave a physiological explanation for the perceived improvement in wellbeing.

The mechanism is thought to be complex and includes the strains’ capacity to directly affect the gut-brain axis neuronal pathways, modify the systemic immune response, and improve the intestinal barrier (thereby lowering inflammatory signals). This combination sets a standard in the field, showing that certain strains of probiotics can have a noticeable, quantifiable effect on mental health and that not all probiotics are made equal.

Bifidobacterium longum 1714: Modulating the stress response and enhancing cognition

Bifidobacterium longum 1714 is another strain that has remarkable human data. Studies on this particular strain concentrate on its capacity to both improve cognitive performance and reduce

the physiological and psychological effects of stress. *B. longum* 1714 was given as a supplement to participants who were experiencing everyday stress and those who were taking a social stress test in a controlled study involving healthy volunteers. The results demonstrated that, in comparison to the placebo group, the probiotic group experienced a lower physiological stress response and reported less subjective stress. The study also found that memory performance had improved.

By reducing the activity of the amygdala and other brain areas involved in the stress response, the strain seems to reduce the intensity of the body's response to stressors. *B. longum* 1714 is a leading psychobiotic for people who want to fight the stress and mental haze that come with high-pressure situations because of its capacity to not only increase emotional resilience but also cognitive measures like memory.

Lactobacillus rhamnosus JB-1: Pioneering evidence for vagus nerve-mediated benefits

Although the ultimate goal is human trials, fundamental animal research offers valuable insights into molecular mechanisms. One of the strains that has been investigated the most in preclinical models is *Lactobacillus rhamnosus* JB-1 (now commonly known as *Lactocaseibacillus rhamnosus* JB-1), and the results have been crucial for the entire field.

Studies conducted on mice revealed that long-term JB-1 administration resulted in significant decreases in behaviours resembling anxiety and depression. The animals' increased resilience in forced swim tests and decreased hesitation in exploratory tests were behavioural improvements suggestive of better anxiety and depression. The mechanism, however, was the most revolutionary finding; mice with surgically severed vagus nerves showed no behavioural changes at all [28-31].

This offered concrete, causal proof that the cerebral superhighway is the primary means by which this particular probiotic strain sends information to the brain. Furthermore, the therapy changed the expression of GABA receptors in certain brain regions, reducing excitability in important areas linked to stress and mood. The JB-1 strain is still a well-known illustration of how a single probiotic can directly affect brain chemistry and behaviour through a well-defined biological pathway, even if human trials are required to validate these effects.

The path to precision mental health support

A paradigm change has occurred with the introduction of particular, thoroughly studied strains of psychobiotics such as these. It shifts the discussion from the broad idea that "probiotics are good for the gut" to a focused approach in which certain strains can be chosen for their proven advantages on anxiety, stress, and cognitive function. This study emphasises a crucial idea: probiotic effects vary greatly depending on the strain. It is not always possible to attribute the advantages of one strain of *Bifidobacterium longum* to another. For both consumers and professionals, this entails closely examining the whole, exact taxonomic name on a supplement label and looking for goods that have been proven to produce the desired health result in human clinical trials.

A customised prescription of particular bacterial strains to support the development of not only a healthy gut but also a resilient and balanced mind may be part of the future of mental wellness as research progresses.

Formulation and synergy: Designing a nutraceutical protocol for the mind

The realities of integrating these ideas will be covered in the last section.

- **The Value of Prebiotics:** Without them, it is impossible to nourish the beneficial bacteria. Maintaining the beneficial psychobiotic communities you introduce requires prebiotic fibres (FOS, GOS).
- **Brain Bioavailability:** Talking about formulations that guarantee these substances pass through the blood-brain barrier (phospholipids for omega-3s in the form of phosphatidylserine, for example).
- **A Holistic Regimen:** stressing that these nutraceuticals work best when paired with fundamental lifestyle habits like mindfulness, exercise, and sleep, all of which have a good impact on the gut microbiota [31].

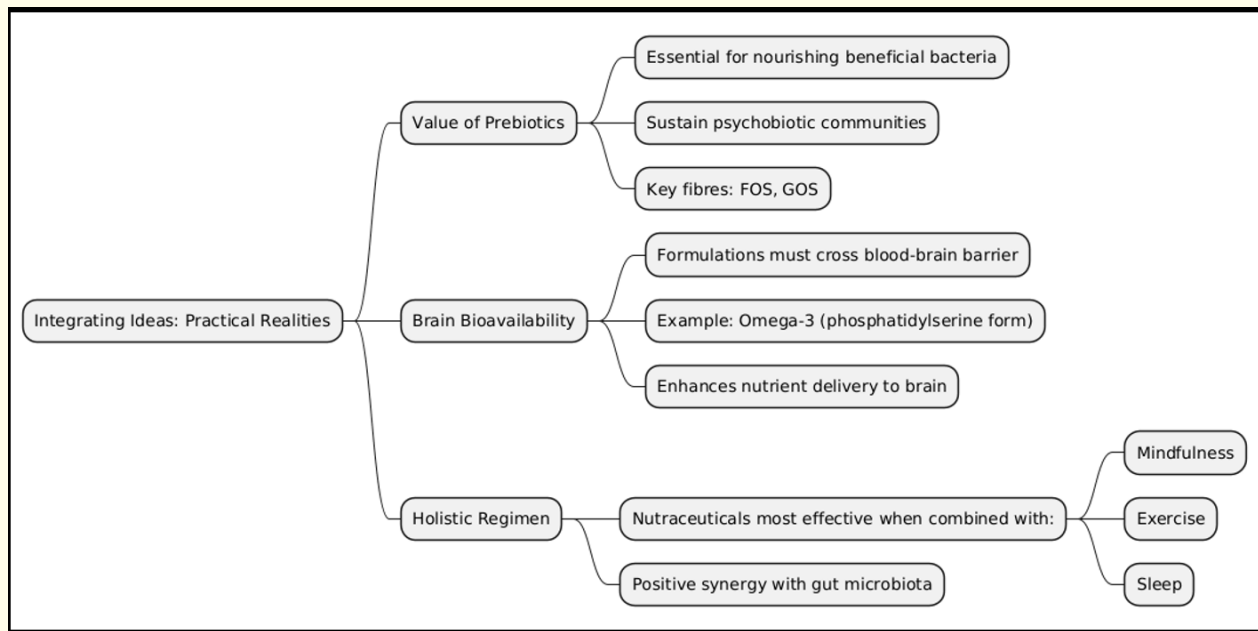


Figure 3: Factual and practical realities of probiotics as dosage.

Conclusion

The fundamental significance of the gut-brain axis has been clearly revealed by emerging science, which has shown a strong bidirectional communication network that closely links our mental and digestive health. This relationship, as discussed in this article, presents a revolutionary new avenue in nutritional psychiatry, advancing beyond overall wellness to focused, research-based treatment. A potent toolkit for regulating this crucial axis is provided by the thoughtful use of psychobiotics-certain probiotic strains with proven neurological benefits-as well as anti-inflammatory botanicals and vital neuro-supportive minerals.

This involves a fundamental altering of our own biochemical milieu to promote resilience, not just supplementation. These focused nutraceuticals provide an additional and proactive route to mental health support by bolstering the intestinal barrier, reducing systemic inflammation, and directly regulating neurotransmitter synthesis and stress hormone control. They give us the ability to improve our mood, hone our cognitive abilities, and develop a stronger stress response from the ground up. In the end, this developing area promotes a holistic approach to mental wellbeing, according to which promoting gut health is equivalent to promoting brain health. We can build a foundation for long-lasting psychological resilience and a more balanced, clearer state of mind by utilizing the power of these nutritional practices, in addition to creating a healthy microbiome.

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