Article type: Perspective

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The gut–brain–metabolism axis: How nutrition shapes cognitive and metabolic health.

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Received: *01-Jan-2025, Manuscript No. JGDD-25-167216;* ***Editor assigned:*** *02-Jan-2025, Pre QC No. JGDD-25-167216 (PQ);* ***Reviewed:*** *15-Jan-2025, QC No. JGDD-25-167216;* ***Revised:*** *20-Jan-2025, Manuscript No. JGDD-25-167216 (R);* ***Published:*** *27-Jan-2025, DOI: 10.35841/JGDD-10.1.249*

Introduction

Historically, the gut, brain, and metabolic system were studied in isolation. Today, the paradigm has shifted with the recognition of the gut–brain–metabolism axis, a tripartite network where the gut microbiota, neuronal signaling, hormonal pathways, and immune responses interact to influence brain function and metabolic status.Nutrition is one of the most powerful modulators of this axis. Diet not only provides essential nutrients but also shapes the microbial environment of the gut, which in turn communicates with the brain and endocrine system. Dysregulation of this axis has been implicated in metabolic disorders like obesity and type 2 diabetes, as well as neurological conditions including depression, anxiety, and cognitive decline .[1].

The gut–brain axis functions through interconnected microbial and neural pathways, primarily involving the vagus nerve, which links the enteric nervous system to the brain and transmits signals affected by microbial activity and nutrient composition. Gut bacteria produce short-chain fatty acids (SCFAs) such as butyrate, acetate, and propionate, which influence inflammation, blood-brain barrier integrity, and neurotransmitter synthesis. Additionally, these microbes can synthesize or affect neurotransmitters like serotonin, dopamine, and GABA, crucial for mood and cognitive functions. Gut microbes also modulate immune responses, with low-grade inflammation impacting brain function and energy metabolism.[2].

A healthy gut microbiome supports key metabolic functions including energy harvesting, insulin sensitivity, and fat storage, often through hormonal regulation involving GLP-1 and leptin. Conversely, dysbiosis—an imbalance in gut microbiota can lead to increased intestinal permeability ("leaky gut"), systemic inflammation, and a heightened risk of metabolic disorders. [3].

Cognitive function is closely linked to nutrition, as the brain relies on a continuous supply of energy and essential nutrients to support mental health. Nutritional imbalances can lead to cognitive fog, often associated with insulin resistance and inflammation; mood disorders, influenced by changes in gut microbiota and deficiencies in nutrients such as omega-3 fatty acids and B vitamins; and neurodegenerative conditions like Alzheimer's disease, which are linked to chronic inflammation and oxidative stress stemming from gut dysfunction. Several key nutrients play a vital role in maintaining this gut–brain–metabolism axis: dietary fiber from fruits, vegetables, and whole grains [4].

fermented by gut microbes into short-chain fatty acids (SCFAs) that reduce inflammation and support brain health; polyphenols found in berries, cocoa, and green tea help modulate gut microbiota and act as neuroprotective antioxidants; omega-3 fatty acids are crucial for brain cell membrane integrity and have anti-inflammatory effects; prebiotics and probiotics enhance the growth of beneficial bacteria and reduce harmful endotoxemia; and tryptophan, a precursor of serotonin found in turkey, eggs, and seeds, supports mood regulation and neurotransmission.[5].

Citation: Worakul S. The gut–brain–metabolism axis: How nutrition shapes cognitive and metabolic health. J Gastroenterology Dig Dis. 2025;10(1):249

Conclusion

The gut–brain–metabolism axis underscores the profound impact of nutrition on both physical and mental health. By nurturing the gut microbiome and adopting nutrient-dense, anti-inflammatory diets, individuals can enhance cognitive performance, stabilize mood, and prevent metabolic diseases. This interconnected understanding paves the way for holistic, evidence-based health strategies.

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Citation: Worakul S. The gut–brain–metabolism axis: How nutrition shapes cognitive and metabolic health. J Gastroenterology Dig Dis. 2025;10(1):249