

The Relationship Between Consumption of Traditional Indonesian Fermented Foods and Mental Health Status in Indonesia: A Narrative Review

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ABSTRACT

Background: Mental health issues in Indonesia are increasing, with a depression prevalence of 1.4% reported in the 2023 Indonesian Health Survey. Indonesia also has a rich heritage of traditional fermented foods, including tempeh, dadih, tape, and oncom, which may influence mental health through the gut-brain axis. However, research specifically examining the relationship between traditional Indonesian fermented foods and mental health remains limited.

Objective: This narrative review aims to examine the scientific evidence linking the consumption of traditional Indonesian fermented foods with mental health status and identify the underlying biological mechanisms.

Materials and methods: A narrative review was conducted using literature published between 2020 and 2025. Literature searches were performed using PubMed/Medline, Google Scholar, and Scopus. Studies were selected based on their relevance to fermented foods, particularly traditional Indonesian fermented foods, bioactive components, mental health, cognitive function, depression, anxiety, and the gut-brain axis.

Results: Seven studies met the inclusion criteria, including controlled clinical trials, a literature review, an animal experimental study, a prospective cohort study, a quasi-experimental study, and a cohort meta-analysis. Overall, most studies indicated a potential positive relationship between fermented food consumption and mental health outcomes, with tempeh having the strongest scientific evidence among Indonesian fermented foods. The proposed mechanisms include modulation of neurotransmitters such as serotonin, GABA, and dopamine, reduction of neuroinflammation, and regulation of the hypothalamic-pituitary-adrenal (HPA) axis. Tempeh consumption was associated with improved cognitive function and neuroprotective effects in older Indonesian adults. Evidence regarding dadih, tape, and oncom remains limited and is primarily based on mechanistic findings.

Conclusion: Traditional Indonesian fermented foods, particularly tempeh, show potential as a localized food-based approach to support mental health through the gut-brain axis. However, evidence for dadih, tape, and oncom remains limited. Further randomized controlled trials involving Indonesian populations are needed to establish causal relationships, determine effective consumption patterns, and support the integration of traditional fermented foods into nutrition policies.

Keywords: fermented foods; mental health; gut-brain axis

BACKGROUND

Mental health is a fundamental component of overall health that cannot be separated from physical health. According to the 2023 Indonesian Health Survey (SKI), the prevalence of depression in Indonesia was recorded at 1.4%, with the highest rate—2%—found among young people aged 15–24, equivalent to more than 9 million cases nationwide.¹ Meanwhile, data from the 2018 Basic Health Research (Riskesdas) survey recorded a prevalence of emotional mental disorders—including symptoms of anxiety and depression—of 9.8% among the population aged 15 and older, a significant increase from the 6.0% figure in the 2013 Riskesdas survey, indicating a consistent upward trend over the past decade.² This burden is particularly evident among adolescents, as demonstrated by the 2022 Indonesia National

Adolescent Mental Health Survey (I-NAMHS)—the first nationwide adolescent mental health survey in Indonesia—which found that one in three adolescents, or 15.5 million individuals, experiences mental health issues, and one in twenty adolescents, or approximately 2.45 million, meets the diagnostic criteria for a mental disorder according to the DSM-5.³

Amid the rising burden of mental illness, the food-based approach has begun to gain attention as an affordable and sustainable complementary strategy.⁴ Research in the field of nutritional psychiatry shows that diet plays a significant role in regulating brain function and mood.⁵ One food group that has come into the spotlight is fermented foods, which contain probiotics, prebiotics, and various bioactive metabolites resulting from the fermentation process.⁶

Indonesia boasts a rich culinary heritage of traditional fermented foods. Among these is tempeh, a fermented soybean product made using the mold *Rhizopus oligosporus*, which has been recognized as a premier functional food beneficial for health.⁷ In addition to tempeh, there is dadih (yogurt) made from fermented buffalo milk, a specialty of West Sumatra; tape, which is made by fermenting cassava or glutinous rice; oncom, made from fermented soybean pulp or tofu; and various other local fermented products that have been consumed empirically across generations.^{8,9,10}

Several studies have explored the relationship between the consumption of fermented foods and mental health. A meta-analysis of 8 cohort studies involving a total of 83,533 participants found that consumption of fermented dairy products, including cheese and yogurt, was significantly associated with a reduced risk of depression.¹¹ A prospective study of medical students also showed that consumption of fermented foods was associated with changes in psychological symptoms, although the direction of the association remains debated.¹² At the mechanistic level, a comprehensive literature review by Balasubramanian (2024) identified three main pathways linking fermented foods to mental health: neurotransmitter modulation, reduction of neuroinflammation, and regulation of the HPA axis via the gut microbiota.⁴ However, nearly all of these studies are based on western fermented foods such as yogurt, kefir, and cheese, or use isolated commercial probiotic supplements rather than traditional fermented foods consumed within local cultural contexts, such as in Indonesia. This creates a significant research gap, given that the bioactive profiles, microbial strains, and consumption patterns of Indonesian fermented foods differ substantially from previously studied fermented products.

The mechanism linking the consumption of fermented foods to mental health is known to be mediated by the gut-brain axis—a bidirectional communication pathway between the gut microbiota and the central nervous system. This pathway involves the modulation of neurotransmitters such as serotonin and gamma-aminobutyric acid (GABA), the regulation of inflammatory responses, and signaling via the vagus nerve.⁴ However, studies specifically exploring traditional Indonesian fermented foods in the context of mental health remain very limited, creating a significant research gap.

Based on this background, this narrative review aims to identify types of traditional Indonesian fermented foods that have potential benefits for mental health, examine the biological mechanisms underlying these relationships, summarize the available scientific evidence, and identify research gaps to guide future research.

MATERIAL AND METHODS

This review employs a narrative review approach to summarize and synthesize the available scientific evidence regarding the relationship between the consumption of traditional Indonesian fermented foods and mental health status. A literature search was conducted from 2020 to 2025 using the electronic databases PubMed/Medline, Google Scholar, and Scopus to identify the relationship between the consumption of fermented foods—particularly traditional Indonesian fermented foods—and mental health. The inclusion criteria for this narrative review are as follows: (1) published between 2020 and 2025; (2) discussed fermented foods, with a focus on traditional Indonesian fermented foods and their bioactive components; (3) examined associations with mental health, cognitive function, depression, anxiety, or the gut-brain axis mechanism; and (4) available in Indonesian or English. Exclusion criteria include animal studies without clear translational relevance, studies with designs whose validity cannot be assessed, or articles with full-text versions that are inaccessible. Animal studies

may be considered for limited inclusion if they explicitly test bioactive compounds derived from Indonesian fermented foods and provide a relevant mechanistic basis (biological plausibility) for effects in humans.

The study selection was conducted in several stages, including: (1) keyword search terms used in the literature review included: “tempe,” “tape,” “dadih,” “oncom,” “Indonesian fermented food,” “traditional fermented food,” “mental health,” “depression,” “anxiety,” “cognitive function,” “gut-brain axis,” “microbiota,” “probiotics,” “isoflavone,” and “psychobiotics”; (2) exploring and selecting article titles, abstracts, and keywords; (3) reading articles in full or in part, depending on the review criteria established by the researcher; and (4) compiling a list of references based on the relevant studies identified in the second phase. This phase is repeated by the author to complete the literature review.

RESULTS AND DISCUSSION

Based on the results of the literature search using the established inclusion criteria, there were 7 articles that met the criteria for further analysis in this narrative review. Overall, the included studies consisted of two controlled clinical trials in an Indonesian elderly population examining the effects of tempeh on cognitive function, one literature review and one animal experimental study examining the biological mechanisms of fermented foods, one prospective cohort study in medical students, one quasi-experimental study using curd in children with COVID-19, and one cohort meta-analysis on the consumption of fermented dairy products. Most studies showed a positive association between the consumption of fermented foods and mental health outcomes, with tempeh being the Indonesian fermented food with the most scientific evidence. One prospective study, however, found an opposite association, which must be interpreted with consideration of its methodological limitations. A summary of the characteristics and findings of each study is presented in Table 1.

Table 1. Summary of studies in a narrative review

No	Author and Title	Study Design	Study Subjects	Results
1	<i>Effect of Tempeh Probiotics on Elderly with Cognitive Impairment</i> ¹³	Randomized controlled trial (RCT)	Elderly individuals with mild cognitive impairment in Indonesia	Consumption of probiotic tempeh significantly improved cognitive scores in the intervention group compared to the control group (p
2	<i>Comparison of the effect of mixed tempeh with soy tempe on cognitive function in older people</i> ¹⁴	Comparative clinical trial	Older adults (≥ 60 years) in Indonesia	Mixed tempeh demonstrated a neuroprotective effect and was superior t, compared to soy tempeh. It also reduced neuroinflammatory biomarkers
3	<i>Fermented foods: Harnessing their potential to modulate the microbiota gut brain axis for mental health</i> ⁴	Literature review	Preclinical studies, RCTs, observational studies	Fermented foods have the potential to support mental health through three main mechanisms in the gut-brain axis: modulation of neurotransmitter release (GABA, serotonin, dopamine), reduction of systemic inflammation, and regulation of the stress response via the HPA axis.
4	<i>Daidzein Alleviates Hypothalamic Pituitary Adrenal Axis Hyperactivity, Ameliorates Depression Like Behavior, and Partly Rectifies Circulating Cytokine Imbalance in Two Rodent Models of Depression</i> ¹⁵	Experimental Studies	Depression mouse models (CMS and learned helplessness)	Daidzein significantly suppressed HPA axis hyperactivity, reduced cortisol and proinflammatory cytokines, and alleviated depressive-like behavior.

Table 1. Summary of studies in a narrative review (continued)

No	Author and Title	Study Design	Study Subjects	Results
5.	<i>Association Between Consumption of Fermented Food and Food-Derived Prebiotics With Cognitive Performance, Depressive, and Anxiety symptoms in psychiatrically healthy medical students under psychological stress: A Prospective Cohort study¹²</i>	Prosepective cohort study	A total of 372 psychiatrically healthy medical students under psychological stress prior to exams	No association was found between the consumption of fermented foods or probiotics and cognitive performance under stress. However, high consumption of fermented foods was associated with more severe depressive symptoms (adjusted β 0.11; 95% CI 0.01–0.20; $p=0.032$) and more severe anxiety symptoms (adjusted β 0.13; 95% CI 0.04–0.22; $p=0.0065$) under stressful conditions. No similar association was found for prebiotic consumption.
6	<i>Supplementation Dadih Pudding as a probiotic on the psychosocial problems of children with Covid 19 undergoing isolation¹⁶</i>	Quasiexperimental study with a post-test and control group design	A total of 43 pediatric and adolescent patients aged 5–18 years who tested positive for COVID19 and were undergoing isolation at the Quarantine Center were divided into two groups: an intervention group that received dadih pudding (23 participants) and a control group that received regular pudding without dadih (20 participants).	There was a significant difference in the mean internalization scores between the control and intervention groups ($p < 0.05$). Children who received curd pudding had fewer psychosocial problems compared to the control group (12.5% vs. 87.5%), while the control group exhibited more psychosocial problems (62.9%) compared to the intervention group (37.1%). Curd pudding supplementation significantly reduced PSC-17 scores in children and adolescents during COVID 19 quarantine.
7	<i>Fermented dairy foods consumption and depressive symptoms: A meta -analysis of cohort studies¹¹</i>	Meta-analysis	A total of 8 cohort studies meeting the inclusion criteria, with a total of 83,533 participants from various countries	Overall, consumption of fermented dairy foods was significantly associated with a reduced risk of depression (OR = 0.89; 95% CI = 0.81– 0.98). In subgroup analyses, consumption of cheese and yogurt was each significantly associated with a reduced risk of depression (OR = 0.91 for cheese and OR = 0.84 for yogurt)

The Gut-Brain Axis Mechanism and Fermented Foods

The relationship between the consumption of fermented foods and mental health is mediated by a pathway known as the gut-brain axis—a complex bidirectional communication system that connects the gut microbiota to the central nervous system through various neural, endocrine, and immunological pathways.¹⁷ Based on a review of the literature, there are three main mechanisms underlying the effects of fermented foods on mental health, namely:

a) Neurotransmitter Modulation

Approximately 90–95% of the body's serotonin is produced in the gut, and its production is significantly influenced by the composition of the gut microbiota. Fermented foods containing lactic acid bacteria (LAB), such as *Lactobacillus plantarum* and *Bifidobacterium* spp., can modulate the production of serotonin and GABA⁴. The isoflavones in tempeh, particularly genistein and daidzein, not only play a role in the tryptophan-based serotonin synthesis pathway but also exhibit weak estrogenic effects that may influence mood balance.¹⁸ Specifically, GABA produced during the fermentation process by *Lactobacillus* spp. can interact with GABA receptors in the brain via the vagus nerve, thereby potentially reducing anxiety symptoms.¹⁹ In addition, tempeh has also been shown to contain *Limosilactobacillus fermentum*, which can synthesize GABA and inhibit the activity of acetylcholinesterase (AChE)—an enzyme that breaks down acetylcholine, a neurotransmitter crucial for memory and cognitive function.¹³

b) Reduction of Neuroinflammation

Low-grade chronic inflammation is recognized as one of the key pathophysiological factors in depression and anxiety disorders. Short-chain fatty acids (SCFAs) produced by the fermentation of dietary fiber—such as butyrate, propionate, and acetate—possess significant anti-inflammatory properties by inhibiting the production of pro-inflammatory cytokines (TNF- α , IL-6, IL-1 β) involved in the pathogenesis of depression.^{20,21} Tempeh, as a source of isoflavones and antioxidants, has the ability to suppress oxidative stress and neuroinflammation, which plays a role in maintaining cognitive function, particularly in the elderly population.¹³

c) HPA Axis Regulation

The hypothalamic-pituitary-adrenal (HPA) axis is the primary stress response system; when chronically hyperactive, it contributes to the pathogenesis of depression and anxiety.²² A study identified that fermented foods have the potential to reduce HPA axis hyperactivity through modulation of the gut microbiota.⁴ Findings from animal models support this mechanism by demonstrating that daidzein, one of the major isoflavones in fermented soybeans, can modulate HPA axis activity, correct cytokine dysregulation, and improve depressive behavioral symptoms.¹⁵

One point to note in this narrative review is that not all evidence points to the benefits of consuming fermented foods for mental health. A study by Karbownik *et al.* (2022), a prospective cohort study of 372 medical students, actually found that a high intake of fermented foods was associated with more severe depressive symptoms and more severe anxiety symptoms under conditions of psychological stress. Meanwhile, no significant association was found between the consumption of fermented foods and cognitive performance.¹²

Indonesian Fermented Foods and Mental Health

Among all traditional Indonesian fermented foods, tempeh has been the most extensively studied in the context of brain health and cognitive function.²³ A comprehensive literature review identified that tempeh contains isoflavones, saponins, and essential amino acids with antioxidant, antihypertensive, and antidiabetic properties.²⁴ The isoflavones—particularly genistein and daidzein—act as phytoestrogens that can interact with estrogen receptors in the brain and influence serotonergic neurotransmission.¹⁸

A clinical study conducted on an elderly population in Indonesia showed that regular consumption of probiotic tempeh is associated with measurable improvements in cognitive function.¹³ Other research has also found that mixed tempeh—a combination of soybeans, sunflower seeds, pumpkin, and adzuki

beans—can provide better neuroprotective effects compared to conventional soybean tempeh.¹⁴ This suggests that diversifying the raw materials used in fermentation can enhance the potential for neuropsychiatric benefits.

In addition to tempeh, various other Indonesian fermented foods also have the potential to provide benefits for mental health. However, to date, they have received relatively little attention in scientific research. One such food is *dadih*, a fermented buffalo milk product originating from the Minangkabau community in West Sumatra.²⁵ The abundant *Lactobacillus* spp. content in *dadih* has the potential to provide benefits for mental health. Various international studies have reported an association between these bacteria and reduced symptoms of depression and anxiety.²⁶

Another local fermented food is *tape*. *Tape* is made from cassava or glutinous rice and is a mixed fermentation product involving yeast and lactic acid bacteria.²⁷ This fermentation process produces various bioactive metabolites, including acetic acid and lactic acid, which play a role in modulating the gut microbiota.²⁸ Although clinical evidence regarding the direct effects of *tape* on mental health remains limited, these biological mechanisms provide a strong foundation for further research, particularly regarding changes in gut microbiota composition following *tape* consumption.

Unlike *tape*, which has the potential to influence mental health through the modulation of the gut microbiota, *oncom* has a potential mechanism related to its bioactive compounds. *Oncom* is a traditional Indonesian fermented product from West Java made from peanut pulp or tofu pulp.⁸ *Oncom* is rich in polyphenols, beta-carotene, and lycopene. These compounds possess anti-inflammatory and antioxidant activities relevant to the pathogenesis of mental disorders, particularly those involving neuroinflammation. However, to date, no clinical studies have directly evaluated the relationship between *oncom* consumption and mental health outcomes.

The above findings have important implications for Indonesia's public nutrition strategies. Traditional fermented foods are an affordable and culturally accepted source of psychobiotics, making them highly promising as a locally-based food intervention (food-based approach) to support mental health—unlike commercial probiotic supplements, which are relatively expensive. The integration of fermented food consumption into national nutrition guidelines requires stronger scientific evidence from the Indonesian population, given that current nutrition programs still focus primarily on physical aspects such as addressing stunting and anemia. The “double burden of malnutrition” faced by Indonesia further underscores the need for a holistic approach that incorporates mental health dimensions into nutrition policy.

However, there are several critical research gaps. To date, there have been almost no randomized controlled trials (RCTs) specifically examining the effects of *dadih*, *tape*, or *oncom* on mental health outcomes in the Indonesian population. The majority of studies on tempeh also remain focused on cognitive function in the elderly, while young adults and adolescents—who actually have the highest prevalence of mental health issues—have not been extensively studied. Furthermore, studies that directly measure changes in gut microbiota composition following the consumption of locally fermented foods remain very limited, and there is no standardization of effective doses regarding recommended frequency or portion sizes.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Indonesian fermented foods, particularly tempeh, *dadih*, *tape*, and *oncom*, contain various bioactive compounds and probiotic microorganisms that have the potential to support mental health through the gut-brain axis. The mechanisms involved include the modulation of neurotransmitters (serotonin, GABA, dopamine), the reduction of neuroinflammation via short-chain fatty acids (SCFAs) and polyphenols, and the regulation of the HPA axis. The strongest evidence to date focuses on tempeh, which has been shown to provide neuroprotective benefits and improve cognitive function in the elderly population of Indonesia. Other fermented foods, such as *dadih*, *tape*, and *oncom*, show strong potential but still require more systematic clinical research.

Recommendations

Based on the findings of this narrative review, several recommendations are proposed. First, randomized controlled trials (RCTs) specifically testing the effects of dadih, tape, and oncom on mental health outcomes in the Indonesian population should be prioritized immediately, given that the available evidence remains very limited. Second, studies on tempeh should be expanded to include not only the elderly population but also young adults and adolescents, who have the highest prevalence of mental health issues in Indonesia. Third, future research should directly measure changes in gut microbiota composition through metagenomic analysis before and after interventions involving the consumption of local fermented foods. Fourth, standardization of effective doses—in terms of recommended frequency and portion sizes—is needed to support mental health. Fifth, the integration of traditional fermented foods into national dietary guidelines must be supported by stronger scientific evidence from the Indonesian population as part of a food-based approach to promoting public mental health.

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