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UNLOCKING FUNCTIONAL POTENTIAL OF FERMENTED RICE: AN EXOTIC SUPERFOOD OF ANCIENT INDIA

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ABSTRACT:
Fermented rice, widely consumed in many Asian countries, is gaining attention for its potential health benefits. Fermented rice naturally contains probiotics and a variety of bioactive metabolites like GABA, polyphenols, vitamins and biogenic amines offering neurocalming, antioxidant, and immunomodulatory properties. The article specifically highlights emerging research on GABA, known for anti-stress, sleep regulation and gut/muscle relaxant effects. Ongoing advances in augmenting bioactives coupled with controlled fermentation can potentiate fermented rice's antimicrobial and respiratory immunity benefits. Further high-quality human studies validating optimal dosage and formulations would help establish fermented rice drinks as functional beverages for boosting health and preventing microbiome-linked diseases. This article provides an overview of the current knowledge on fermented rice and its potential as a functional food.

Keywords: Fermented Rice, Bioactives, Probiotics, GABA, Microbiome

I. INTRODUCTION:

Fermented rice has been an integral part of the Indian diet for centuries. It's a popular breakfast option for many people across the country and is enjoyed in various forms. From Poila Bhat to Pazhamkanji, Geel Bhat to Chaddannam, there are several variants of fermented rice that one can find in India (Pushkarna 2023 Jul 9). Fermented rice is considered to be a nutritional powerhouse, consumed by the southerners in colonial India, when the aristocracy lived off of coffee. As farming represented one of the primary occupations in those days, people drank fermented rice beverage (Neeragaram) to get them energized for the day's work (Mani 2022 Aug 6). The fermentation is the result of microorganisms breaking down the rice, which may cause modifications to the rice's flavor, texture, and nutritional makeup (Grosse 1988). This review aims to spotlight the resurgence and assess the nutritional composition of fermented rice, emphasizing its potential as an ancient Indian superfood.

II. FERMENTATION OF RICE AND BIOACTIVES:

Fermentation is a process in which microorganisms or enzymes cause desirable biochemical changes in food or beverages. (Blandino et al. 2003). Fermented rice contains a rich array of health-promoting bioactive compounds including phenolics, GABA, vitamins, enzymes, phytosterols, saponins, polysaccharides, biogenic amines, isoflavones and resistant starch produced by microbial enzymatic activity. (Agista et al. 2022). Epidemiological studies indicate that the health benefits of rice are due to the additive/synergistic effects of several bioactive compounds. Various processing techniques including parboiling, steaming, soaking, atmospheric conditions and chemical inputs influence the bioactive present in rice. (Goufo and Trindade 2016)

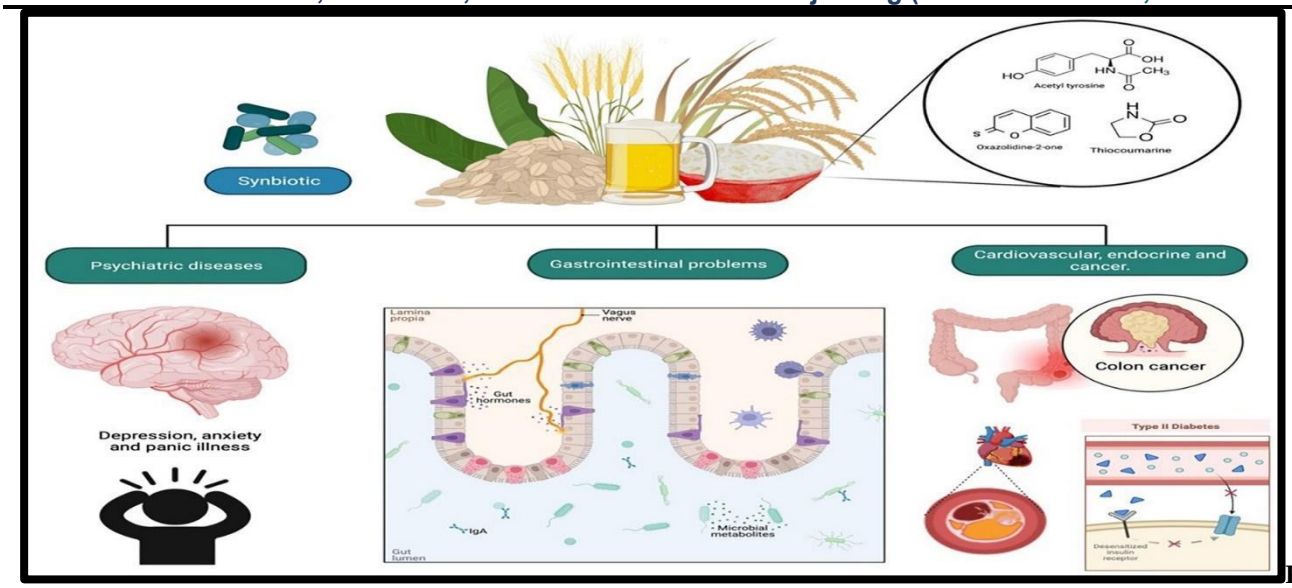

Figure 1: Health Benefits of Fermented Rice

Table 1: Bioactives present in Fermented Rice

S. No	Name of the bioactive	Source of the bioactive	Immunomodulatory effects	Summary	References
1	Monacolins	Monascus-fermented rice	• Anti-hyperlipidemic effect • Anti-hypertensive effect	It significantly reduces the blood LDL cholesterol level by inhibiting HMG-CO reductase.	(Lin et al. 2008)
2	GABA	Korean fermented brown rice	• Anti-stress effect • Anti – fatigue effects	During fermentation, lactobacillus reuteri generated high level of GABA which helps in stress reduction and regulation of physiological functions.	(Tyagi et al. 2021)

3	Peonidin-3 glucoside	Black rice (H7F)	• Anti-pathogenic effect • Prebiotic growth promoting ability	It has unique antioxidant, anti-inflammatory and cholesterol lowering bioactive to benefit for heart health, cancer prevention, diabetes management and digestive health.	(Sutthanut et al. 2022)
4	Ankaflavin	Monascus - fermented red mold rice	• Anti- cancer effect • Anxiolytic activity	Prevent Apoe4 related Alzheimer's	(Lee and Pan 2011)
5	Dimerumic acid	Monascus-fermented rice	• Hepato-protective effects	It can be used in liver injury and inhibit NADPH and iron dependent lipid peroxidation	(Lin et al. 2008)
6	Polyphenols	Fermented brown rice	• Anti-cancer or anti-tumor effects	Reduce the incidence of colorectal cancer	(Tyagi et al. 2021)
7	Tryptamine	Fermented rice bran	• Anti-inflammatory effects	Improves blood circulation and regulate gastrointestinal motility	(Agista et al. 2022)

III. GABA – NEUROCALM ELITE:

Gamma-aminobutyric acid (GABA), a non-proteinogenic amino acid, serves as a major inhibitory neurotransmitter in the central nervous system. Beyond its neurological roles, GABA exhibits diverse pharmaceutical properties, impacting peripheral tissues positively. (Ngo and Vo 2019)

- In Alzheimer's disease, there is an imbalance between brain excitation and inhibition. Key substances involved in brain function, such as glutamate (excitatory) and gamma-aminobutyric acid (GABA, inhibitory), contribute to maintaining a healthy balance. Disruption in this equilibrium is associated with the progression of Alzheimer's disease. (Czapski and Strosznajder 2021)
- GABA, a natural relaxant, reduces stress and anxiety within an hour of oral administration. Derived from the fermentation of specific lactic acid bacteria, it not only aids relaxation and concentration but also boosts immunity under stress, offering potential therapeutic benefits. (Abdou et al. 2006)
- Oral intake of GABA can help people to fall asleep quickly (YAMATSU et al. 2015). Traditional Balinese liquor made with fermented white rice and coconut palm flower used to promote relaxation and quality sleep (Bair 2023 Mar 2). GABA mechanisms significantly influence sleep regulation, supported by studies highlighting the efficacy of GABA receptor agonists and uptake inhibitors in alleviating sleep disturbances. Thalamic GABAergic neurons are implicated in sleep regulation,

suggesting increased GABA availability may counteract caffeine's effects on GABAA receptors. Moreover, GABA may boost melatonin and serotonin levels, enhancing its sleep-promoting properties.

- A study suggests that in the brain, GABA and glutamate are released together, affecting a pathway connected to depression. Controlling this release is key in determining how negative events impact mood and behavior. (Shabel et al. 2014)
- GABA is involved in fear memory, affecting its acquisition, consolidation, and extinction. Studies show drugs enhancing GABA disrupt fear memory formation and extinction, suggesting a common mechanism of reduced GABA activity in memory stability during initial learning and extinction training. (Makkar et al. 2010)
- GABA, a key neurotransmitter, inhibits excessive brain activity. In seizure control, it limits abnormal electrical signals by inducing hyperpolarization in neurons. Medications targeting GABAergic pathways help prevent or reduce seizures. (Rowley et al. 2012)
- The antispasmodic effects of GABA contribute significantly to its muscle-relaxing properties. From research, it is suggested that GABA induces relaxation in the rat proximal duodenum longitudinal muscle, as per the Canadian Journal of Physiology and Pharmacology. (Filho et al. 2022)
- The article explores GABA's role in the gut, regulating gastrointestinal functions through the enteric nervous system. GABA acts as both a neural and endocrine mediator, influencing excitatory and inhibitory signaling via specific receptors. It impacts GI motility, enhancing gastric emptying and intestinal transit, and shows potential anti-inflammatory effects in colonic and inflammation models. (Auteri et al. 2015)
- GABA exhibits anti-aging potential by enhancing antioxidant capacity, regulating energy balance, modifying aging-related gene expression, and influencing aging-related signaling pathways. It's associated with lowering carbohydrate and lipid levels, increasing anti-oxidative capacity, and regulating mRNA expression of longevity-related genes. (Tu et al. 2022)
- The relationship between the neurotransmitter gamma-aminobutyric acid (GABA) and Polycystic Ovary Syndrome (PCOS) is a subject of study. GABA exhibits an excitatory effect on Gonadotropin-releasing hormone (GnRH) secretion, widely recognized as a factor in PCOS pathogenesis. (Szeliga et al. 2022). GABA regulates fertility through GnRH release. Developmental changes and EDC exposure affect GABAergic actions, impacting reproductive function. (Sánchez-Garrido et al. 2022)
- A high-fat diet reduces GABAergic outputs, contributing to mental issues and obesity. Enhancing GABAAR-α5 or suppressing 5-HT3R in MC4RdBNST neurons not only mitigates mental dysfunction but also robustly reduces both food intake and body weight, suggesting a potential link between GABA and obesity. (Xia et al. 2021)
- GABA, a brain chemical, is linked to tinnitus. Imbalances in GABA function may contribute to the perception of ringing or sounds in the ears. Medications targeting GABA receptors are explored as potential treatments for tinnitus. (Witkin et al. 2022)

IV. EMERGING RESEARCH:

As natural synbiotics, fermented rice drinks contain immunostimulatory probiotic cultures, prebiotic fibers and bioactive phytochemicals that promote symbiotic gut colonization while simultaneously exerting systemic immune enhancement. Regular intake helps balance beneficial microbiota, stimulate IgA production, increase NK cell proliferation, and regulate anti-inflammatory signaling through precise immunomodulation (Jane 2022 Mar 13). Ongoing advances in isolating and augmenting potent strains combined with controlled fermentation now allows potentiation of antimicrobial, antiviral and respiratory immunity via gut-axis pathways. Backed by emerging human trials, the functional beverage applications of gluten-free fermented rice formulations for boosting wellness and preventing microbiome-linked diseases continue to expand, especially for infant, elderly and immuno-compromised groups. (Fuloria et al. 2022)

V. CONCLUSION:

Fermented foods have deep roots in ancient Indian civilization, where the age-old practice of food fermentation was pioneered over generations as a means to preserve and fortify available food resources to address nutritional deficiencies. This tradition continues to be improved upon through scientific advances. Fermented rice has emerged as one such functional superfood that harbors a wealth of health-promoting bioactive compounds produced through microbial fermentation. The combined neuroprotective, antioxidant, anti-inflammatory, antihypertensive, anticancer and immunomodulating properties of these rice-based bioactive holds great promise in the targeted medical nutrition realm for boosting immunity, regulating metabolism, enhancing quality of life and supporting healthy longevity. However, further high-quality clinical research is warranted to establish optimal formulations, dosages and duration of intake needed to truly harness fermented rice's pharmacological benefits in humans for managing chronic nutrition-related conditions. By merging age-old wisdom with modern science, the untapped functional food potential of Indian fermented foods like rice can be translated into life-enhancing and sustainable dietary solutions catering to 21st century chronic disease epidemics globally.

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VII. CONFLICT OF INTEREST:

The author declares no conflict of interest regarding the content or publication of this manuscript.

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