



PREVENTING AND MANAGING METABOLIC DISORDERS WITH FUNCTIONAL NUTRACEUTICALS: A COMPREHENSIVE REVIEW

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Abstract

Odisha, a state in eastern India, is renowned for its rich agricultural biodiversity, especially indigenous rice landraces that possess high nutritional and nutraceutical potential. Unlike modern high-yielding polished rice, traditional rice varieties from Odisha—including pigmented and aromatic genotypes—contain a range of bioactive compounds such as antioxidants, fibre, vitamins, and minerals that may help manage lifestyle diseases such as type-2 diabetes, cardiovascular disorders, obesity, and metabolic syndrome. This review synthesises literature on these rice varieties, their nutritional attributes, mechanisms relevant to metabolic health, and implications for dietary and public health interventions.

Keywords: Odisha, Indigenous rice landraces, Pigmented rice, Aromatic rice, Nutraceutical properties, Bioactive compounds, Antioxidants, Dietary fibre, Metabolic health, Lifestyle diseases, Type-2 diabetes, Cardiovascular disorders, Obesity, Metabolic syndrome, Functional foods, Public health nutrition

Introduction

Rice (*Oryza sativa*) is the principal staple food for a large proportion of the Indian population, providing a major source of daily energy and nutrition. In eastern India, particularly in the state of Odisha, rice occupies a central position in agricultural practices, food culture, and rural livelihoods. For generations, rice has been cultivated not only as a food crop but also as a component of traditional knowledge systems maintained by indigenous and tribal communities. India, being one of the largest producers and consumers of rice globally, relies heavily on this cereal for ensuring food security and nutritional sustenance.

With the advancement of modern milling and processing technologies, the consumption of polished white rice has increased substantially in recent decades. Polishing removes the outer bran and germ layers of the grain, resulting in improved appearance, longer shelf life, and enhanced palatability. However, this process also leads to significant losses of dietary fibre, vitamins, minerals, and bioactive compounds. Polished white rice is characterised by a high glycemic index (GI), which causes rapid postprandial increases in blood glucose levels. Regular consumption of such refined rice has been associated with an increased risk of non-communicable diseases (NCDs), including type 2 diabetes mellitus, cardiovascular disorders, obesity, and metabolic syndrome. These lifestyle-related diseases are emerging as major public health challenges in India, particularly in urban and semi-urban populations. In contrast, traditional medicinal and pigmented rice landraces from Odisha have gained renewed attention due to their superior nutritional and functional properties. These indigenous varieties, which include red, black, brown, and aromatic types, are generally consumed in unpolished or minimally processed forms. As a result, they retain higher levels of dietary fibre, essential micronutrients such as iron, zinc, magnesium, and B-complex vitamins, as well as various phytochemicals including phenolic compounds, flavonoids, and anthocyanins. These bioactive constituents exhibit antioxidant, anti-inflammatory, and metabolic regulatory activities, which may contribute to the prevention and management of lifestyle diseases.

Historically, these traditional rice varieties were developed and preserved through farmer-led selection and seed conservation practices, particularly among tribal communities of regions such as Koraput, Mayurbhanj, and Kandhamal. These communities recognised the medicinal and therapeutic value of specific rice types and incorporated them into their daily diets and traditional healthcare systems. However, with the widespread adoption of high-yielding modern varieties during the Green Revolution, many indigenous landraces were gradually marginalised and became endangered. In recent years, there has been growing interest in reviving these traditional rice varieties due to increasing awareness of their health benefits and ecological resilience. Organisations such as 30 Stades and various research institutions have highlighted the efforts of tribal farmers in conserving and promoting these nutritionally rich landraces. Such initiatives have played an important role in reconnecting traditional agricultural practices with contemporary health and sustainability goals.

The renewed focus on medicinal and pigmented rice from Odisha reflects a broader shift towards functional foods and preventive nutrition. Integrating these traditional varieties into modern dietary patterns may offer a sustainable and culturally acceptable approach to addressing the rising burden of lifestyle diseases. Therefore, understanding the nutritional significance, therapeutic potential, and socio-cultural relevance of these rice landraces is essential for developing effective strategies for public health promotion and sustainable agriculture [1].

TABLE 1 Nutritional Composition of Selected Medicinal Rice Varieties of Odisha

Rice Variety	Type	Fibre (g/100g)	Iron (mg/100g)	Zinc (mg/100g)	Anthocyanin (mg/100g)	Glycemic Index
Kalajeera	Aromatic pigmented	2.4–3.1	1.8–2.5	1.5–2.1	12–18	50–55 (Low)
Kandulakathi	Red rice	3.2–4.0	2.4–3.2	1.9–2.6	20–35	48–52
Tikichudi	Red rice	3.5–4.3	2.8–3.5	2.0–2.8	25–40	45–50
Kalamalli	Brown rice	2.9–3.8	2.2–3.0	1.7–2.4	10–20	50–56
Bedagurumukhi	Black rice	4.2–5.5	3.0–4.1	2.5–3.4	120–250	42–48
Bhatamali	Red rice	3.0–3.9	2.1–2.9	1.8–2.5	22–36	47–53



Medicinal Rice Varieties In Odisha

Koraput Kalajeera And Pigmented Rice

Among the indigenous rice varieties of Odisha, Koraput Kalajeera occupies a distinctive position due to its exceptional aroma, fine grain texture, and dark-pigmented husk. This traditional aromatic rice has been awarded a Geographical Indication (GI) tag, recognising its unique regional identity and cultural significance. Historically, Kalajeera has been valued not only for its superior sensory qualities but also for its perceived medicinal properties, particularly in promoting digestion and general vitality. Reports highlighted by Free Press Journal have emphasised its growing popularity among health-conscious consumers and gourmet markets.

In addition to Kalajeera, several indigenous pigmented rice landraces are cultivated and conserved by tribal farmers in Odisha. These include varieties such as Bedagurumukhi, Bhatamali, Haladiganthi, Kandulakathi, Kalachudi, Malimakada, Paradhan, and Tikichudi. These rice types are characterised by red, brown, or black pericarp layers, which are rich in natural pigments and bioactive compounds. Due to their high anthocyanin, phenolic, and flavonoid content, pigmented rice varieties exhibit strong antioxidant activity, helping to reduce oxidative stress and inflammation in the body. Documentation by 30 Stades highlights how these varieties are being revived through community-led conservation and sustainable farming practices.

The nutritional richness of these pigmented rice landraces makes them particularly relevant in the context of lifestyle disease management. Their higher fibre content contributes to slower glucose release, while their antioxidant profile supports cardiovascular and metabolic health. As a result, these traditional varieties are increasingly being recognised as functional foods with therapeutic potential [2].



Fig 01: Eight pigmented rice varieties [3].

Red and Other Traditional Landraces

In regions such as Mayurbhanj and Koraput, tribal communities have played a crucial role in reviving and sustaining red rice and other traditional landraces. Red rice varieties are particularly valued for their dense nutrient profile and robust adaptability to local agro-climatic conditions. These varieties are commonly processed using dhenki, a traditional wooden pounding device that gently removes the husk without stripping away the bran layer.

Unlike modern milling methods that lead to significant nutrient loss, the dhenki process preserves essential minerals and vitamins present in the bran. As a result, traditionally processed red rice remains rich in iron, zinc, magnesium, calcium, and B-complex vitamins. These nutrients are essential for maintaining healthy blood circulation, bone strength, nerve function, and metabolic balance. According to reports by Gaon Connection, the revival of dhenki-processed rice has contributed to improved nutritional security among rural households.

Furthermore, red rice varieties possess higher levels of resistant starch and dietary fibre, which support gut health and enhance insulin sensitivity. Their regular consumption has been associated with improved energy levels, reduced fatigue, and better management of anaemia and metabolic disorders. Beyond their health benefits, these landraces also represent a sustainable agricultural model, as they are often resilient to pests, drought, and low-input farming systems.

Overall, Koraput Kalajeera, pigmented rice varieties, and traditional red rice landraces of Odisha represent a valuable convergence of biodiversity, nutrition, and indigenous knowledge. Their revival not only supports the preservation of cultural heritage but also offers promising dietary strategies for preventing and managing lifestyle-related diseases in contemporary society [4].

Nutritional And Nutraceutical Properties

Macronutrient Profile

Traditional rice landraces tend to retain higher fibre, complex carbohydrates, and less refined starch compared to polished milled rice. They often have lower glycemic responses, beneficial in glycemic control for diabetics.

Micronutrients and Bioactive Compounds

Research on rice landraces from southern Odisha (e.g., Kalamalli, Kandulakathi, Tikichudi) has shown significant levels of iron, zinc, magnesium, phosphorus, and various vitamins. These micronutrients are largely lost in polished rice but remain abundant in unpolished, colored rice.

Pigmented rice types specifically contain anthocyanins and phenolic compounds that act as powerful antioxidants, lowering oxidative stress—a key factor in cardiovascular disease and diabetes pathology [5].

Mechanisms Linked With Lifestyle Disease Management

Glycemic Control And Diabetes

- ☐ Low to Moderate Glycemic Index: Pigmented and whole grain traditional rice releases glucose slowly and avoid abrupt blood sugar spikes, which is crucial for type-2 diabetes management.
- ☐ A reported low-carbohydrate rice cultivated in Odisha was specifically noted for its potential benefit in diabetic diets due to reduced carbohydrate content.
- Antioxidant and Anti-Inflammatory Action

Antioxidants such as flavonoids and phenolic acids in pigmented rice help neutralise free radicals and reduce oxidative stress associated with cardiovascular disease, metabolic syndrome, and certain cancers.

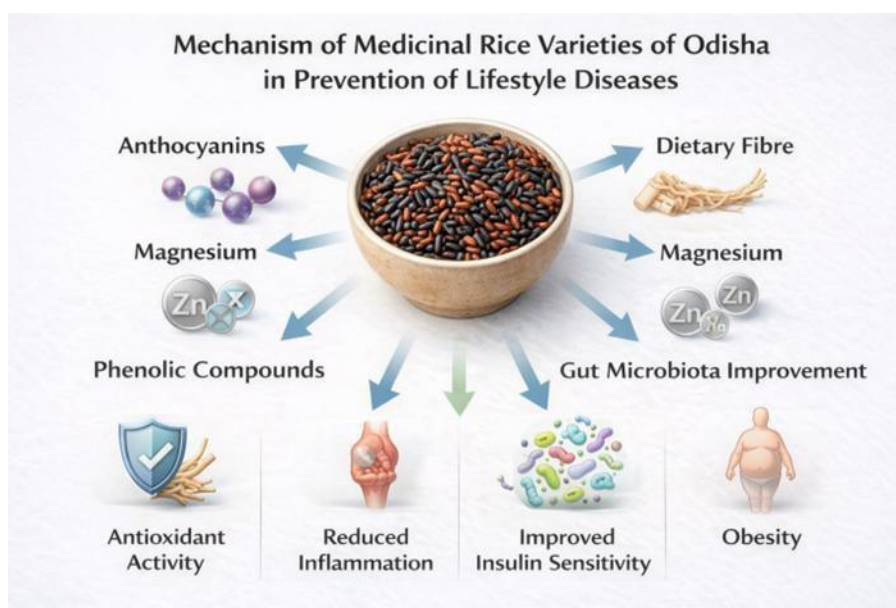
Micronutrient Support and Metabolic Health

Iron and zinc are vital for energy metabolism, immune function, and the prevention of anaemia, which indirectly supports metabolic health. Higher magnesium and B-vitamin content supports metabolic pathways involved in glucose homeostasis [6].

TABLE 2 Bioactive Compounds and Their Mechanisms in Lifestyle Disease Management

Bioactive Compound	Source (Rice Type)	Biological Action	Target Disease	Mechanism
Anthocyanins	Black rice (Bedagurumukhi)	Antioxidant	Type-2 Diabetes	Reduces pancreatic β -cell oxidative damage
Phenolic acids	Red rice	Anti-inflammatory	Cardiovascular disease	Inhibits NF- κ B inflammatory pathway
Flavonoids	Pigmented rice	Anti-atherosclerotic	CVD	Prevents LDL oxidation
Resistant starch	Whole/unpolished rice	Low glycemic response	Diabetes	Slows carbohydrate digestion

Dietary fibre	Brown/red rice	Lipid lowering	Obesity	Delays gastric emptying
Magnesium	Unpolished rice	Metabolic regulator	Metabolic syndrome	Improves insulin receptor sensitivity
Zinc	Traditional rice	Immune modulation	Metabolic disorders	Enhances insulin secretion
Probiotic metabolites	Fermented rice (Pakhala)	Gut microbiota modulation	Metabolic syndrome	Improves intestinal microbiome balance



Traditional Consumption Practices And Dietary Role

Rice consumption patterns in Odisha are deeply rooted in traditional food practices, among which fermented rice preparations, especially pakhala bhata, hold a central place. Pakhala is prepared by soaking cooked rice in water and allowing it to ferment naturally for several hours or overnight. This process leads to the development of beneficial microorganisms, organic acids, and bioactive metabolites, which enhance the nutritional and functional quality of the rice. Traditionally, pakhala is consumed during hot and humid seasons, as it provides a cooling effect and helps maintain hydration and electrolyte balance.

The natural fermentation of rice promotes the growth of lactic acid bacteria and other probiotic microorganisms that support gut health. These beneficial microbes help improve intestinal microflora balance, enhance digestion, and facilitate better absorption of nutrients. A healthy gut microbiome is increasingly recognised as a key regulator of metabolic functions, immune responses, and inflammatory pathways. Regular consumption of fermented rice dishes may therefore contribute to improved gastrointestinal health, reduced digestive disorders, and enhanced overall metabolic efficiency.

In addition to probiotic benefits, fermentation leads to partial breakdown of complex carbohydrates and antinutritional factors such as phytic acid. This improves the bioavailability of minerals like iron, zinc, and calcium, which are essential for metabolic and physiological functions. The mild acidity developed during fermentation also slows gastric emptying and glucose absorption, potentially supporting better glycemic regulation. Although direct clinical evidence linking pakhala consumption with improved liver function or glucose metabolism remains limited, its nutritional profile suggests potential protective effects against metabolic stress and oxidative damage.

Furthermore, pakhalā is usually consumed with traditional accompaniments such as green leafy vegetables, curd, roasted fish, and indigenous herbs, forming a balanced and nutrient-rich meal. This dietary pattern reflects an integrated approach to nutrition, where food choices are aligned with climate, lifestyle, and physiological needs. Such combinations may synergistically enhance antioxidant intake, improve lipid metabolism, and reduce low-grade inflammation associated with lifestyle diseases.

Overall, fermented rice-based dietary practices in Odisha represent an important aspect of indigenous nutritional wisdom. They demonstrate how traditional food systems can promote gut health, metabolic balance, and immune resilience. While further scientific studies are required to establish their direct role in managing diabetes, liver disorders, and other metabolic conditions, these practices highlight the significance of culturally embedded diets in supporting long-term health and disease prevention [7].

TABLE 3 Traditional Processing Methods and Their Nutritional Impact

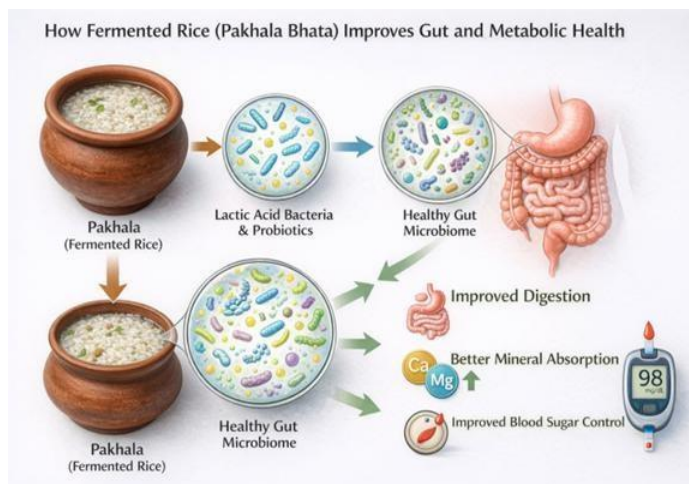
Processing Method	Description	Nutritional Impact	Health Benefit
Dhenki processing	Wooden pounding removes husk only	Retains bran & germ	Higher vitamins and minerals
Sun drying	Natural drying after harvest	Preserves phytochemicals	Antioxidant retention
Hand pounding	Minimal polishing	Maintains fibre	Lower glycemic response
Modern polishing	Industrial milling	Removes fibre, iron, zinc	Higher diabetes risk
Parboiling	Steaming before milling	Mineral diffusion into grain	Better micronutrient retention

Challenges And Future Perspectives

Despite promising nutritional profiles, many traditional rice landraces are threatened with extinction due to replacement by high-yield modern varieties and a lack of market incentives. Reviving and scaling the cultivation of beneficial rice varieties requires support for seed systems, marketing, and consumer awareness [8].

Future research should include:

- ☐ Clinical trials evaluating the metabolic outcomes of consuming these rice varieties.
- ☐ Mechanistic studies on how specific bioactives impact glucose, lipid metabolism, inflammation, and antioxidant defences.
- ☐ Biofortification to enhance nutrient content further while preserving traditional traits.



Conclusion

Medicinal and traditional rice varieties from Odisha—especially pigmented, aromatic, and red rice landraces—hold significant promise in managing lifestyle diseases such as diabetes, cardiovascular disease, and metabolic syndrome through their nutrient density, antioxidants, low GI, and micronutrient content. Reintroducing these varieties into mainstream diets and agricultural systems could contribute both to public health and livelihood support for rural communities [9].

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