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Review Paper

Comprehensive Review on Rice (Oryza sativa L.): Characteristics, Quality, and Applications

Pratik Dhokne*, Swapnil Tirmanwar, Shivani Wadichar, Ragini Dani, Akash Shembekar, Rutuja Thakre

Priyadarshini J. L. College of Pharmacy, Nagpur, Maharashtra, India – 440016.

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ABSTRACT

The Green Revolution emphasized high-yielding rice varieties, which often led to a neglect of traditional rice's medicinal properties. Traditional rice offers high yields and valuable traits like stress tolerance and superior nutrition, including lower sugar content, vitamins, fiber, and glutamic acid to manage diabetes and weight. In India, traditional rice is integral to Ayurvedic and Unani medicine, and it is used to treat high blood pressure, digestive problems, childhood diarrhea, and skin inflammation. Recognizing the health benefits of these rice varieties is vital for encouraging their consumption. This review discusses the bioactive compounds in rice, their extraction methods, and associated health benefits. With various types of rice supporting over 60% of the global population, many phytochemicals provide antioxidant, anticancer, antidiabetic, and anti-inflammatory benefits, making rice an essential part of a healthy diet.

INTRODUCTION

Rice is a cereal grain and staple food for over half of the world's population, particularly in Asia and Africa. It comes from the grass species *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Asian rice was domesticated in China around 13,500 to 8,200 years ago, while African rice was domesticated about 3,000 years ago. In 2021, 787 million tons of rice were produced, ranking it fourth after sugarcane, maize, and wheat, with only 8% traded internationally. China, India, and Indonesia are the largest consumers. Many developing nations lose a significant amount of their rice production due to inadequate transportation and storage. Yields can also be affected by pests, weeds, and diseases like rice blast. Sustainable practices, such as rice-duck farming and integrated pest management, help control these challenges. Rice is a staple food for about 90 percent of Asians and is often referred to as the "grain of life." It consists of 80% carbohydrates, 3% fat, 3% fiber, and 8% protein

***Corresponding Author:** Pratik Dhokne
Address: *Priyadarshini J. L. College of Pharmacy, Nagpur, Maharashtra, India – 440016.*
Email ✉: pratik.dhokne@gmail.com

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(Juliano, 1985). Rice fulfills the energy needs of approximately 2 billion people in Asia alone. However, the current trend of consuming junk food, which appeals to people's taste buds, has led to a concerning increase in lifestyle-related diseases. Indian nutritionists frequently recommend using food as a source of nutrients, serving as a "drug molecule" to supplement dietary requirements. Unlike many other countries, India boasts a rich diversity of rice, with over 200,000 varieties available. [1,2,3] Some of the rice varieties are listed below:

Table No. 1 Different varieties of rice from different countries.

Country	Rice Variety
India	1. Pusa Basmati 2. 1121 Basmati 3. Ranbir Basmati 4. Dehraduni Basmati 5. Gobindobhog (West Bengal) 6. Ambemohar (Maharashtra) 7. Kala Jeera (Odisha/Chhattisgarh) 8. Kalanamak (Uttar Pradesh) 9. Joha Rice (Assam) 10. Chinigura (Eastern India) 11. Mysore Mallige (Karnataka) 12. Black Rice (Manipur, Northeast) 13. Red Matta Rice (Kerala) 14. Njavara Rice (Kerala, medicinal) 15. Karuppu Kavuni (Tamil Nadu) 16. Chakhao Amubi (Manipur, black aromatic) 17. Bora Rice (Assam, sticky rice) 18. Komal Saul (Assam, soft rice) 19. Sona Masuri (Andhra Pradesh, Karnataka) 20. Ponni Rice (Tamil Nadu) 21. Ratna Choodi (Karnataka) 22. Swarna (Odisha/West Bengal) 23. Jeera Samba (Tamil Nadu) 24. Sahyadri 25. Arize Series (by Bayer) 26. Indira Sona 27. DRRH (Direct Seeded Rice Hybrids) 28. Drought-resistant: Sahbhagi Dhan 29. Flood-tolerant: Swarna Sub1 30. Salinity-tolerant: Luna Sankhi, Luna Suvarna 31. HMT Rice 32. Masoori 33. Pusa Sugandh 34. Samba Mahsuri 35. Surti Kolam

High-Yielding Indian Varieties	1. MTU-1010 (Durga) 2. MTU-7029 (Swarna) 3. CR1009 (Tella Hamsa) 4. CO 51 (Tamil Nadu variety) 5. PR 121 (Punjab
Chinese	1. Shanyou 63 2. Yuxiangyouzhan 3. Yueguangdao 4. Liangyoupei 9 5. Longliangyou 915 6. Y Liangyou 1 7. Wuchang Rice (from Heilongjiang Province) 8. Guilin Fragrant Rice 9. Dongxiang Black Rice 10. Black Rice (He Mi) 11. Red Rice (Hong Mi) 12. Xiangshui Glutinous Rice 13. Guizhou Glutinous Rice 14. Yue Rice (Guangdong Province) 15. Zhenjiang Rice (Jiangsu Province) 16. Heilongjiang Japonica Rice 17. Keng Rice (for Japonica rice from Sichuan) 18. Baijiaoxiang 19. Meiguang
Japan	1. Koshihikari 2. Akitakomachi 3. Hitomebore 4. Sasanishiki 5. Hinohikari 6. Yume Pirika 7. Tamanishiki 8. Haenuki 9. Kinuhikari 10. Yamada Nishiki 11. Omachi 12. Mochigome 13. Shirakiku Mochi 14. Aomori Tsugaru Roman 15. Nanatsuboshi 16. Tsuyahime 17. Nikomaru 18. Yumegokochi 19. Milky Queen
America	1. LaKast 2. CL153 3. Roy J 4. Diamond 5. Jazzman

	6. Cypress 7. Della 8. Calhikari-202 9. Calhikari-201 10. S-102 11. California Calrose 12. Wild Rice (Zizania spp.) 13. Specialty Long-Grain 14. Jupiter 15. Titan 16. Bengal 17. M202
Africa	1. Barth's rice 2. African rice 3. Longstamen rice 4. Red rice 5. Eichinger's rice

With the advent of the Green Revolution, high-yielding varieties of rice gained prominence, while the medicinal properties of landraces and traditional rice varieties were largely overlooked. Traditional rice varieties offer a combination of desirable traits, including high yields and tolerance to extreme stress conditions, and they are also rich in nutritional and therapeutic value. These varieties have lower sugar content, making them preferable for individuals looking to regulate their sugar intake or for those suffering from diabetes or being overweight. Additionally, traditional rice varieties contain higher amounts of glutamic acid, fiber, and vitamins. They have been regarded as an energizing food and were recommended by traditional healers for their medicinal benefits, which are said to promote youthfulness and longevity. [2,3,4]

Plant Profile

Kingdom: Plantae
Clade : Tracheophytes
Clade : Angiosperms
Clade : Monocots
Clade : Commelinids
Order : Poales
Family : Poaceae
Genus : *Oryza*
Species : *O. sativa*

Figure No. 1 Rice plant and Grains

The rice plant can grow to over 1 m (3 ft) tall; if in deep water, it can reach a length of 5 m (16 ft). A single plant may have several leafy stems or tillers. The upright stem is jointed with nodes along its length; a long slender leaf arises from each node.[1] The self-fertile flowers are produced in

a panicle, a branched inflorescence that arises from the last internode on the stem. There can be up to 350 spikelets in a panicle, each containing male and female flower parts (anthers and ovules). A fertilized ovule develops into the edible grain or caryopsis.[5,6] In addition to the common white rice varieties, some grains are classified as pigmented rice, which includes types like black, brown, purple, and red. The distinctive colors of these rice grains are due to the high concentrations of anthocyanin pigments present in the rice coating (Huang & Lai, 2016; Pornngarm, Warathit, & Sariya, 2019). Recently, rice has garnered increased attention from consumers, nutritionists, and health practitioners alike due to its significant nutritional value, high biological activity, and potential health benefits. As a result of its superior nutritional quality, greater digestibility, biological activity, and potential health benefits, rice is often referred to as the "queen" among cereals [7]

Chemical Composition

Rice is made up of various phytochemicals and nutrients, which are the sources of numerous bioactive compounds. These include flavonoids, particularly anthocyanins, and proanthocyanidins; carotenoids, such as α-carotene, β-carotene, lutein, and lycopene; and phenolic compounds, including caffeic acid and ferulic acid. Additionally, rice contains phytosterols like β-sitosterol, stigmasterol, and campesterol; vitamin E isoforms such as α-tocotrienol, γ-tocotrienol, δ-tocotrienol, and tocopherols; γ-oryzanol; coumaric acid; phytic acid; and tricin, among others. [8,910] In addition to the primary nutritional components, rice contains various bioactive compounds found in its different parts, such as the bran, germ fraction, and endosperm. These bioactive compounds, which are primarily concentrated in rice bran, have demonstrated various biological activities (Ghasemzadeh, Karbalaii, Jaafar, & Rahmat, 2018; Huang & Lai, 2016). Although these compounds are beneficial for human health, they are not essential for the body's growth and development. [3,12] Rice bran's phytochemicals and nutrients are comparable to those in other cereal brands, such as corn, wheat, and oats. After the dietary intake of rice, bioactive compounds exhibit protective effects against human diseases and have positive impacts on the body's immune system. However, the nutritional values and bioactive compounds in rice can vary among different cultivars, due to factors such as soil fertility, fertilizer application, and other environmental conditions. A consistent pattern emerges when comparing rice to other cereals: it has a low-fat content after the bran is removed, a low protein content (approximately 7–10%), and a higher digestibility of protein. Freshly harvested rice grains consist of about 80% carbohydrates, including starch, glucose, sucrose, and dextrin. [7,13] Rice bran also contains several nutritional components alongside the bioactive compounds. These include cellulose, hemicellulose, pectin, arabinoxylan, lignin, β-glucan, polyphenolics, γ-oryzanol, β-sitosterol, various vitamins (such as B9 and several isoforms of vitamin E, including α γ-, and δ-tocotrienols and tocopherols), micronutrients (such as calcium and magnesium), and essential amino acids (such as arginine, cysteine, histidine, and tryptophan) [3,8,9,10] Rice (*Oryza sativa* L.) is a staple food for people in many countries and serves as a primary dietary component. It is valued for its direct consumption as human food and its use as animal feed, making it one of the world's most important nutritious crops. Rice is primarily a source of carbohydrates, containing a moderate amount of protein and fat, as well as essential B vitamins such as niacin, riboflavin, and thiamine (Fresco, 2005). The carbohydrates in rice are mainly starch, composed of two components: amylose and amylopectin. The grain of rice consists of approximately 12% water, 75–80% starch, and only 7% protein, which includes a complete profile of amino acids. Its

protein content, which has a higher concentration of lysine (around 4%), is highly digestible (93%) and has a high biological value (74%), alongside a protein efficiency ratio of 2.02%–2.04% Additionally, rice contains important minerals, including calcium (Ca), magnesium (Mg), phosphorus (P), and trace amounts of copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn). [2,3,6,7,8,9,13]

Extraction, identification, and quantification

Extraction is the initial step in utilizing rice bioactive compounds for the development of cosmetics, dietary supplements, food ingredients, nutraceuticals, and pharmaceutical products. The main challenge lies in isolating compounds from various classes, such as phenolic acids, flavonoids, and proanthocyanidins, while also removing potential interferences. These compounds can be extracted from fresh, dried, or powdered rice samples. Typically, before extraction, assessing the major biological activities and health benefits of these compounds is essential. [2,6,15]

Major biological activity and health benefits

Bioactive compounds found in various cellular components, including proteins, lipids, and DNA, are known to contribute to oxidative stress. This oxidative stress can eventually lead to a range of health issues, such as cardiovascular diseases, cancer, aging, and inflammatory disorders. These bioactive compounds are present in many natural sources, including cereal grains, fruits, and vegetables. As a result, these natural sources are increasingly seen as a profitable alternative to synthetic antioxidants. [3,6,15]

Medicinal Rice Varieties: A Storehouse of Nutrients

In India, both Ayurvedic and Unani systems of medicine utilize the therapeutic properties of rice. Traditional rice is extensively used for controlling high blood pressure, maintaining body balance, treating digestive system disorders, alleviating diarrhoea in children, addressing skin inflammation, regulating blood sugar levels, and managing various specific diseases. Therefore, medicinal rice varieties serve as a rich source of nutrients. Additionally, rice cultivation is a significant source of income for many people. [13] Rice is a nutritious and beneficial food that aids in digestion and has diuretic properties. It is known as a starchy food and a source of carbohydrates, containing a small amount of protein as well. No other crop can match rice for its unique qualities and irreplaceability. It provides internal harmony and is an excellent addition to a balanced diet. Incorporating medicinal rice varieties into our daily lifestyle can significantly reduce our dependence on external medications. Rice seeds can be used internally to treat urinary dysfunction and reduce excessive lactation. Germinated rice seeds help improve poor appetite and alleviate bloating. One special variety, dark Basmati rice, is rich in iron, while brown rice is high in calcium, which helps relax nerve issues. In India, rice water is recommended as an external ointment for inflamed skin. The Laicha rice variety is specifically used to prevent Laicha disease, a type of skin infection. Sticky rice can help relieve heartburn, stomach upset, and nausea. Additionally, brown rice has properties that may treat warts, breast issues, and stomach cancer. Its magnesium content is also beneficial for treating Alzheimer's disease and counteracting high blood pressure. Brown rice provides several nutrients, including niacin, vitamin D, calcium, fiber, iron, thiamine, and riboflavin. Recently, there has been a growing interest in compounds such as oryzanol, tocopherol, and tocotrienols due to their antioxidant properties. Furthermore, the by-products of rice cultivation offer various useful and valuable products. For instance, a decoction made from rice straw is suggested for treating kidney and gallbladder stones, as well as urinary disorders. [1,2,3]

Table No. 2 Different Indian Varieties of medicinal rice and their medicinal properties.

Rice Variety	Medicinal property
Sali rice	Sali rice roots aid in natural rejuvenation (Brahma Rasayana) Used to cure piles and check hemorrhoid bleeding Sali rice mixed with ghee is for skin burns applied Sali with barley cures anaemia Paste made from Sali rice with ghee used against Fractures Red Sali rice powder with milk and honey is used against irregular uterine bleeding (menometrorrhagia). Increases milk in the mother Red Sali rice gruel cures pain in the head, pelvis, and chest
Sashtika rice	Sashtika rice when consumed with ghee and milk helps to delay degenerative processes in the body. Tablets made from swastika rice are used as an aphrodisiac. Sashtika and barley are used to cure urinary problems such as premia Treats stomach problems (gruel made from Sashtika rice soaked in cow urine and consumed with milk)
Laja rice	Sensations such as vomiting, burning, thirst, and debility can be cured by consuming saturated drinks from laja rice. A dish made from laja rice powder, sugar, honey, ghee, and kosakar, is taken against Diarrhoea. Laja rice powder with honey and ghee gives relief against vomiting. Internal bleeding can be cured by consuming a drink made from laja rice powder with ghee and honey.
Nivara rice	Oil: Used to treat age-related problems such as osteoarthritis (cervical spondilytis), rheumatoid arthritis, back pains, paralysis, and neurological and muscular disorders Increases weight in babies and also cures ulcers in the abdomen Used against skin diseases such as skin lesions and Psoriasis Used to treat snake poison. Gruel made from rice along with meat is used to gain body weight Nivara rice paste mixed with Coconut and sesame oil is used against polio Raw rice soaked in milk and roasted in cow milk is taken against Haemorrhoids Flakes of nivara Rice with ashwagandha and sugar are used to stimulate sexual desire Root Decoction of Nivara given to children with urinary complaints.
Karung kavuni	Used to treat Elephantiasis Dilutes the bad cholesterol Used to treat dog bites
Aalcha Baissor	Aalcha cures acne, cures skin abscesses in children Baissor cures long-term headaches and also cures an acquired brain injury such as stroke(epilepsy)

Gathuwanor Karhani Kalimoonch Maharaji Bhajari Dhanwar	Rheumatism Paralysis Skin diseases As a post partum tonic for women after childbirth Placenta resumption in cows Renewal of placenta in cows
Aalcha, Nagkesar	Skin problems

CONCLUDING REMARKS AND FUTURE

Rice is a vital staple crop for food security and livelihoods, especially in developing countries. This review focuses on the genetic, agronomic, and nutritional aspects of rice, as well as advancements in breeding and sustainable practices. Combining traditional knowledge with modern techniques, such as genomic selection and precision farming, can help address challenges like climate change and pests. Key goals include increasing yields, enhancing resistance to stresses, and improving nutritional content to meet the needs of a growing population. Additionally, conserving diverse rice germplasm is essential for resilience against environmental changes. Collaborative efforts among researchers, policymakers, and farmers are crucial for establishing a sustainable rice production system to support global food security. In summary, investing in rice research and sharing findings with farming communities will foster a resilient and sustainable rice sector.

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