# Genetic diversity, nutritional and medicinal properties of pigmented upland rice varieties of Jharkhand: A review

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**Abstract**

Rice exists in different colours such as white, black, red and brown. The most common rice consumed by people is white rice, followed by brown rice. However, rice landraces genotypes with red, purple, or black bran layer have been cultivated for a long time in Asia and Africa. The process of dehulling and milling discards most micronutrients, fatty acids, antioxidants, and fibre. As a result, diets those are over-reliant on white rice risk deficiencies for several nutritional factors. Improving the nutritional quality of rice grains through the modulation of bioactive compounds and micronutrients represents an efficient means of addressing nutritional security in societies that depend heavily on rice as a staple food. This review reveals fact of Pigmented landrace rice contains a variety of flavones, tannins, phenolics, sterols, oryzanols, and essential oils, which acts as bioactive compounds involved in a wide range of beneficial health effects. It can also have potential use in food and cosmetic industry.

**Keywords:** phytochemicals, upland landrace , genotype

## Introduction

Rice is a staple food for over half of the world's population. The demand for rice supply has been predicted to reach 9.7 billion by 2050, and meeting this demand is essential for ensuring food and nutritional security(1)Indigenous diets have always proved to meet the needs of local communities over a long period, and the knowledge associated with these should be viewed as a resource to inform the discussion concerning the place of rice in the modern diet. (2)Most of the nutrients found in rice grain accumulate in the outer aleurone layer and embryo, while the endosperm is mainly composed of starch.(3) The nutritional quality of the grain produced by certain traditional landraces is higher than that of the grain produced by conventional, modern rice varieties, primarily due to their more effective accumulation of bioactive compounds. The major bioactive compounds found in red, black, purple, and brown rice include gallic, protocatechuic, hydroxybenzoic, vanillic acid, and cyanidin 3-O-glucoside, peonidin-3-O-glucoside, proanthocyanidin, flavanol, catechin and epicatechin, carotenoids, and γ-oryzanol.(4,5,6) Several studies have provided evidence that pigmented rice grain possesses

antioxidant, antidiabetic, anti-hyperlipidemic, and anticancer activity. Similarly, the intake of germinated coloured rice varieties is capable of controlling postprandial glucose contents in the blood while balancing the secretion of insulin in persons with high blood glucose content.(7.8 ).Phytochemicals found in pigmented rice are not present in white rice because many valuable phytochemicals, fibre, vitamins, and nutrients are lost during refining and milling processes. Polished white rice is a processed food; after removal of the bran and germ, hence it can never sprout. Sprouted coloured rice is even more beneficial.(9) When compared to a white rice diet, a brown rice diet was found to reduce weight, body mass index (BMI) significantly, diastole blood pressure and inflammatory biomarkers such as C-reactive proteins (CRP) (11). Arabinoxylan and β-glucan, prebiotics found in brown rice, are beneficial for human gut microbiota, such as Bifidobacterium and Lactobacillus.(12) Due to such a nutritional profile, the focus of a number of major rice research programs is turning to the nutritional quality of pigmented rice, encompassing an improved micronutrient and antioxidant content, along with a reduction in the glycaemic index of the grain (13,14,15)

**Paddy Cultivation in Jharkhand: Current Scenario**

Jharkhand is primarily an agricultural State. It is a homeland of 30 tribes including eight primitive tribes.(16) The economy of tribes in the State is primarily rural and predominantly agricultural. Tribes have rich knowledge about the indigenous practices especially in soil management, seed protection and post- harvest management on paddy. This traditional knowledge has been derived from the tribe's farming experience through trial and error method and handed down from previous generations to present generation. These indigenous methods and practices are very human in nature. This indigenous knowledge can be blended with existing scientific technologies to explore more sustainable and human-friendly methods of agricultural practices (17).

During 2008-2010, in Jharkhand rice was cultivated in 1767 thousand acres of land. Out of this hybrid rice occupied almost 30 per cent area, higy yielding variety (HYV) rice occupied almost 49 per cent area and traditional varieties occupied remaining 21 per cent area. Total rice production in Jharkhand during the same year was 7136.5 thousand metric tonnes. Out of which hybrid rice contributed 44.5 per cent, HYV contributed 42.5 per cent and traditional varieties contributed only 13.0 per cent. Jharkhand currently consists of 24 districts. Out of these 15 districts are tribal districts officially recognised as Schedule V area. These districts together contributed 76.4 per cent area of rice cultivation and 73.8 per cent of rice production of Jharkhand during 2013-14. In the tribal districts, hybrid rice was grown in

34.4 per cent area, HYV in 47.8 per cent area and traditional varieties in only 17.8 per cent area (Table 1). However, production-wise, hybrid contributed45.7 per cent of production followed by HYV rice 42.9 per cent and traditional varieties 11.4 per cent.

**Table 1 : Coverage and Production Different Rice Varieties in Tribal Districts and in Jharkhand During 2008-2010(Area in '000'ha & Production in '000' M tonnes)***

| Place | Hybrid | | HYV | | Traditional | | Total | |
|---|---|---|---|---|---|---|---|---|
| Area | | Production | Area | Production | Area | Production | Area | Production |
| Jharkhand | 529.5 | 3177 | 865.7 | 3030 | 371.8 | 929.5 | 1767 | 7136.5 |
| (29.98) | | (44.5) | (48.99) | (42.5) | (21.0) | (13.0) | (100) | (100) |
| Tribal | 464.5 | 2409 | 645.7 | 2262 | 239.8 | 599 | 1350 | 5270 |
| districts | (34.4) | (45.7) | (47.8) | (42.9) | (17.8) | (11.4) | (100) | (100) |
| (15 nos.) | | | | | | | | |

Source: State Agriculture Department, Jharkhand.

*Ha=Hectare, Mton= Metric Tonne

Figures in parentheses are in percentage of row total.

*Genetic Diversity of Paddy in Jharkhand*

Traditional varieties refer to those varieties which are adapted to local climatic and ecological situation and are cultivated and multiplied by farmers for at least last half a century.( Traditional varieties are by and large ecologically adapted stable genetic strains.(15) These varieties are the basis of any genetic improvement programme including hybrid varieties. If these varieties become extinct, human civilization will lose precious genetic inheritance. Rice belongs to the genus *Oryz* of, the sub-tribe *Oryzineae* in the family of Gramineae. The genus includes 24 accepted species of which 22 are wild and two *Oryza sativa* and *Oryza glaberrimma* are cultivated. (16)In India and Asia, *Oryza sativa* is cultivated. In India alone, around 4,000 varieties are reported to have been recorded (18,19).Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh identified around 600 rice varieties from Chotanagpur plateau and Santhal Pargana region of Jharkhand. Few institutes are trying to preserve these varietal strains. (20)However, due to their internal policy, they did not share its information with the author. College of Biotechnology, Birsa Agriculture University has developed one gene bank for all traditional varieties of Jharkhand. National Bureau of Plant Genetic Resources (NBPGR) .

**Up - Land Pigmented Rice and Varietal Characteristic, Agronomical Practices, Economic and Nutritional Importance of Upland Rice Varieties**

| | | | | |
|---|---|---|---|---|
| Hathi Panjar (Hathi Panja | Reddish brown Size: 5.8 mm Medium coarse rice | Sown by only transplanting in Doin I Base of stem is little blackish Easy for weeding | Very high yield in normal conditions (no commercial fertiliser is used) High straw yield, non- shattering Strong straw so plants do not fall easily | Medium taste Market value medium Usna rice is preferred Good for hardworking village people |
| LalDhan<br>Don Karanga | Light red Size: 6.4 mm<br>Coarse rice | Sown by broadcasting and transplanted Broadcast in end of April to early May, transplanted in July and harvested in Nov- Dec | Stand upright even after the maturity of grains in the panicles Drought tolerant Less investment Non-shattering quality | Rich in vitamins and minerals Good for hard working villagers Sweet in taste Less requirement of rice supplements Laldhan is good for puffed rice/ pressed rice |
| Dhusri Rani Kajar | Light reddish brown colour Size: 6.6 mm Fine rice | Sown by broadcasting and transplanted Broadcast in April – May , transplanted in July- August and harvested in Nov- Dec | Low Investment Previous year stocked seed is used for cultivation Less use of commercial fertilisers | Parboiled rice is good in taste Good for hard working people in villages Rich in minerals and vitamins |
| Khanika Sar<br>Bhorang Sar | 2. Size: 6.2 mm | Medium coarse rice April-May and transplanted in July-August and reaped in November - December | | 4.Good for poor and marginalised farmers.<br>2.Good for hard working people in villages<br>3.Rich in minerals and vitamins<br>4.Cooked stale rice can be eaten for next day<br>5.Starchy water is very helpful to keep fresh and energetic |
| Agin Sar | Light red colour1. Sown by broadcasting | 1. Good yield even if rain fails<br>2.High paddy straw produce | Parboiled rice is good in taste | flood-tolerant varieties |
| Arsanga Arsunga Gora | Lightred colour 1. Short duration semi dwarf 2Size:6.1mm Sown by Low investment Minimum use of fertilizers | Coarse ricebroadcasting in June in the early rain after first shower, reaped in September end or early October Early maturity Drought tolerant | Medicinal value Preparation of rice beer Grain is hard, non-glutinous and non- scented | Nutritious and hard grain; if villagers consume one time they can work in their field for whole day without feeling hungry |
| Khating | 1. Light red colour 1. Sown by Broadcasting in<br>1. Low investment | .Nutritious and hard grain; if villagers consume one<br>2. Size:6.1-6.3mm<br>3. Coarse rice<br>June and reaped in September<br>2.Medium height | Minimum use of fertilizers<br>3.Early maturity<br>4.Drought tolerant | time they can work in their field for whole day without feeling hungry<br>2. Hydrated starch ( Mar) is thick |
| Dani Gora Lal Gora Kala Gora | 2.Red colourSize: 6.3 mm<br>3.Coarse rice<br>1.Sown by broadcasting in June at the beginning of rain<br>2.Early crop for farmers | 1.Low investment<br>2.Minimum use of fertilizers<br>3.Early maturity<br>4.Drought tolerant | Nutritious and hard grain; if villagers consume one time they can work in their field for whole day without feeling hungry | Effective in gastric problem<br>3. Rich in carbohydrate, protein & minerals,<br>4. Hydrated starch ( Mar) is drunk as food supplement |
| Agin arKhanika Sar Bhorang Sar | 1. Light red in colour<br>2. Size: 6.3mm<br>3. Coarse rice | 1. Sown by broadcasting in June at the beginning of rain<br>2. Early crop for farmers | 1. Medium investment,<br>2. Low grain yield,<br>3. Medium straw yield<br>4. Medium Drought tolerant | 1.Good source of B1,B3 and carbohydrates ,<br>2.Medium quality of rice beer is made<br>3.Hard grain and takes time to digest<br>4.Good for hardworking people |

**Nutritional Profile of Pigmented Rice**

**Phytosterols (21,22)**

Pigmented grain appears to accumulate a higher level of γ-oryzanol than non-pigmented grain. The grain accumulates the active antioxidant γ-oryzanol, which comprises a mixture of several phytosteryl ferulates. Phytosterols can both inhibit the absorption of cholesterol and control the blood's content of undesirable lipoproteins. The predominant phytosterols detected in commercial rice varieties are β-sitosterol, followed by campesterol, Δ5 - avenasterol, and stigmasterol. Some black rice varieties alsocontain additional sterols (24-methylene-ergosta-5-en-3β-ol, 24-methylene-ergosta-7-en-3β-ol, and fucosterol).

**Flavanones** Apigenin, luteolin, tricetin, tricin, quercetin, and myricetin have all been detected in extracts of red and brown rice bran. Other flavonoid-like compounds identified in rice include quercetin-3-O-glucoside, quercetin3-O-rutinoside, methoxy-flavanol-3-O-glucoside, and isorhamnetin-3-O-glucoside. The flavone and flavonol contents concentrations were significantly higher in black rice than in red, brown, or white rice. This was especially true concerning taxifolin O-hexoside, quercetin 3-O-glucoside, and quercetin 3-O-rutinoside, which were detected only in black rice. White rice predominantly containstricin-O-rhamnosideO-hexoside and apigenin-6-C-glucosyl-8-C-arabinoside. (23,24)

**Anthocyanins** T hese are responsible for purple to blue pigmentation and represent the bulk of the flavonoids present in black and purple rice. The main anthocyanins in black rice are present in quantities more than 95% and include cyanidin 3-O-glucoside and peonidin-3-O-glucoside. Black rice bran shows the highest content of total anthocyanins, followed by red and brown rice. White rice grains have been classified as lacking anthocyanin. Studies confirmed that coloured rice exhibits stronger anthocyanin and antioxidant activities than those exhibited by non-coloured rice. (25)

**Proanthocyanidins and Catechins T** hese make up the bulk of the phenolic compounds found in red rice, responsible for the pericarp's red pigmentation. No proanthocyanidins have been detected in white rice accessions. Red rice is characterized by a high quantity of oligomeric procyanidins wmore than 60% of total phytochemicals found in the rice seeds. The concentration of catechin is generally much higher in red rice (92 μg/g) than in black rice (20 μg/g) (26).

**phenolic compounds,** including vanillic acid, protocatechuic acid, chlorogenic acid, ferulic acid, and coumaric acid, has been detected in black rice with the dominant phenolic acids are present in red/ black rice bran. Low levels of these phytochemicals are found in white rice as a consequence of the milling process.(27)

**Carotenoids** Most of this class of compound is present in the bran, with little or no carotenoids being found in milled rice. Red and black rice accumulate an exceptionally high carotenoid content, while white rice accumulates very little. Lutein is the primary carotenoid found in red rice varieties. Vitamins and Micronutrients Rice grain represents a good source of vitamin E, including.(28)

**Benefits of Pigmented Rice Consumption**

Compared to a white rice diet, a brown rice diet significantly reduces weight and body mass index (BMI), diastole blood pressure, and inflammatory biomarkers such as C-reactive proteins (CRP). Arabinoxylan and β-glucan, prebiotics found in brown rice, are beneficial for human gut microbiota, such as Bifidobacterium and Lactobacillus. (29)Brown rice was used as an intervention for preventing type 2 diabetes due to the presence of a critical component, γ-oryzanol.(30) Not only is natural pigmented rice higher in the beneficial antioxidant activities of black and red rice, but it also displays strong anti-inflammatory, anticancer and antimetastasis activities.

**Antioxidant Activity**

Dietary antioxidants represent an effective means of combating the accumulation of harmful reactive oxygen species (ROS) and balancing the body's redox status. Analysis of extracts made from pigmented rice grain shows that the phenolic compounds tocopherol andanthocyanin are efficient neutralizers of reactive oxygen species. (31)The antioxidant activities correlated well with the polyphenol and phytochemical content that contribute to the intense colour of the pigmented rice

**Anti-Inflammatory Properties**

S ome reports have demonstrated that lipophilic phytochemicals in pigmented rice germ and bran, such as γ-oryzanol and vitamin E derivatives, exertantiinflammatory activities. Moreover, coloured rice contains high amounts of medium polar or hydrophilic compounds such as phenolics, bioflavonoids, anthocyanin, and proanthocyanidins that have been reported for their anti-inflammatory properties.(32) Anthocyanin-rich black rice and proanthocyanidinrich red rice exhibit therapeutic potential for the treatment of inflammatory diseases.

**Antidiabetic Property**

Unlike white rice consumption, which raises blood glucose levels, consuming pigmented grain can reduce blood glucose levels. Coloured rice extracts effectively inhibit endogenous α-amylase and α-glucosidase activity, preventingthe conversion of starch to glucose in the small

intestine. The anthocyanins found in the whole grain of black rice acts as a potent inhibitor of β-glucosidase,(33) thus delaying the absorption of carbohydrates. Extracts of black rice bran have also been shown to induce the repair and regeneration

**Anti-Cancer Activity**

The phenolic acids, flavonoids, anthocyanins, and phytic acid present in extracts of purple/ black rice bran have been shown to act as anti-mutagens and potential suppressors of cancer. These phytochemicals act by either blocking the carcinogenetic cytochromes P450 or by effectively scavenging free radicals. The phytosterols (24-methylenecycloartanol, β-sitosterol, gramisterol, campesterol, stigmasterol, cycloeucalenol, 24-methyleneergosta-5-en-3β-ol, and 24-methylene-ergosta-7-en-3β-ol) which are present in extracts of black rice bran, have also been reported to be effective as agents restricting the proliferation of murine leukemic cells.(34) Some reports showeda negligible effect of brown or purple bran on leukaemia and cervical cancer cells, while red bran had a robust inhibitory effect.

**Anti-Obesity**

Effect Pigmented rice has proved to have an effect in weight reduction as it contains high fibre and low digestible starch content, which assists to stop signals of hunger and discourage excessive consumption. Antioxidant-rich pigmented rice alleviates oxidative stress induced inflammation which represents a key signal during obesity.(35)Coloured rice supplementation also decreases lipid accumulation in liver and adipose tissue and reduces lowdensity lipoprotein while increasing high-density lipoproteins.

**Skin Antiaging Properties**

Both proanthocyanidin and catechin significantly induce the synthesis of collagen and hyaluronic acid, an essential biological target for skin antiaging agents and they are naturally found in red rice. Many studies have shown that bioactive compounds found in pigmented rice, such as proanthocyanidin, catechin, vanillic acid, and oryzanol, may be helpful in the cosmetic and nutraceutical industries as skin antiaging agents(36) Natural or herbal products that can exert skin benefits, including scavenging reactive oxygen species (ROS), the suppression of extracellular matrix degradation enzymes, and the inhibition of melanin synthesis, can be applied in skincare products for their beneficial skin antiaging properties. Pigmented rice can be a potential source here.

**Conservation Initiatives**

Conservation of these rich genetic diversities to a large extent will ensure the survival of paddy cultivation during any epidemic attack, and failure of improved strains (as happened in Bt

Cotton) (37). Conservation of genetic can be done in two ways. First, by growing the variety every year either in research station or in farmer's field and preserving the freshly harvested seed for multiplication in the following year and second preserving seeds below $-10^0$ C in any suitable container free from any kind of damage. In this way seed can be multiplied once in eight to ten years.

NGOs like Gene Campaign have been trying hard to conserve the traditional paddy varieties at farmer's field. Such initiative has added benefit of maintaining variety specific paddy culture alive at farmer's level. This is important as ethnic group's several songs and dances have direct link with the varieties and their cultivation. These cultural dialect and heritage may be lost if farmers stop growing the variety.(38)

Conservation of paddy variety at research station may be safer because these are handled by scientists with improved technologies. But scientists may not have the cultural bondage with the variety like any ethnic farmer or farming community. Lack of cultural touch and emotional bondage may develop a casual and routine attitude to the entire preservation aspects. This was evident when we observed that good number of varietal strains is kept with code number without having any name or description of varietal characters in several research stations. The above mentioned research stations and plant genetic bureau have all latest technology to conserve the traditional paddy varieties for next few centuries at least. Preservation of gene bank is expensive. In the event of any severe varietal crisis will these centres be able to revive these varieties through rapid multiplication within a short period or only multinational seed firms will reap the full benefit of these gene bank is a matter of concern.(39)

**Conserving Biodiversity at Farm Level**

Farm level conservation of biodiversity has multiple benefits. There is an old adage 'out of sight, out of mind'. This is quite applicable in biodiversity conservation. Existence of any species/plant varieties also helps in practice of conservation alive. The knowledge that evolves out of practice remains alive and may get refined as long as those particular species/plant varieties are in Cultivation of traditional paddy varieties generated vast pool of agronomical knowledge among various tribes/castes. This knowledge is likely to be eroded once people stop cultivating the same.

Furthermore, farm level biodiversity conservation is also responsible for evolution of cultural heritage. These are expressed in the form of folklore, songs, dance, drama and arts. Many of these cultures will no longer exist once the tribe/people' group become disassociated with the

plant/animal conservation (40). Oraons and Sadans of Jharkhand share a rich paddy culture in the form of folklore, seasonal songs/ragas, dances and arts. Rapid urbanisation has already caused much erosion of the paddy linked cultural heritage (41,42,43); 44). Discontinuation of traditional varieties may hasten the further erosion of paddy culture

**Conclusion**

Although India is home to traditional red rice varieties and their use has been common among the practitioners of traditional medicine and communities as part of their cultural heritage, their functional effects and health benefits in terms of modern scientific methodology are far and few. Due to the insufficient availability of data, the beneficial properties of these varieties still remain unknown to a majority of the population. So, to leverage their health benefits, extensive research on these native coloured varieties by the stakeholders needs to be promoted so that they are available to consumers as a part of the daily diet or specialty functional foods.

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