

Nutritional and financial security through red rice cultivation in the Himalayan region

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Red rice, also known as 'Laal Dhaan' in Hindi, holds a prominent place as a renowned indigenous variety in the mid and high hills of the North Western Himalayan states. Red rice is predominant in the Indian market, preferred more by consumers and grown widely in the farmers' fields. Red rice farmers varieties like Chhohartu, Jattoo, Matali, Lal Zhini from Himachal Pradesh; Zag from Jammu & Kashmir & Chawar and Bartia from Uttarakhand are popular farmers varieties registered under PPVFRA, New Delhi. These varieties possess unique textures, delightful aroma, rich flavour & nutrition, and captivating visual allure positioning them at a premium price point. They have the enormous potential to improve economic and nutritional security in the Himalayan region by establishing distinct and lucrative markets for these varieties.

Keywords: Himalayan, Red rice, Uttarakhand, Varieties

While white rice serves as a primary dietary staple globally, several nations in Southeast Asia (SEA) also incorporate pigmented varieties like red, black, purple, and brown rice into their diets. Notably, India and Indonesia boast larger cultivated areas for pigmented rice compared to other Southeast Asian countries. However, the proportions of pigmented rice cultivation remain smaller when compared to that of the white rice cultivar. Among pigmented cultivars, red rice is predominant in the Indian market, preferred more by the consumers and grown widely in the farmers' field. From the consumer and market perspectives, 'red rice' is typically defined as rice with a red bran layer, regardless of the husk/hull colour. However, in field conditions, farmers use the term 'red rice or Laal Dhan' under three different situations: a) rice varieties with red husk/hull but a white bran layer; b) rice varieties with yellow husk/hull but a red bran layer; and c) rice varieties with both red husk/hull and red bran layer. In many cases, the term 'Red Rice'

or 'Laal Dhan' is assigned due to its distinctive attribute of having a varying degree of red hue in its husk-free grains. The outer husk (palea and lemma) shares similarities with white rice, displaying a pale yellow colour.

Categories of red rice

Red rice can be categorized into three main groups viz., wild, weedy and cultivated based on their habitat. Its kernels range from dark to light-coloured husks. In India, wild red rice species include *Oryza granulata*, *O. officinalis*, *O. rufipogon*, and *O. nivara*, whereas Africa hosts *Oryza longistaminata* and *Oryza punctata*. *Oryza rufipogon* and *O. nivara* are used both for food and medicinal purposes. Weedy rice refers to off-type plants with red pericarp or seeds. It exhibits varying degrees of awns, a high out-crossing rate, frequent seed shedding and dormancy. Weedy rice sheds seeds earlier than cultivars, displaying hardiness, prolific nature, and genes for tolerating adverse conditions. It is believed that weedy rices have evolved through hybridization

between wild and cultivated rices. Cultivated red rice consists of many land races and improved cultivars from different regions. Like white rice, red rice has a wide range of varieties. They are glutinous and non-glutinous, fragrant and non-fragrant, late and early maturing, short and long-grained. However, the majority of red rices are coarse-grained. Among the long-grained red rices, Himalayan red has made an impression on the export market as well. Some of well known red rice varieties are Matta from Kerala, Patni from Maharashtra.

Development and genetics of red colour

Different types of the *Oryza sativa* plant, such as red rice and cultivated rice, engage in intercrossing both amongst themselves and with other species within the AA group. Rice cultivars primarily undergo self-pollination, with an average outcrossing rate of about 0.5% (ranging from 0 to 3.4%). While rice and red rice also exhibit similar low interbreeding rates, the precise dynamics of gene flow between them in field conditions remain

insufficiently understood. Red rice varieties likely emerged through the interbreeding of traditional white-grained varieties and annual weedy rice (*Oryza spontanea/fatua*), both of which coexist within rice fields. The original progenitor of rice exhibited a reddish grain colour.

The change from the red seeds in wild rice to the white seeds found in cultivated rice (*Oryza sativa*) was brought by a powerful selective process driven by a single mutation – a frame-shift deletion (a 14-bp deletion in the rc allele within exon 6) within the Rc gene. This mutation is present in 97.9% of contemporary white rice varieties. Interestingly, this prominent mutation originated in the *japonica* subspecies and successfully crossed geographical and sterility barriers to become established in the *indica* subspecies. Strikingly, some genetic mutations connected to rice domestication are shared across all rice types. The alteration in the Rc gene responsible for transforming the red seeds of wild rice into the white seeds of present-day rice is widespread among a vast majority of rice varieties, irrespective of their subspecies. The intensity of red pigmentation is governed by two complementary genes: Rc (located on chromosome 7), encoding a basic helix-loop-helix (bHLH) transcription factor, and Rd (on chromosome 1), encoding a form of dihydroflavonol 4-reductase. This enzyme enhances the accumulation of proanthocyanidin, contributing to the red pericarp colour. Rc is responsible for proanthocyanidin build-up in the pericarp, while Rd regulates the extent of accumulation. However, Rc also has close ties with shattering and grain dormancy, which made it an unfavourable trait during the domestication process. Rc-Rd genotypes produce red grain, whereas Rcrd genotypes produce brown grain. Red kernel colour in rice primarily follows a monogenic dominant pattern, though in certain ecotypes, two dominant genes with complementary interactions have been observed. Rice can produce grains with brown, red, purple, and even black pericarps. The black and purple hues arise from anthocyanin

accumulation, whereas red pericarps result from proanthocyanidins. Pigmented rice varieties tend to possess higher protein content with a balanced amino acid composition, improved glycemic index, and elevated levels of fats, fibre, and vitamin E (tocopherols and tocotrienols). Additionally, they showcase potent antioxidant and free radical scavenging capabilities owing to elevated phenolic compound levels. The development of colours in rice grains occurs at various stages of growth. In red rice, the red colour in the caryopsis (grain) becomes apparent only at the stage of maturity when grain fully ripened, whereas in black rice varieties, the colour in the caryopsis (grain) can be observed from the dough stage onwards.

Health benefits of red rice

Red rice is a nutritionally dense grain that offers a range of health benefits. It possesses several nutritional advantages compared to polished white rice. Red rice often, if not universally, contains higher levels of zinc and iron compared to white rice. Fe and Zn content of some red genotypes is mentioned in Table 1. Additionally, it serves as a more abundant source of magnesium and calcium than its white counterpart. Moreover, red rice is enriched with protein, dietary fibre, antioxidants, vitamins, and essential minerals (Table 2). Notably, red rice contributes positively to diabetes management due to its low glycemic index, facilitating gradual digestion and a steady energy release, making it particularly beneficial for diabetic individuals. Furthermore, red rice has the potential to contribute to asthma prevention and control by enhancing pulmonary functions. This effect is attributed to its substantial magnesium content, which promotes improved oxygen circulation within the body, thereby potentially mitigating asthma symptoms. Additionally, red rice plays a role in digestion enhancement. With its ample fibre content, it aids various digestive processes and acts as a natural laxative.

Table 1. Fe and Zn content in dehusked red rice genotypes

Red rice genotypes	Fe (ppm)	Zn (ppm)
IC 258343	7.1	35.2
IC 258347	7.4	24.8
IC 266923	8	30.7
IC 279479	7.3	27.6
IC 355830	10	28.1
IC 258357	7.8	24.4
IC 392627	10.9	27.7
IC 568237	8.7	30.5
IC 568275	8.6	28.8
IC 582493	8.3	24.2
VL Dhan 69	6.7	20
VL Dhan 159	9.7	30.1

Table 2. Comparison of various nutrient content in red rice and white rice (per 100g)

Nutrient content	White rice	Red rice
Calories/ Energy Content	349 kcal	341 kcal
Carbohydrates	78 g	70 g
Crude protein content	7.6 g	10.4g
Crude fat content	0.62 g	1.81 g
Crude fibre content	0.23 g	2.7 g
Total ash content	0.46 g	1.53 g
Calcium content	7.94 mg	8.71 mg
Magnesium content	46.45 mg	192.27 mg

Cultivation of red rice in NW Himalayas

Red rice, also known as 'Laal Dhan' in Hindi, holds a prominent place as a renowned indigenous variety in the mid and high hills of the North Western Himalayan states, namely Himachal Pradesh, Uttarakhand, and the union territory of Jammu & Kashmir. In the period before the green revolution, it stood as a vital staple food for the inhabitants of the Himalayan hills. The red rice cultivars found in the North Western Himalayan Hills, including Chhohartu, Jatoo, Matali, Lal Zhini from Himachal Pradesh, 'Zag' from Jammu & Kashmir, and Chawar and Bartia from Uttarakhand are still popular. They are cultivated within their specific geographical regions and contribute significantly to the overall cultivation of red rice in these areas. The cultivation process

of red rice is similar to other rice varieties. Just like other rice, red rice is cultivated during the *kharif* season, and there is no remarkable difference in the cultivation practices of the two. In the mid hills of the North Western Himalayas, the transplanting period typically spans from June to July. It is recommended to sow the seeds 3-4 weeks before the planned transplanting date. The stage of harvestable maturity is reached in about 120-140 days, around September to October. Red rice and regular rice share similar morphological characteristics. Largely, soils in the North Western Himalayas are characterized as acidic, resulting in a substantial availability of iron. Over the course of thousands of years of evolution, traditional varieties have likely developed genetic adaptations for enhanced iron absorption and do not exhibit any signs of iron toxicity symptoms, unlike in some semi-dwarf varieties introduced in the late 1970s.

Red rice varieties were very popular in the region but the advent of commercial high-yielding varieties in the region after the green revolution and more craze & preference for white grain rice adversely affected the cultivation of red rice. Further, its sensory qualities (nutty flavour and chewiness), limited availability, more cost than other types of rice and lack of awareness about its nutritional potential are other factors responsible for its limited demand among consumers. Therefore, awareness generation about its functional and health-promoting properties among the consumers, popularization of high-yielding red rice varieties among

farmers, ensuring the quality seed and technical backstopping for its improved production are urgently needed to promote its utilization and wider adoption.

Improved varieties and landraces of red rice in Uttarakhand hills

Improved varieties of red rice

VL Dhan 69 (IET 26596, VL 32130): This variety was released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, New Delhi vide S.O. 8(E) dated 24th December, 2021 for cultivation in Uttarakhand, Sikkim and Union territory of Jammu and Kashmir. It has been developed from the cross 'VL 10689/UPRI2005-15' at ICAR-VPKAS, Almora and is suitable for cultivation in mid hills under irrigated transplanted condition. It has unique decorticated grain colour (reddish brown) which surely fetch higher price in the market as compared to normal rice. It recorded 79.9% hulling, 69.1% milling, 55.4% head rice recovery, intermediate ASV (5.0) and amylose content of 26.78%. It has shown moderate resistance to leaf blast, neck blast, brown spot and sheath rot. It has short bold grain, plant height 95-105 cm, matures in 125-130 days and high (282) panicles/m². On an average of three years of testing, VL Dhan 69 provided grain yield of 4,255 kg/ha in medium hill as compared to national check, Vivek Dhan 62 (3,010 kg/ha); regional check, VL Dhan 65 (3,599 kg/ha) & Local check (2,769 kg/ha) with yield advantage of 41.37, 18.22 and 53.65%, respectively.

VL Dhan 159 (IET 26598, VL 20083): This is an early maturing

variety under rainfed upland ecosystem which matures between 110 to 115 days. It is sown in the month of June (Jethi Dhan) in the hilly region of Uttarakhand. It has long bold grain with plant height 95-105 cm. This variety has resistance against major diseases viz., leaf and neck blast, brown leaf spot, sheath rot, false smut, leaf scald and insect pests viz., stem borer and leaf. This was released by the State Variety Release Committee of Uttarakhand and notified vide S.O.500 (E) dated 29.01.2021. It was a cross between VL 66 and HPR 2143. This variety has shown an average yield of 1,964 kg/ha under organic conditions which was 21.74% yield superiority over the best check, VL Dhan 221.



Farmers variety/Land races

Chawar Dhan: It is a farmers' variety of rice registered under Plant Varieties Registry in 2022 of the Protection of Plant Variety and Farmers Rights Act, 2001 with the help of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora. This variety with red grains has been conserved for several years and extensively grown in the Purola and Mori regions of Uttarkashi district. It is adapted to both irrigated & rainfed conditions, and has ability to provide good production even in unfavorable conditions. It is nutritious and possesses medicinal properties. The demand for this variety with red grains exists in local markets and neighbouring states like Himachal Pradesh.



Chawar Dhan of Purola and Mori in Uttarkashi District



Grain sample of VL Dhan 69 (VL 32130)
(a) with hull/husk, (b) after hulling, (c) after milling, (d) after intense milling

Bartiya Dhan: This is another farmers' variety of rice registered under Plant Varieties Registry in 2022 of the Protection of Plant Variety and Farmers Rights Act, 2001 with the help of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora. This variety has been cultivated for many years by the farmers of village Chetchimala (Kawadhar) under Tehsil Munsiyari in Pithoragarh district and has been conserved for several years due to its high yield and nutritional qualities. It is primarily used to make dishes like khaja, chyura, kheer etc. It is well suited to irrigated conditions.



Bartiya Dhan of Munshyari,
Pithoragarh District

Under the provisions of the PPVFRA, the custodian farmer

groups of conserved paddy variety can obtain various benefits such as the exclusive right to produce, sell, market, distribute, import or export the variety for initial terms of six years & renewable for the remaining years and of authorizing any other person to do so. Further, farmers are eligible for award for contribution to the conservation and development of agricultural diversity, or along with the recognition. Additionally, if this species is used in the development of a new variety, then the farmers also get the right to share the benefits earned by the new variety. This acknowledges the dedication of the farming communities who have inherited this variety from their ancestors and have been cultivating and preserving it for generations. Cultivators of protected species are entitled to compensation even if they are used undeclared by any other commercial breeder. But one step ahead if red rice gets registered under the Geographical Indications of Goods (GI) Act, it holds

significance. This legal framework allows only authorized users or residents within a specific region to utilize the product's renowned name (e.g., like basmati rice). By securing GI registration for red rice, farmers and others would gain the ability to promote their product globally. This move is poised to invigorate exports, ultimately benefiting the growers.

SUMMARY

Himalayan red rice has secured a spot in the global market of trade. The distinctive qualities of Himalayan red rice strains, including their exquisite texture, delightful aroma, rich flavour, and captivating visual allure, position them at a premium price point. If these varieties establish their distinct and lucrative market niche, akin to the specialty rice basmati, they have the potential to bring significant economic advantages to farmers.

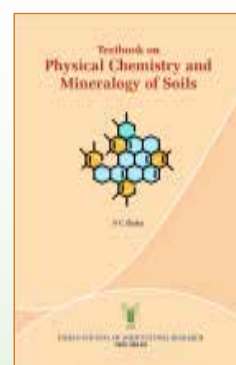
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