

NUTRITIONAL PROPERTIES AND HEALTH BENEFITS OF BLACK RICE: A REVIEW

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Abstract- Rice (*Oryza sativa* L.) is widely known as staple food of half of the population of Asian countries. Traditional white rice varieties are riched in carbohydrates responsible for increment in sugar level in blood. Now a days, colored rice varieties impose special attention due to its presence of minerals and other bioactive compound that have numerous health benefits .Presence of essential amino acids, functional lipids, Phytosterols, tocopherols, Phytic acid can also makes it a super food and neutralized free radicals when regularly consumed. This paddy is also known as functional food due to presence of minerals including iron, zinc, calcium, phosphorus and selenium. The processing product of black rice like rice bran oil, bakery products, power soup can help to reduce multiple risk of hypertension, cancer , digestive and neurological problems, diabetes, weight management. Antioxidants, like phenolics, flavonoids and mainly anthocyanin, act as a valuable component of black rice has the capacity to control reactive oxygen species and makes this food preferable for patients and also distinguish this paddy among others as first line of defense. This nutrient rich crop is widely grown in countries like Nepal, China, Korea, New Zealand, Thailand and northeastern states of India such as West Bengal, Odisha, Maharashtra, Bihar and Jharkhand. This crop now acquires the geographical indication tag (GI tag) to black rice variety of Manipur (Chakhao) will definitely expands its demand as a novel food all over the world. The local farmers of many rural parts of India are unaware about the cultivation and processing technology of black rice. Thus more training and awareness programs should be conducted by government and NGOs increase the knowledge and infrastructure for cultivation of this crop. This chapter mainly focuses the nutritional properties and tremendous health benefits and also its role in crop improvement.

Index terms: Paddy, black rice, antioxidants, Super food, functional food

I INTRODUCTION

Rice (*Oryza sativa* L.) is consumed by more than half of the world's total population become staple food for many developing countries This widely known paddy belongs to the family Gramineae and further subdivided into 3 sub-species javanica, japonica, and indica and among which Indica species is commonly grown in India and others tropical and sub-tropical countries. According to current statistics, consumption of this staple food has increased about 15% in the crop year 2020-2021 as compared to the crop year 2008-2009 [1]. Important constituent of rice is carbohydrate which gives energy for activation and functioning of metabolism and also for enzymatic activities. There are at least 175 countries and territories, consumed rice across the world and per person consumption ranges between 100 to 200 kg per person in daily life. Among the staple food, rice has potentially in high demand after several epidemiological studies represents positive correlation between a less possibility of cancers and coronary heart disease with rice consumption. Large amount of fibres and bioactive phytochemicals such as tocopherols, tocotrienols, oryzanol, dietary fibres , and antioxidant like phenols presents in rice bran. Anthocyanins is a highly distributed plant pigment, have been known to reduce the risks of serious diseases such as Cancer and obesity and the compounds have antiviral, anti-inflammatory, and anti-skin aging effects [2].

Globally, rice consumed is categorized into two major types i.e non pigmented and pigmented rice. Non- pigmented (white rice) is commonly used all over the world, however, pigmented rice is also gaining interest because it constitutes high amount of antioxidant compound than non-pigmented rice. Pigmented rice varieties have famous for its excessive amount of phenolic compounds, such as proanthocyanidin, anthocyanins, avonols, and with significant antioxidative and neutralizing free radicals properties [3]. Again the pigmented rice is categorized into brown, red and black rice.

Brown rice: Brown rice contains same amount of energy as white rice (non-pigmented rice) but it also riched in fibre, protein and antioxidants that has the capacity of scavenging free radicals and also contain large amount of magnesium.

Red rice: Red rice contains iron, that helps in reduction inflammation and lower blood pressure issues and also contains fibre like brown rice.

Black rice: Initially black rice was originated from China and later on cultivated in many asian countries such as Japan, Korea, Thailand, Indonesia, India, Sri Lanka and Nepal. The cereal is used in various physiological function used for the treatment of

Broken bone and also helps in enhancement of blood circulation, kidney function, eyesight. Alternative names of black rice are purple rice, forbidden rice, heaven rice, imperial rice, king's rice [4]. Amino acids like lysine, tryptophan and vitamins such as vitamin B1, vitamin B2 and folic acid and also a good source of iron, zinc, calcium, phosphorus and selenium present in black rice that makes it highly nutritious [5]. Black rice also contains phytochemicals like phenolic, flavonoids then other and also contains 6 times more antioxidant as compare to brown rice. Elemental Color of black rice has from deep purple to black; the unveiling and consistency in color are useful to classify endosperm into the two different groups' non-glutinous and glutinous endosperm. The reason behind this classification is non-glutinous black rice is acquired to have the greater demand compared with the glutinous black rice. The present study focuses on review regarding nutritious value, cultivation and health benefits of black rice.

II NUTRIENTS

- Black rice of 1/4 cup or 50 gram constitutes approximately 160 calories energy that contains 9.1 grams of protein per 100 grams while white rice has 6.3 grams of protein per 100 grams.
- Lower glycemic index value helpful for diabetic patients.
- Some important constituents are 18 amino acids, Iron, Zinc, Copper, carotene, good amount of Vitamin E and also has more arsenic content than white rice
- Production of adiponectin in body may be increased due to presence of this nutritious crop.
- Regulation of appetite becomes possible due to decreased level of the hormone leptin
- High antioxidant concentration in black rice content protects cells against oxidative stress. Aman [6]
- As per previous studies, the Phytochemical composition of different varieties rice were classified into several groups such as carotenoids, phenolics, alkaloids, nitrogen and organosulfur containing compounds. The major group among antioxidants is Phenolics which further subgrouped as phenolic acids, flavonoids, coumarins and tannins. Similarly among flavonoid compounds anthocyanin plays a major role in regulation of diet [7]; [8]. Total anthocyanin content (327.60 mg 100 g⁻¹) is highest in black rice among all of the studied colored grains [9].

TABLE 1 Nutritional composition of Black rice [10]

	Black rice	Brown rice	Red rice	White rice
Carbohydrate (g)	34 ± 0.05	24 ± 0.07	23 ± 0.04	28 ± 0.03
Protein (g)	8.5 ± 0.5	7.9 ± 0.07	7 ± 0.05	2.7 ± 0.04
Fat (g)	2 ± 0.06	0.8 ± 0.02	0.8 ± 0.01	0.3 ± 0.01
Fiber (g)	4.9 ± 0.3	1.8 ± 0.5	2 ± 0.6	0.6 ± 0.1
Zinc (mg)	3.16 ± 0.05	1.8 ± 0.05	1.91 ± 0.036	1.41 ± 0.039
Thiamine (mg)	0.46 ± 0.032	0.54 ± 0.07	0.33 ± 0.15	0.7 ± 0.06
Riboflavin(mg)	0.403 ± 0.04	0.1 ± 0.2	0.105 ± 0.03	0.03 ± 0.33
Tocopherol (mg)	12.54 ± 0.34	2.2 ± 0.76	10.77 ± 0.24	0.1 ± 0.14
Iron (mg)	3.5 ± 0.15	2.2 ± 0.07	5.5 ± 0.14	1.2 ± 0.19

III TYPES AND AROMATIC COMPONENTS

Types of black rice:

Black japonica rice: The commonly known variety of combined black short-grain rice and mahogany-grain rice like fresh earthy cultivated soil with clement, sweet spicy in taste.

Black glutinous rice: This variety is also known as black sticky rice characterized by short height with sweet flavor and sticky type texture with unevenly coloured grains generally used to make sweet dishes in tropical and sub-tropical countries.

Italian black rice: This variety is originated by combination of Chinese black rice with Italian rice characterized by long-grain rice riched in buttery flavor.

Thai black jasmine rice: This medium grain rice from Thailand has ultra-fine floral fragrance when cooked is combination of Chinese black rice with jasmine rice.

Aromatic component of black rice

The intense flavor of black rice makes it distinct from other types of aromatic rice. Flavor is always plays an important role as single most measurement of quality trait in rice largely affecting the inclinations of consumer. Black rice has a has luscious eccentric taste, soft textured, and deep purple colouring that makes it delicious appearance in any dish. There were 10 aromatic, 4 nitrogen-containing, 6 alcohol, 10 aldehyde, 3 ketones and 2 terpenoids identified by Gas chromatography-mass spectrometry [6].

IV PRODUCTION

All over the world there are more than 200 types of varieties of black rice present and only China is the country contributed 62% of global production. China has developed more than 54 modern black rice varieties with unique traits of high yield characteristics and multiple resistances and productivity of 148.87 mmT. India seeking 2nd position followed by China with productivity of 112.91 mmT cultivates most of the black rice. Thailand occupies the ninth position in black rice cultivation and contributed to productivity of 20.37mmT across world [11]; [12]; [6].

V HEALTH BENEFITS

Benefits from Antioxidant's Property

Antioxidants are compounds that prevents the regular oxidation process in body and reactive oxygen species. DPPH analysis generally can be used from black rice extract for determination of antioxidants. can be determined using in-vitro DPPH (•) and FRAP (ferric reducing antioxidant power assay). Antioxidants otherwise called scavengers of free radicals because it inhibits free radicals activity results in structural and functional damage of the cell [13].

Reactive oxygen species (ROS), that react with the building elements of cell like lipid, nucleic acid, protein, and enzymes may cause genetic modification as mutation and may responsible for cancer. Antioxidants generally diminish oxidative damage to nucleic acid and assist in the lowers the abnormal cell multiplication. Naturally occurring antioxidants are like butylated hydroxyl anisole (BHA), butylated hydroxyl toluene (BHT), and tocopherols, Tocotrienols, oryzanol, polyphenols, flavonoids, vitamin-C like bioactive compound[14] enzymes like super oxide dismutase, glutathione peroxidase, glutathione reductase neutralized free radicals by quenching reactions. Variety of metal binding proteins such as ferritin, albumin, leptoferrin have the capability to catalyse oxidative reactions in body [15]. Black rice bran oil are recently gaining attention due to presence of potential characteristics like abundance of anthocyanin, and less-sugar edible oil [16].

Anti-Inflammatory property

Inflammation refers to an attenuation process of the body when gets infected by bacteria or viral infection, physical injuries and produce toxins. ROS production in the body can reduce by anti-inflammation property of black rice and helps in prevention of joint pains, atherosclerosis, and early aging [17]. The principal constituents of black rice extract were purified anthocyanins and hydroxybenzoic acid of black rice helps in suppression of pro inflammatory molecule like nitric acid and cytokines and regulates the activity NO synthase and cyclooxygenase-2 like pro-inflammatory enzymes. But there is there is no significant change occur in the effect of cyanidin-3-glucoside- a type of cardinal anthocyanin of black rice. On cooking the anthocyanin percentage generally does not get changed when cooking but the phenolic content gets decreased slowly. Several researches has been done on the effect of black rice bran to reduce dermatitis like skin condition [18].

Role of black rice in weight loss

High fibre content of black rice promotes healthy gut, decreasing the pain during hunger, favours the easy peristaltic movement and helps in releasing toxins from intestine ultimately reduce weight [19].

Maintenance of healthy condition in heart

Intake of food riched in carbohydrates, salts, saturated and unsaturated fats including trans-fat generallu blocks the arteries by plaque formation that may leads to several cardiovascular diseases [20]. Consumption of black rice also helps to strengthening the good cholesterol such as high-density lipoprotein (HDL) cholesterol and reduces the chances of heart failure. The high fibre content of rice in diet also helps in maintaining good cholesterol [21]. A report was also given that illustrates the control of hypercholesterolemia in rats by consuming black rice [22].

Role of Black Rice in prevention of cancer

Frequently occurring diseases like cancer of colon, breast and prostate can prevented by inclusion of healthy diet in our daily life style. [23] studied that the assessor pigment carotenoids have the capacity to reduce cancer and other cardiovascular diseases. It is also found that the extraction of anthocyanin from black rice bran prevents the growth of cancerous cells of liver and also have

imp role in treating skin cancer. The purple pigment anthocyanin prevents from oxidative damage ultimately relieve from carcinogenic effect.

Maintenance of Liver and Kidney condition through Black Rice

Researches are available regarding potential effect of black rice in healing of hepatic and kidney injuries. The in vitro study has been reported by [24] that concluded phenolic compounds metabolism helps in systemic and local chronic diseases prevention.

Regulation of diabetes Mellitus (Type 2) by Black Rice

The most commonly consumed white rice has rich in sugar and carbohydrates that may be inappropriate for diabetic patients specially type 2 diabetes. Black rice has gained more attention due to its response to postprandial blood glucose. The important antioxidants of black rice contents phenolic that hinders the activity of pancreatic α -amylase and intestinal α -glucosidase [25]. Similarly, ferulic acid has also pharmacological activities that regulate blood glucose. Thus, the black rice can be act as a super food to improve healthiness of body. The black rice contains low sugar and high fiber content of black rice makes this crop highly valuable that regulates the blood glucose by increasing insulin sensitivity in blood and also controls blood pressure [26].

Improvement and maintenance and functioning of brain

The anthocyanin content of black rice in daily diet helps to reduce depression due to over work load and keeps the brain healthy and well functioned. Antioxidant properties of black rice has also enhance memory reduces premature cognitive aging, Alzheimer's disease and also prevents neurological disorder and anxiety due to alcohol consumption [27]; [28].

IV CULTIVATION OF BLACK RICE

Rice cultivation incorporate techniques involving from traditional methods to modern world mechanized methods. Black rice as highly nitrified crop needs good quality and quantity of productivity and field management to withstand against stress condition. For suitable field and cropping management favourable and sustainable techniques needs to know at farmer level. As rice crop needs more water than other crops, irrigation management is an important criteria for good yield. Herbicide treatment is also required to remove weeds when required. Fertilizers of proper dose should applied to enhance production. Presently, green manures like *Sesbania* spp., dhaincha, *croton* spp. and plants like *Azolla* and *Anabena* are also used to maintain soil fertility.

A. Broadcasting method

In this method seeds needs to sow in random scattering manner in field. This is the easiest method ever known because it requires less input and sowing can done by hand. But demerit is uneven planting depths responsible for poor contact of soil to seed contact and ultimately reduced yield. Depending upon the variety The seeds according varieties can take hours of time to break their dormant period and after suitable period seeds get germinated. Average of 100kg seeds required for cultivation at one hectare of land. Then the sprouted seeds are broadcasted uniformly in muddy and well aerated field by maintaining suitable distance.

B. Drilling method

This is the best method of cultivation and a seed driller should sows seeds in proper distance and depth. As seeds covered by soil, there is less chance of damage caused by birds or any other agents.

C. Japanese method

It is one of the highly adopted variety used in India for high yielding varieties raised in nursery beds. Then these seedlings are transplanted to puddled field in equal distance in rows and columns. Here wet cultivation methods used according to availability of rain. High dose of fertilizers used in this technique, thus yield is very high.

D. Transplantation methods:

This method is normally started with raising seedlings in nursery and then transfers those into well prepared field for further growth after 15 to 20 days. This method is highly economical but simultaneously labour intensive [6].

V ROLE OF BLACK RICE IN CROP IMPROVEMENT

Several researches has been done regarding the role of pigmented rice in crop improvement through mutagenesis specially application ionizing radiation. [29] characterized 146 accessions of upland rice (*Oryza sativa* L.), based on qualitative and quantitative agro-morphological descriptors. Polymorphism was observed among two of 14 qualitative characters evaluated, whereas significant differences ($p < 0.05$) were observed for 11 of the 14 analyzed quantitative traits. There is high variability among the rice accessions from the germplasm collection studied, which presents great importance for breeding programs or for genetic studies on this species. [30] characterized seventy-one aromatic rice germplasm from IGKV, Raipur. These germplasms were characterized and grouped on the basis of anthocyanin pigmentation, plant habit, and awning character. On the basis of pigment distribution, a total of twelve groups were formed with group one having no pigmentation and group twelve with

pigmentation in nine plant parts. On the basis of plant habit and awning character, three groups of each were formed. [31] studied 64 hill rice landraces were collected from the state of Arunachal Pradesh of NorthEastern region of India, and assessed by agromorphological variability and microsatellite markers polymorphism. According to farmer's classification, hill rices were categorized into two groups: umte (large-grained, late maturing) and tening (small-grained, early maturing). Qualitative and qualitative differences in polar metabolites of red, black and white rice have studied using Gas Chromatography Mass Spectrometry (GC-MS) and conclude that presence of vanillic acid, protocatechuic acid and glycerol-3 phosphate differentiate black rice from red and white rice. Bioactive compounds like erythritol and ribonic acid present only in red rice and radical scavenging capacity of pigmented rice are higher than normal white rice varieties due to presence of high phenolic content in grains [32] Thus, further studies in the way to molecular, biochemical, physiological and agronomic perspective will give better enlightens regarding discovery of qualitative and quantitative trait and their role in crop improvement.

VI CONCLUSION

Current review critically evaluated the literature on the functional role of black rice in maintaining health and to prevent diseases. Due to presence of high nutrient density, enriched in fiber antioxidants makes this paddy distinct from white and brown rice. Currently, black rice is regarded as a nutraceutical and functional food because beyond supply of nutrients it involves in the prevention and control of diseases. A new series of varieties of black rice shows the great results if going for mutagenesis and hope for better innovations in future. As Anthocyanin being originated as a new movement in the direction to increase the cultivation value in current decades that brings a new revolution in the cultivation of Rice in India and across the world.

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