

Review Article

Role of Black Rice in Health and Diseases

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ABSTRACT

Black rice is a type of rice species *Oryza sativa L.* and is consumed as functional food due to the usefulness to health. Black rice contains higher levels of proteins, vitamins and minerals than common white rice. Black rice contains essential amino acids like lysine, tryptophan; vitamins such as vitamin B₁, vitamin B₂, folic acid; and it is a good source of minerals including iron, zinc, calcium, phosphorus and selenium. It contains the highest amount of antioxidants, protein and dietary fiber of all rice varieties, besides it has phenolics, flavonoids, and anthocyanins. Antioxidants are first line of defense against free radical damage, and are critical for maintaining optimum health and well-being. These antioxidant compounds have tremendous health benefits and can reduce the risk of developing various chronic diseases. This rice enhances health and longevity, protects heart health, reduces atherosclerosis, controls hypertension, improves digestive system, has anti-inflammatory action, reduces allergy, detoxifies the body, improves lipid profile, reduces risk of diabetes, helps in weight management, reduces growth of cancer, boost cognitive function and increases quality of life. Hence Black rice is an excellent alternative to white and brown rice, due to its nutrient density, high fiber content, and rich antioxidant content.

Key words: Black rice, Dietary fiber, Phenolics, Flavonoids, Anthocyanins, Antioxidant content, Free radicals.

INTRODUCTION

Rice is the staple food for most of the people in different countries. Black rice is one kind of rice that is getting more popular recently and is consumed as functional food due to the usefulness to health. [1]

Black rice is also known as purple rice, forbidden rice, heaven rice, imperial rice, king's rice and prized rice. [2] Black rice contains higher levels of proteins, vitamins and minerals than common white rice. [3] Black rice contains essential amino acids like lysine, tryptophan; vitamins such as vitamin B₁, vitamin B₂, folic acid; and it is a good source of minerals including iron, zinc, calcium, phosphorus and selenium. [4] Black Rice is a good source of fiber and even a good source of plant-based protein.

It contains the highest amount of antioxidants, protein and dietary fiber of all rice varieties. [5] One serving of black rice (1/4 cup or 50g) contains approximately 160 calories. Each serving of this type of rice contains 5g of protein and 2g of fiber and 1g of iron. [6] Both brown rice and black rice contain vitamins, minerals, and dietary fiber. However, black rice is superior when compared with brown rice because it contains more protein and fiber than brown rice. And also black rice has an extremely high antioxidant content, which provides a number of additional health benefits. [7] Pigmented black rice contains about 6 times more antioxidants than brown rice. Rice (*Oryza sativa L.*) pigmented varieties, such as black rice, have a higher content of

phenolic compounds as compared to other rice varieties. [8]

Phytochemical content of the various rice types were divided into several groups such as carotenoids, phenolics, alkaloids, nitrogen and organosulfur containing compounds. Phenolic compounds were sub-grouped as phenolic acids, flavonoids, coumarins and tannins. Similarly, anthocyanins are one of such flavonoid compounds. [9,10] Black rice has the highest content of total anthocyanins (327.60 mg 100 g⁻¹) among all of the studied colored grains. [11] Anthocyanins as functional ingredient has role in preventing chronic and degenerative diseases due to their antioxidant, anti-inflammatory, anti-cancer, hypoglycemic activities. [12] Anthocyanins are also considered as powerful dietary antioxidants. [13]

Today black rice is becoming popular because of its health benefits. Black rice provides many health benefits including prevention and treatment of diseases and conditions such as heart disease, cancer, diabetes, high blood pressure, and extend the quality of life. [14] Several studies suggest that black rice components play a role in the maintenance of health and prevention of diseases. [15]

Role of Black Rice in Health and Diseases Black Rice and Antioxidants

Antioxidants are first line of defense against free radical damage, and are critical for maintaining optimum health and well – being. [16] Oxygen is a highly reactive atom that is capable of becoming part of potentially damaging molecules commonly called “free radicals.” Free radicals are capable of attacking the healthy cells of the body, causing them to lose their structure and function. [17]

Reactive oxygen species (ROS) is a term which encompasses all highly reactive, oxygen-containing molecules, including free radicals. Types of ROS include the hydroxyl radical, the superoxide anion radical, hydrogen peroxide, singlet oxygen, nitric oxide radical, hypochlorite radical, and various lipid peroxides. All are capable of

reacting with membrane lipids, nucleic acids, proteins and enzymes, and other small molecules, resulting in cellular damage. [18] Oxidants are capable of stimulating cell division, which is a critical factor in mutagenesis. Thus, a mutation can arise which in turn is an important factor in carcinogenesis. [19] Antioxidants are capable of stabilizing or deactivating free radicals before they attack cells. It is believed that antioxidants exert their protective effect by decreasing oxidative damage to DNA and by decreasing abnormal increases in cell division. [20]

To protect the cells and organ systems of the body against reactive oxygen species, both endogenous and exogenous components function interactively and synergistically to neutralize free radicals. These components include:

- Nutrient-derived antioxidants like ascorbic acid (vitamin C), tocopherols and tocotrienols (vitamin E), carotenoids.
- Antioxidant enzymes, e.g., superoxide dismutase, glutathione peroxidase, and glutathione reductase, which catalyze free radical quenching reactions.
- Metal binding proteins, such as ferritin, lactoferrin, albumin, and ceruloplasmin that are capable of catalyzing oxidative reactions.
- Numerous other antioxidant phytonutrients present in a wide variety of plant foods. [21]

Epidemiological evidence consistently relates low antioxidant intake or low blood levels of antioxidants with increased health risk. The day to day concern about the side effects of synthetic antioxidants like butylated hydroxyl anisole (BHA) and butylated hydroxyl toluene (BHT) have increased the interest among researchers and nutritionists in exploration of antioxidants from natural sources, which are both economically and physiologically justified. [22] It has been validated by researchers that changing the dieting habits from artificially processed to a naturally providing foods having high content of

bioactive components including antioxidants like tocopherols, tocotrienols, oryzenols, polyphenols, flavonoids, vitamin-C, play an important role in defending the body from attack of chronic diseases. [23] Pigmented rice having pleasant taste and odour are also associated with numerous health benefits. Pigmented rice possesses pigmented compounds such as Cyanidin-3-O- β -D-glucopyranoside in abundant content, which is associated with diverse functional properties such as, protection against cytotoxicity, anti neurodegenerative activity, inhibition of glycogen phosphorylase, and possessing antioxidant and scavenging activity higher than white rice varieties. [24]

Black rice bran has more anthocyanin antioxidants than blueberries. However, black rice bran has more health benefits. It contains more fiber and vitamin E (another essential antioxidant) and less sugar than blueberries. Antioxidants are able to neutralize free radicals, and can help to prevent oxidative damage. Studies show that antioxidant supplementation can exert a preventive effect against the development of serious conditions like cancer, and may improve overall health. [25]

Black Rice and Anti-Inflammation

Systemic inflammation is considered a key contributor to a number of diseases and illnesses prevalent in society today. This includes arthritis and other joint issues, asthma, Alzheimer's disease, heart disease, and even cancer. Black rice bran has the capacity to reduce inflammation at a cellular level. This results in a reduction in the amount of systemic inflammation within the body, improving cell health, and acting as a therapeutic agent for the treatment of inflammatory disease and illness. [26] Black rice contains anti-inflammation properties that decrease reactive oxygen species in the body. Black rice also increases anti-inflammatory mediators such as superoxide dismutase, leading to better prevention against allergies, joint pains, atherosclerosis, and other symptoms related to aging. The anti-inflammation compounds found in rice

could also help to prevent certain types of cancer. [27]

Another important health benefit of black rice is its ability to reduce inflammatory responses in the body. Inflammation is the body's natural response to protect us from bacterial and viral infections. Chronic inflammation seems to be at the root of many serious illnesses and diseases. Research carried out on the anti-inflammatory effects of pigmented rice proved that it helped to reduce inflammation. Other researchers found that a diet containing black rice bran helped to suppress inflammatory skin conditions like dermatitis. They concluded by saying that black rice bran is anti-inflammatory and anti-allergic and can be used to treat and prevent diseases associated with chronic inflammation. That study also showed that brown rice had no effect on reducing inflammation in the body. So, that is another reason why black rice is superior to brown rice. [28]

Black Rice and Weight Management

Black rice has an extremely high fiber content, which can promote gut health, and aid with digestive processes. Furthermore, as fiber is digested slowly (and subsequently stays in our stomach longer), it can reduce feeling of hunger, and results reduction in daily energy intake. This reduction in energy intake leads to weight loss. [29] Black rice contains twice the amount of fiber content of brown rice. Fiber bulks up the stool so it can be passed to the colon and out of the body effortlessly. Fiber also binds with toxic compounds in the colon so it is flushed out from the body as waste. [30]

Black Rice and Heart Health

Black rice has also been demonstrated to reduce plaque build-up within arteries. Plaque build-up within the arteries can cause the wall of those arteries to harden and become blocked. This negatively affects the function of those arteries, while also placing an increased demand on the heart, causing a significant rise in blood pressure. This is considered a

key risk factor to both heart attacks and strokes. By reducing plaque build-up in the arteries, black rice can directly reduce the likelihood of developing cardiovascular and heart disease, while also improving heart health and function. [31]

Adding black rice in the diet may also help to alter cardiovascular parameters, leading to lower triglycerides, it also improves HDL levels. Anthocyanins are capable of preventing the progression of atherosclerotic plaques, the main cause of most heart attacks. Anthocyanins play a key role in lowering triglycerides. Research published in The Journal of Nutrition found that black rice helps to increase high-density lipoprotein (HDL) cholesterol. This is the type of “good” cholesterol that a healthy cardiovascular system needs to function properly. The study showed that black rice also helps to prevent hardening of the arteries that can lead to heart failure. Black rice is a rich source of dietary fiber. However, dietary fiber has also been linked with preventing heart disease, high blood pressure, stroke, and elevated blood sugar levels. [32]

It was observed in the study “The role of black rice (*Oryza sativa L.*) in the control of hypercholesterolemia in rats” that diet containing black rice reduced the level of plasma cholesterol, triglycerides, and low-density lipoprotein and improved high-density lipoprotein values. The diet containing black rice was more effective in controlling the hyperlipidemia. [33]

Black Rice and Cancer Prevention

Cancer is characterized by the proliferation of abnormal cells that fail to respond correctly to normal regulatory mechanisms. Carcinogenesis, a term used to describe cancer development, is a multiple-step process consisting of initiation, promotion, and progression of uncontrolled cells. At the initiation step, damage to deoxyribonucleic acid (DNA) occurs. Cells begin to proliferate and expand into abnormal cells during the promotion step. Finally during the progression step, further

changes occur to these abnormal cells, leading to formation of malignant cells. [34]

Oxidative stress is the result of an imbalance between the production and the removal of reactive oxygen species (ROS) or reactive nitrogen species (RNS). ROS or RNS can be generated from exogenous and endogenous sources. [35] The body’s antioxidant defense mechanisms include glutathione, superoxide dismutase, and catalase, protect against oxidative stress. Excess production of ROS has been associated with carcinogenesis with damage to nucleic acids, proteins, or lipids. During carcinogenesis, breaks in DNA strands and formation of abnormal DNA linkages have been observed. Oxidative stress plays important role in the pathogenesis of many cancers. [36]

Cancer is caused by the interaction of dietary, genetic, and environmental risk factors. Dietary factors are considered to play a major role in cancer etiology. [37] Healthy diet and lifestyle are excellent potential for cancer prevention and might reduce the burden of frequently occurring cancers of the breast, prostate and colon. Several epidemiological and laboratory studies suggest a strong relationship between colon cancer risk and dietary factors. There is increasing evidence that risk is increased by high intakes of red meat and saturated fat, and that risk is decreased by high intakes of fruits, vegetables, and whole cereals. [38]

Natural dietary agents have drawn a great deal of attention because of their potential to suppress cancers and to reduce risk of cancer development by decreasing oxidative stress. [39] Although a chemoprevention approach, which is a relatively new and promising strategy to prevent cancer using natural dietary compounds and synthetic substances, showed promising results in in vitro and animal studies. Natural dietary agents have drawn a great deal of attention because of their potential to suppress cancers and to reduce risk of cancer development by decreasing oxidative stress. [40]

Antioxidant phytochemicals may modulate the initiation of carcinogenesis process by protecting against DNA damage. Antioxidant phytochemicals could inhibit cell proliferation and induce cancer cell death. [41] Antioxidants stop the formation of free radicals, which in turn, protects the body from the onset and development of cancer.

Furthermore, black rice consumption has demonstrated in lowering tumor metastasis (referring to the spread of cancer around the body). The antioxidant anthocyanins in black rice helps to protect from cell damage in the body that can cause cancer. In fact, extracts from black rice have been shown to have an anti-cancer effect and prevent the growth and spread of tumors. [42]

One explanation for this relationship is that vegetables, fruits and whole grains contain a wide variety of phytochemicals (like terpenes, isothiocyanates, carotenoids, and flavonoids), which have potential to modulate cancer development. Flavonoids are plant secondary metabolites, with a wide variety of beneficial biological properties such as anticarcinogenic and antioxidative modes of action. Many researches proved anti carcinogenic effect of one class of flavonoids, anthocyanins. The prevention of cancer-cell invasion property of peonidin, peonidin 3-glucoside, cyanidin 3-glucoside, and other major anthocyanins of black rice has been reported. [43] In recent years, considerable studies have exhibited the ability of anthocyanins to inhibit oxidative stress and to induce apoptosis in malignant cells which suggest that anthocyanins may prevent carcinogenesis. Anthocyanins extracted from black rice, especially cyanidin and peonidin-3-glucoside, showed an in vitro inhibitory effect on cancer cell proliferation a high protection of endothelial cells from oxidative stress events. [44,45]

Black Rice and Liver Health

Based on in vitro and in vivo studies, natural bioactive food components derived from plants and animals such as phytosterols, carotenoids, polyphenols and

fatty acids, have been proposed as valuable substitutions for anticipation and management of hepatotoxic effects and its chronic complications. [46]

Remarkable studies demonstrated that the health promoting effects of bioactive components of black rice have been frequently attributed to their antioxidant properties and facilitate to increase cellular antioxidant defense system and thereby scavenge free radicals, inhibit lipid peroxidation, augment anti-inflammatory potential, and further protect the liver from damage. [47] The inclusion of black rice into the diet has shown to reduce risk factors that lead to fatty liver disease, suggesting its direct influence on liver health. By supporting liver health and function, black rice can further protect us from a number of negative health issues. The antioxidant properties of black rice can also help to detoxify liver and improve liver function. Black rice increased fatty acid metabolism and helped to reduce the risk of elevated blood sugar levels and high cholesterol. There was also a lower risk of developing liver disease. [48]

Black Rice and Management of Type 2 Diabetes Mellitus

The number of cases of type 2 diabetes is increasing worldwide. This disease can be characterized by insulin resistance and pancreatic β cell dysfunction, which lead to macro- and micro vascular complications. [49] Anthocyanins are flavonoids that occur naturally in plants and are responsible for their color. Studies with cell lines and animal models and clinical trials in humans suggest that anthocyanins in black rice exhibit antidiabetic properties. Published data suggest that anthocyanins may lower blood glucose by improving insulin resistance, protecting β cells, increasing secretion of insulin and reducing digestion of sugars in the small intestine. The mechanisms of action are primarily related to their antioxidant properties, but enzymatic inhibition and other pathways may also be relevant. [50]

Black Rice and Brain Function

The antioxidant effect of anthocyanins also has a beneficial effect on improving brain function. This means that black rice can help to improve memory impairment and prevent or reduce the risk of diseases like Alzheimer's disease, dementia, and depression. Clinical studies also showed that anthocyanins helped to improve learning capacity and reduce symptoms of depression. By adding black rice in the diet, help to boost memory and prevent premature cognitive aging. ^[51]

SUMMARY AND CONCLUSION

This review evaluated the literature on the role of black rice in health and diseases. Black rice is an excellent alternative to white and brown rice, due to its nutrient density, high fiber content, and rich antioxidant content. 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. Several researches suggested that black rice may have the capacity to reduce the likelihood of developing a number of diseases and illnesses, suggesting that black rice consumption may promote heart and liver health, weight loss, control on blood glucose level and lipid profile, prevention and control of inflammation and cancer.

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