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Nutrition profiles of different colored rice: A review

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Abstract

Rice is the most important cereal crops and staple food of over half of the world's population. As the primary dietary source of carbohydrate in these populations, rice plays an important role in meeting energy requirements and nutrient intake. In human nutrition, starch plays an important role in supplying metabolic energy which enables the body to perform multitude of functions. Recent studies suggest that high consumption of rice accelerates the development of diabetes. With sharp increase in life-style related health problems, scientists are looking at quality traits other than carbohydrates, proteins and fat in food stuffs (primary metabolites). As the consumers become more health conscious and more aware of the benefits of functional foods, diets containing bio-active compounds (secondary metabolites) such as antioxidants have received greater attention.

Keywords: Nutrition profiles, colored rice, carbohydrate, consumption

Introduction

Rice exists in different colors such as white, purple, black, red and brown. The most common rice consumed by human being is white rice followed by brown rice. However, rice genotypes with red, purple, or black bran layer have been cultivated for a long time in Asia (Ahuja *et al.*, 2007) ^[1] and pigmented rice has a long history for human consumptions especially in Southeast Asia (Hu *et al.*, 2003) ^[8]. Although, white rice is the most widely consumed rice, pigmented rice is considered as enriched rice for taste and health benefits due to the presence of anthocyanin (Ryu *et al.*, 1998) ^[15]. Colored rice possess unique color, flavor therefore they are used as an Ingredient in many dishes and pigmented rice is becoming popular among health-conscious food consumers for its antioxidants mainly because it is a good source of bioactive compounds. Colors in the rice are due to the deposition of large amounts of anthocyanin or Proanthocyanidines pigment in the rice coat (Chaudhary, 2003) ^[3]. In red rice varieties, the major phenolic acids in the free form are ferulic, protocatechuic and vanillic acid where as in black rice, protocatechuic acids are dominant followed by vanillic and ferulic acids. Colored rice varieties are rich sources of fat-soluble bioactive compounds, in particular γ -oryzanol, vitamin E isomers and carotenoids.

Brown rice is a nutrition power house compared to white rice. Most consumers are already aware that conventional brown rice is nutritionally superior to white rice in the way of fiber and beneficial vitamins because it's outer layer (also known as husk or chaff) and bran layers remain intact during processing. Both brown and black rice are low in fat and are good source of healthy carbohydrates. The range of iron and zinc concentration in brown rice were 6.3-24.4 ppm and 13.5-28.4 ppm respectively. After polishing, about 90% of iron and 40% of zinc is lost because iron is located in outer aleurone layer whereas zinc is distributed in the endosperm (Ravindra Babu *et al.*, 2014) ^[14]. The rice bran oil is a good source of essential fatty acids and antioxidants like tocopherols (Vitamin E), tocotrienols and γ -oryzanol which have anti-tumor/cancer and blood cholesterol reducing properties and thus help prevent heart problems. Consumption of brown rice would also help prevent iron deficiency anaemia, zinc deficiency related disorders including problems of vision and scores of other vitamin deficiency diseases. Any whole grain rice including black, brown, purple, red, wild and half milled contains more fiber, iron, vitamins than white rice. White rice loses much of its nutritional value in the refining processes that strips it of its germ and outer bran layer. The brown rice bran contain higher concentration of γ -oryzanol antioxidants that lower LDL bad cholesterol and help prevent heart disease. While brown rice is not a good source of anthocyanin, it is a source of vitamin E which is also an important antioxidant that might offer protection against chronic illness. The mineral content between both black and brown rice is very similar. A serving of either rice meets 8% of the daily value for zinc and 20% of the daily value for phosphorus. But the black rice is a slightly better source of iron meeting 6% of the daily value compared to 5% of the daily value in a serving of brown rice. Researchers discovered that white rice was more prone to contribute to insulin resistance as well as diabetes risk.

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Table 1: Approximate composition of rough rice and its milling fractions at 14% moisture (Juliano & Bechtel, 1985)

Rice fraction	Crude protein (g N x 5.95)	Crude fat (g)	Crude ash (g)	Available carbohydrates (g)	Crude Fiber (g)
Rough rice	5.8-7.7	1.5-2.3	2.9-5.2	64-73	7.2-10.4
Brown rice	7.1-8.3	1.6-2.8	1.0-1.5	73-87	0.6-1.0
Milled rice	6.3-7.1	0.3-0.5	0.3-0.8	77-89	0.2-0.5
Rice bran	11.3-14.9	15.0-19.7	6.6-9.9	34-62	7.0-11.4
Rice hull	2.0-2.8	0.3-0.8	13.2-21.0	22-34	34.5-45.9

The colored varieties have better antioxidant properties than non colored varieties. Recent studies have demonstrated that pigmented rice has a wide range of biological activities including amelioration of iron deficiency anaemia of the body, antioxidant, anti-carcinogenic and anti-allergic activities. Antioxidants in pigmented rice are able to reduce atherosclerotic plaque formation and some metabolic abnormalities associated with high fructose (Tananuwong and Tewaruth, 2010)^[17]. Red rice is known to be rich in iron and zinc while black and purple rices are especially high in protein and crude fiber. Because of dark colour black rice bran contains the same anthocyanin antioxidants found in blueberries or blackberries. Many research reports suggest that black rice has a scavenging activity higher than red rice variety while non colored rice has phenolic content and antioxidant activities which are lower than the colored rice varieties. Despite its less anthocyanin content, red rice contains higher antioxidant activity compared to black rice due to its proanthocyanidin content (Finocchiaro *et al.*, 2007)^[6]. Anthocyanins are water soluble which has antioxidants that can reach many different parts of our body. Black rice bran has an advantage over blueberries, because blueberries still contain a high level of sugar. Black rice is lower in carbohydrates but higher in fiber and a better source of protein than brown rice. A 1/3 cup serving of dry black rice contains 43g of carbohydrates, 3 g of protein and 2 g of fat while the same serving of brown rice contains 47 g of carbohydrates, 2 g of fiber, 5 g of protein and 2 g of fat. Ten spoonfulls of cooked black rice is the equivalent of one spoonful of black rice bran, the exterior of the rice has as much anthocyanin as a spoonful of blueberries. Black rice bran possess strong scavenging activities for reactive oxygen species (ROS). These anthocyanin compounds are found to possess both strong ROS scavenging activities and to suppress cell damaging effects of UVB indicating that both cyanidin-3-glucoside and cyanidin are the active components involved in the antioxidative activity of black rice bran extracts. A team of researchers at Cornell University found antioxidants are about six times higher in black rice than in common brown and white rice.

Table 2: Chemical composition of phenolic compounds in whole rice of different colored rice

Analysis	Black rice	Whole brown rice	Red Rice
Lipids (%)	3.87	0.9	-
Ash (%)	1.98	0.46	1.53
Protein (%)	11.9	2.58	10.5
Dietary Fiber (%)	5.67	1.8	2.71
Carbohydrates (%)	63.45	72.96	70.19
Phenolic compounds (mg= g)	23.78	2.45	20.79
Energy (kcal)	362	349	341

Out of all the available rice types, black rice is the one that contains the highest amount of nutrition. A comparison of different types of rice that differ in terms of nutrition when

compared with 100 g serving of each kind is given below.

Polished white rice	6.8 proteins, 1.2 iron, 0.5 zinc and 0.6 fiber
Brown rice	7.9 proteins, 2.2 iron, 0.5 zinc and 2.8 fiber
Purple rice	8.3 proteins, 3.9 iron, 2.2 zinc and 1.4 fiber
Red rice	7.0 proteins, 5.5 iron, 3.3 zinc and 2.0 fiber
Black rice	8.5 proteins, 3.5 iron, 5.0 zinc and 4.9 fiber

Health benefits of Black rice

Free radicals, reactive oxygen species and reactive nitrogen species are generated by our body by various endogenous systems, exposure to different physiochemical conditions or pathological states. A balance between free radicals and antioxidants is necessary for proper physiological function. If free radicals overwhelm the body's ability to regulate them, a condition known as oxidative stress ensues. Free radicals thus adversely alter lipids, proteins, and DNA and trigger a number of human diseases. Hence application of external source of antioxidants can assist in coping this oxidative stress. Antioxidants are able to neutralize these free radicals and help to prevent oxidative damage. These antioxidants delay or inhibit cellular damage mainly through their free radical scavenging property (Shi *et al.*, 1999)^[16]. Feeding black rice to rodents in place of white rice has resulted in increased high density lipoprotein concentration in hypercholesterolemic rabbits which corresponded to a reduction in the size of atherosclerotic lesions in the same animals (Ling *et al.*, 2001)^[13]. A recent report showed that the supplementation of atherogenic diets with black rice pigment markedly reduced oxidative stress and inflammation in addition to modulating atherosclerotic lesions in the apolipoprotein E deficient mice (Xia *et al.*, 2003)^[19]. Anthocyanins present in the aleurone layer of black rice, in particular cyanidin-3-glucoside contributed to marked antioxidant activities in preventing DNA damage and LDL deterioration *in vitro* (Hu *et al.*, 2001)^[7]. Black rice is rich in both anthocyanin and tocopherols which are also known as vitamin E. Black rice is a great source of iron, potassium, vitamin B and it is relatively high in protein. Aside from being an extremely rich source of nutrients, black rice is cheaper and lower in sugar than other super foods like berries. Black rice has a super-satiation effect that can greatly assist all those whom weight management is a concern

Continuous ROS exposure can stimulate skin aging through antioxidant system destruction, wrinkle formation and melanogenesis (Kim *et al.*, 2011)^[10]. Several studies showed that phenol and flavonoid content of *O. sativa* possess anti-elastase activity (Karim *et al.*, 2014)^[11]. However, vanillin has the highest elastase inhibitory activity. Antioxidant nature of colored rice is effective in safeguarding skin. Black rice also helps to prevent skin from damage by pollutants or sun. It helps to prevent aging of skin as well as decreases signs of aging such as wrinkles, dark spots and fine lines. Black rice provides antioxidants and other proteins to skin which help in restoring skin elasticity and maintain firmness. Research demonstrated that black rice consumption can help to detoxify

the body and cleanse the liver of harmful toxic build up. Chiang *et al.* (2006)^[5] reported that anthocyanin from black rice attenuated oxidative stress by reducing ROS and increasing antioxidant enzyme activities both *in vitro* and *in vivo*. In addition, anthocyanin is associated with the reduction of cardiovascular diseases, cancer and liver damage (Chen *et al.*, 2006)^[4].

Black rice applications

Black rice powder extracted from the rice bran could be used as a healthful food coloring dye in sodas, functional foods, cosmetics, nutraceutical and other health products. Black and red rice bran can be an excellent ingredient to increase the nutritional value and antioxidant properties of noodles (Kong *et al.*, 2012)^[12]. Black sticky rice is also used primarily in sweet snacks and desserts in Asia. Black rice extracts is an excellent natural food coloring dye. The pigments in black rice extracts can produce a variety of colors from black to pink which make the black rice bran powder a good source for natural and healthier alternative to artificial food colorants. Chinese black rice is used to make black vinegars and different kinds of wine. The antioxidative activity of alcoholic beverages made from the cooked black rice was higher than that of beverages made from cooked black rice (Teramoto *et al.*, 2011)^[18]. Thus, now black rice and its products are becoming increasingly popular and they are widely consumed in China, Japan, Korea and other East Asian countries such as Thailand (Caro *et al.*, 2013)^[2].

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