Chapter 5
Black, Brown, and Red Rices

5.1 Major Differences Among Different Rice

Rice (*Oryza sativa* L.) 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). 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 anthocyanins (Ryu et al. 1998). Colored rice possess unique color and flavor, therefore they are used as an ingredient in many dishes (Rhee et al. 2000). However, due to the limitation in term of hard texture of cooked colored rice, they are not popular for consumption even though it has been long known about the beneficial effects of pigment in these groups of rice. There are naturally occurring color substances in pigmented rice that belong to the flavonoid group called anthocyanins. Positive health effects of the pigments present in the bran layer of rice have been reported by many scientists. A commonly found anthocyanin in colored rice is acetylated procyanidins which is reported to possess a free radical scavenging activity (Oki et al. 2002). Pigmented rice has become increasingly interested for its antioxidants, mainly due to that it is a good source of bioactive compounds such as γ-oryzanol, α-tocopherols, and phenolic compounds. The phenolic compounds in pigmented rice have been reported to contain anthocyanins cyanidin-3-glucoside as a major in black rice (Osawa 1999); proanthocyanidins is a major in red rice (Nawa and Ohtani 1992) and other phenolics (Yawadio et al. 2007). Antioxidant activities of the color pigment in aleurone layer of rice have been already demonstrated by Hu et al. (2003); Ichikawa et al. (2001) and Oki et al. (2002). Colored rice varieties are rich sources of fat-soluble bioactive components, in particular, c-oryzanols, vitamin E isomers, and carotenoids. In addition, it provides a structural basis for studying the biological functions of these bioactive components at molecular levels. Most consumers are already aware that conventional brown rice is nutritionally superior to white rice in

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the way of fiber and beneficial vitamins because its outer layer (also known as a husk or chaff) and bran layers remain intact during processing. Abundant saturated fatty acid in these colored rice varieties are palmitic acid (c16:0) followed by stearic acid (c18:0) (Minatel et al. 2014). The colored varieties have better antioxidant properties than noncolored varieties. Thus it can be concluded that colored varieties could be used as a natural antioxidant source (Moko et al. 2014). Recent studies have demonstrated that pigmented rice has a wide range of biological activities, including amelioration of iron deficiency anemia of the body, antioxidant, anti-carcinogenic, antiatherosclerosis, and antiallergic activities (Deng et al. 2013). Rice genotypes with pigmented caryopses have now received increased attention because of their antioxidant properties. Previous works evidenced that the kernel of red rice is characterized by the presence of proanthocyanidins, whereas black rice is characterized by the presence of anthocyanins. Surprisingly, the rice grain has no vitamin A, vitamin D, or vitamin C (FAO 1954) (Table 5.1).

5.1.1 White, Long-Grain Rice

Raw, long-grain white rice is a relatively good source of energy, carbohydrates, calcium, iron, thiamin, pantothenic acid, folate and vitamin E, compared to maize, wheat and potatoes. It contains no vitamin C, vitamin A, beta-carotene, or lutein +zeaxanthin, and is notably low in fiber (Ricepedia[1]) (Fig. 5.1).

5.1.2 Colored Rice

Brown rice retains the bran layer (containing many vitamins and minerals as well as fiber), as this has not been polished off to produce white rice. Red rice is known to be rich in iron and zinc, while black and purple rices are especially high in protein, fat, and crude fiber. Red, black, and purple rices get their color from anthocyanin pigments, which are known to have free radical scavenging and antioxidant capacities, as well as other health benefits (Ricepedia) (Table 5.2).

Pigmented rice has a long history for human consumptions, especially in Southeast Asia (Hu et al. 2003). Antioxidant activities of paddy varieties containing color pigments such as red Thai, black rice, red brown, and dark purple had been intensively studied by Muntana and Prasong (2010) and Yodmanee et al. (2011), and they reported that rice with noncolor pigments contain lower phenolic content and antioxidant activities. Many studies have reported that black rice contains anthocyanin and other polyphenolic compounds more abundantly than white rice (Ryu et al. 1998; Zhang et al. 2006). Previous research about antioxidant properties

[1]Ricepedia www.ricepedia.org Retrived 5 July 2015.

Table 5.1 Approximate composition of rough rice and its milling fractions at 14 % moisture (Juliano 1985; Pedersen and Eggum 1983)

Rice fraction	Crude protein (g N × 5.95)	Crude fat (g)	Crude fiber (g)	Crude ash (g)	Available carbohydrates (g)	Neutral detergent fiber (g)	Energy content (kJ)	(hcal)	Density (g/ml)	Bulk density (g/ml)
Rough rice	5.8–7.7	1.5–2.3	7.2–10.4	2.9–5.2	64–73	16.4–19.2	1580	378	1.17–1.23	0.56–0.64
Brown rice	7.1–8.3	1.6–2.8	0.6–1.0	1.0–1.5	73–87	2.9–3.9	1520–1610	363–385	1.31	0.68
Milled rice	6.3–7.1	0.3–0.5	0.2–0.5	0.3–0.8	77–89	0.7–2.3	1460–1560	349–373	1.44–1.46	0.78–0.85
Rice bran	11.3–14.9	15.0–19.7	7.0–11.4	6.6–9.9	34–62	24–29	670–1990	399–476	1.16–1.29	0.20–0.40
Rice hull	2.0–2.8	0.3–0.8	34.5–45.9	13.2–21.0	22–34	66–74	1110–1390	265–332	0.67–0.74	0.10–0.16

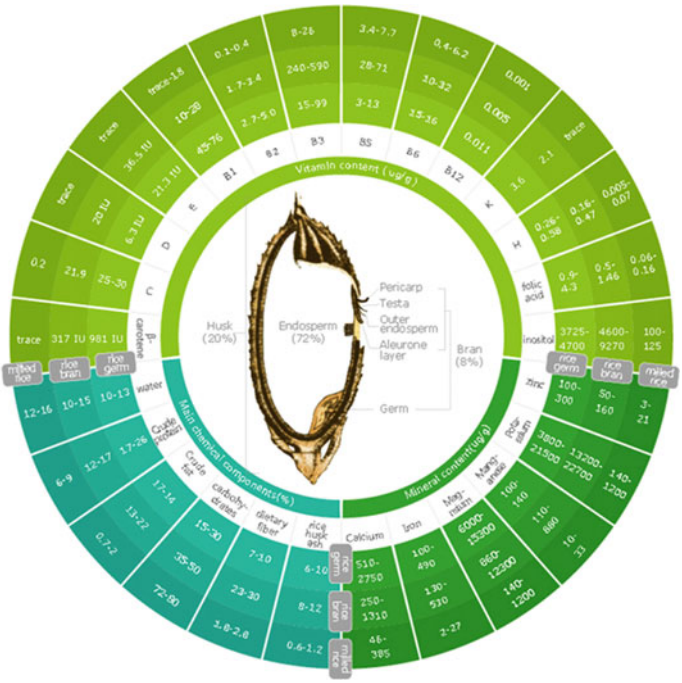

Fig. 5.1 Basic structure of a grain of rice, form the inside out, can be divided into five layers sequences. www.worldgranary.com Retrived 23 October 2015

of colored rice bran indicates that rice bran with certain color contains anthocyanin that has a reductase enzyme inhibitory and antidiabetic activity (Yawadio et al. 2007; Kim et al. 2008). Moreover, antioxidants in pigmented rice are able to reduce atherosclerotic plague formation, and some metabolic abnormalities associated with high fructose (Tananuwong and Tewaruth 2010) (Table 5.3).

The distribution of phenolic acids and anthocyanins in endosperm, embryo, and bran of white, red, and black rice grains was studied. It is found that the total phenolic content (TPC) was highest in the bran averaging 7.35 mg GAE/g and contributing 60, 86, and 84 % of phenolics in white, red, and black rices. The average TPC of the embryo and endosperm were 2.79 and 0.11 mg GAE/g accounting for 17 and 23 %, 4 and 10 %, and 7 and 9 % in white, red, and black rices, respectively. *Cis-p*-coumaric was detected in bound form in bran while *cis*-sinapic acid was detected in the free/conjugated form in embryo and bran. Cyanidin-3-O-glucoside and peonidin-3-O-glucoside were identified mainly in black rice bran as the total anthocyanins. Cyanidin-3-O-rutinoside was also detected in black rice bran (Shao et al. 2014a, b). Black rice bran has higher content of phenolics, flavonoids, and anthocyanins and has higher antioxidant activity compared to white rice bran (Table 5.4).

Table 5.2 Vitamin and mineral content of rough rice and its milling fractions at 14 % moisture (Juliano 1985; Pedersen and Eggum 1983)

Rice fraction	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	a - Tocopherol (mg)	Calcium (mg)	Phosphorus (g)	Phytin P (g)	Iron (mg)	Zinc (mg)
Rough rice	0.26–0.33	0.06–0.11	2.9–5.6	0.90–2.00	Oct-80	0.17–0.39	0.18–0.21	1.4–6.0	1.7–3.1
Brown rice	0.29–0.61	0.04–0.14	3.5–5.3	0.90–2.50	Oct-50	0.17–0.43	0.13–0.27	0.2–5.2	0.6–2.8
Milled rice	0.02–0.11	0.02–0.06	1.3–2.4	75–0.30	30-Oct	0.08–0.15	0.02–0.07	0.2–2.8	0.6–2.3
Rice bran	1.20–2.40	0.18–0.43	26.7–49.9	2.60–13.3	30–120	1.1–2.5	0.9–2.2	8.6–43.0	4.3–25.8
Rice hull	0.09–0.21	0.05–0.07	1.6–4.2	0	60–130	0.03–0.07	0	3.9–9.5	0.9–4.0

Table 5.3 Amino acid content of rough rice and its milling fractions at 14 % moisture (Juliano 1985; Pedersen and Eggum 1983)

Rice fraction	Histidine	Isoleucine	Leucine	Lysine + cysteine	Methionine + tyrosine	Phenylalanine	Threonine	Tryptophan	Valine	Amino acid score[a]
Rough rice	1.5–2.8	3.0–4.8	6.9–8.8	3.2–4.7	4.5–6.2	9.3–10.8	3.0–4.5	1.2–2.0	4.6–7.0	55–81
Brown rice	2.3–2.5	3.4–4.4	7.9–8.5	3.7–4.1	4.4–4.6	8.6–9.3	3.7–3.8	1.2–1.4	4.8–6.3	64–71
Milled rice	2.2–2.6	3.5–4.6	8.0–8.2	3.2–4.0	4.3–5.0	9.3–10.4	3.5–3.7	1.2–1.7	4.7–6.5	55–69
Rice bran	2.7–3.3	2.7–4.1	6.9–7.6	4.8–5.4	4.2–4.8	7.7–8.0	3.8–4.2	0.6–1.2	4.9–6.0	83–93
Rice hull	1.6–2.0	3.2–4.0	8.0–8.2	3.8–5.4	3.5–3.7	6.6–7.3	4.2–5.0	0.6	5.5–7.5	66–93

[a]Based on 5.8 g lysine per 16 g N as 100 % (V/HO, 1985)

Table 5.4 Bioactive compounds present in rice bran (Friedman 2013)

Phenolic and Cinnamic acids	Anthocyanis, flavonoids	Steroial compounds	Polymeric carbohydrates
Caffeic acids	Anthocyanin monomers, dimers, and polymers		Arabinoxylan
Coumaric acid	Apigenin	Acetylated steryl glucosides	Glucans
Cathecins	Cyanidin glucoside	Cycloartenol ferulate	Hemicellulose
Ferulic acid	Cyanidinrutinoside	Campesterol ferulate	
Gallic acid	Eriodtyol	24-methylenecycloartenol ferulate	
Hydroxybenzoic acid	Hermnetins	r-oryzanol	
Methoxycinnamic acid	Hesperetin	b-sitosterol ferulate	
Sinopic acid	Isorhamnetins	Tocopherols	
Syringic acid	Luteolin	Tocotrienol	
Vanillic acid	Peanidin		
	Glucoside		
	Tricin		

5.2 Brown Rice

Brown rice is the most widely produced rice variety worldwide. The bran of brown rice contains a higher level of gamma-tocotrienol (vitamin E compounds) and gamma-oryzanol (an antioxidant) which are lipid-soluble antioxidants. Numerous studies showed that these antioxidants can reduce blood levels of low density lipoprotein (LDL) cholesterol so-called "bad" cholesterol and may help fight heart disease. Temple University scientists have found a specific natural compound in brown rice that can reduce high blood pressure and protect blood vessels. Similarly, Harvard University research suggests consuming brown rice may prevent type-2 diabetes. The overall amylolytic activity of germinated black rice is observed to be higher than that of brown rice (Lee et al. 2013). A higher priority may be given to the development of rice varieties that contain high amounts of various bioactive compounds without altering their agronomic performance as well as preserving the cultural and socially acceptable organoleptic qualities. Brown rice seeds are rich in more nutritional components, such as dietary fibers, vitamins B and E, gamma-oryzanol, and amino butyric acid (GABA) than the ordinary milled rice grains. GABA or 4-aminobutyrate is a well-known non-protein-based amino acid is one of the major inhibitory neurotransmitters in the sympathetic nervous system. The changes of blood cholesterol can be modulated by using brown rice varieties instead of polished rice in human diet. Brown rice varieties are capable to show the hypercholesterolemic effect (Roohinezad et al. 2009). Rice millers remove only the outer husks, or chaff, from each rice grain to produce brown rice. If they process

Table 5.5 Nutrient content of long-grain white raw rice. Nutritional value per 100 g (3.5 oz) (USDA Nutrient Database)

Energy	1,527 kJ (365 kcal)
Carbohydrates	80 g
Sugars	0.12 g
Dietary fiber	1.3 g
Fat	0.66 g
Protein	7.13 g
Vitamins	
Thiamine (B1)	0.0701 mg (6 %)
Riboflavin (B2)	0.0149 mg (1 %)
Niacin (B3)	1.62 mg (11 %)
Pantothenic acid (B5)	0.164 mg (20 %)
Vitamin B6	0.164 mg (13 %)
Minerals	
Calcium	28 mg (3 %)
Iron	0.80 mg (6 %)
Magnesium	25 mg (7 %)
Manganese	1.088 mg (52 %)
Phosphorus	115 mg (16 %)
Potassium	115 mg (2 %)
Zinc	1.09 mg (11 %)
Other constituents	
water	11.61 g

Percentages are roughly approximated using US recommendations for adults. µg = micrograms; mg = milligrams; IU = International units

the rice further, removing the underlying nutrient rich "bran" it becomes white rice. Consumers must have heard that brown rice is more nutritious than white rice. The reason is that the bran of brown rice contains higher level of gamma-tocotrienol (vitamin E compounds), and gamma-oryzanol antioxidants which are lipid-soluble antioxidants (Table 5.5).

Brown rice is a nutrition power house compared to white rice. Brown rice is rich in fiber, vitamin E, and cholesterol. Both brown and black rice are low in fat and are good source of healthy carbohydrates. Laboratory research conducted jointly at Temple University School of Medicine in Philadelphia and the Nagaoka National College of Technology in Japan attributes the cardio-protective effects of brown rice to a thin layer of tissue known as the sub aleurone layer that is rich in oligosaccharides and dietary fibers that is stripped away when brown rice is polished to make white rice. The researchers believe that missing layer may work against angiotensin II, an endocrine protein which contributes to the development of high blood pressure and atherosclerosis. According to these scientists, this could help to explain why fewer people die of cardiovascular disease in Japan compared to the US. In Japan most people eat at least one rice-based dish per day but in the US rice is not a mainstay of the daily diet. Brown rice is produced by removing

Table 5.6 Chemical analysis and phenolic compounds of Black rice (IAC 600) and whole rice in dry matter (Salgado et al. 2008)

Analysis	Black rice	Whole rice
Humidity (%)	87.95	73.09
Lipids (%)	3.87	0.9
Ash (%)	1.98	0.46
Protein (%)	11.9	2.58
Dietetic fiber (%)	5.67	1.8
Carbohydrates (%)	63.45	22.96
Phenolic compounds (mg = g)	23.78	2.45

only the outermost layer, the hull of the rice kernel keeping most of its nutritional value intact. But when the rice kernel is milled and polished to make it white, it gets destroyed. Along with it, all of the dietary fiber, vitamin B3, vitamin B1, vitamin B6, manganese, phosphorus, irons and all of the essential fatty acids get destroyed. Black rice offers the same health benefits of brown rice but it is also packed with some serious antioxidants. Because of its dark color, black rice bran contains the same anthocyanin antioxidants found in blueberries or blackberries. 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 (Table 5.6).

5.3 Red Rice

In red rice varieties, the major phenolic acids in the free form are ferulic, protocatechuic and vanillic acid, whereas in black varieties protocatechuic acids are dominant followed by vanillic and ferulic acid. Antioxidant capacity of rice varieties range within 0.9–8.1 mmol Fe(II)/100. g DM for FRAP (Sompong et al. 2011). It is found that the total phenolic content of white, red, and black rice bran extract are in the range of 0.8931–0.9884, 1.0103–1.0494, and 1.0810–1.2239 mg gallic acid equivalent (GAE mg (−1)), respectively. However, the antioxidant activity of all rice bran extracts shows high antioxidant efficiency in the following order: red > black > white color rice brans (Muntana and Prasong 2010). Angrraini et al. (2015) reported that the non polished colored rice have higher antioxidant activity than white rice. The total phenolic content (TPC) and antioxidant capacity are highest at maturity stage in black rice (56.5–82.0) whereas in white (14.6–33.4) and red rice (66.8–422.2) highest accumulation is found 1 week after flowering. The total anthocyanin, cyanidin-3-glucoside, and peonidin-3-glucoside contents of black rice at second and third weeks of development after flowering are significantly higher than at other stages. While several phenolic acids are detected in the bound fraction, with ferulic as the dominant acid, red and black rice show high levels at first week development and at maturity (Shao et al. 2014a, b). It has also been reported that black rice has a scavenging activities higher than red rice variety, while noncolored rice has phenolic content and antioxidant activities which are

lower than the colored rice variety (Muntana and Prasong 2010; Yodmanee et al. 2011). Despite its less anthocyanin content, red rice contains higher antioxidant activity compared to black rice (Muntana and Prasong 2010) due to its proanthocyanidin content (Finocchiaro et al. 2007). In a study, purple bran exhibited a minor effect on leukemia and cervical cancer cells, and the red bran exhibited strong inhibitory effects on leukemia, cervical and stomach cancer cells. Chemical analyses suggested that proanthocyanidins might be the major compounds in red bran extract attributed to the anti cancer bioactivity. Red bran has the potential to serve as a functional food supplement for human consumption (Chen et al. 2012).

Red rice cultivars contain malvidin. The total anthocyanin content varies greatly among black rice cultivars (79.5–473.7 mg/100 g), but is lower in red rice cultivars (7.9–34.4 mg/100 g). Total phenolic contents are similar between red (460.32–725.69 mg/100 g) and black (417.11–687.24 mg/100 g) rice. The oxygen radical absorbing capacity is ranked as follows: red (69.91–130.32 μmol Trolox/g) > black (55.49–64.85 μmol Trolox/g) > green (35.32 μmol Trolox/g) > white (21.81 μmol Trolox/g) rice. The antioxidant capacity results mainly from the seed capsule not from the endosperm. The anthocyanin pigments contribute little to the total antioxidant capacity of red (0.03–0.1 %) and black (0.5–2.5 %) rice cultivars. Hence, the antioxidant capacity is derived mainly from other phenolic compounds (Chen et al. 2012). Cells treated with red bran extract (RBE) showed higher protective effect compared to cells treated with white grain extract (WGE) against oxidative insult. According to "Consumer Reports *ShopSmart*" of April 2011 issue.

> Any whole grain rice including black, brown, purple, red, wild, and half milled contains more fiber, iron and vitamins than white rice. White rice loses much of its nutritional value in the refining process that strips it of its germ and outer bran layer. Recent research has linked as yet unnamed compound in that layer to reduced blood pressure and a lower risk of clogged arteries. And black rice in particular contains a high level of anthocyanins, a class of disease fighting antioxidants.

5.4 Black Rice

Black rice contains higher levels of anthocyanins than white rice, mainly composed of cyanidin 3-O-glucoside and peonidin 3-O-glucoside (Lee et al. 2014). Black rice contains more nutritional components such as dietary fibers, phytic acid, vitamin E, and vitamin B, than the ordinary milled rice (Banchuen et al. 2010). Salgado et al. (2008) reported that anthocyanin from black rice found higher antioxidant activity than red rice and rice berry. From the nutritional point of view, black rice is the most famous one and generally used as an ingredient is snack and desserts (Tananuwong and Tewaruth 2010). In addition, rough rice retains higher levels of anthocyanin and antioxidant activity after germination than that of rice prepared from dehulled. Therefore, rice with husk intact should be employed for the preparation of germinated pigmented rice to protect anthocyanin and its antioxidant

activity loss during germination process (Sutharut and Sudarat 2012). In northern Philippines, a black rice variety, locally known as Ballatinao rice, is consumed widely in the Mountain Province, Benguet and other neighboring provinces. Chemical analysis of Ballatinao rice showed that it has the highest levels of anthocyanin, vitamin B, crude protein, total phenolics, and fatty acids when compared to red (Chochoros) and non-pigmented (NSIC Rc 160) rice varieties (Romero et al. 2012).

The lipid-soluble antioxidants found in black rice bran possess higher level of anthocyanins which are water-soluble antioxidants. Thus black rice bran may be even healthier than brown rice bran. The ethanolic extracts from pigmented rice cultivars show greater antioxidant activity than that of the normal white rice. The black rice exhibit the highest free radical scavenging activity, ferrous chelating ability, and total phenolic and flavonoid contents (Kang et al. 2013). Previous studies have also demonstrated that black rice bran could exert greater antioxidative, anticancer, anti-endotoxemia, antihepatic steatosis and anti inflammatory in animal models effects compared with white rice (Choi et al. 2010; Jang et al. 2012). It has been suggested that these properties of black rice are due to its high content of total protein (approx. 9.7–10.6 %) and crude fiber, as well as dark pigment ingredients (Hong and Oh 1996). Black rice shows greater effect against oxidative stress as compared to common rice. However, black rice bran is difficult to digest and shows slower absorption in the gastrointestinal system. Meng et al. (2005) have reported that black rice contains iron, zinc, calcium, copper and manganese higher than those in red rice. Dark purple grain has higher iron content, polyphenol content and antioxidant capacities than red brown grain (Yodmanee et al. 2011). Whole cereal grains have been received increasingly attention by consumers due to their potential health benefits because of their antioxidant capacity, which is probably derived from their high contents of phenolics, flavonoids, and other phytochemicals. Black rice bran has higher content of phenolics and anthocyanins, and has higher antioxidant activity when compared to white rice bran (Zhang et al. 2010; Goffman and Bergman 2004).

According to Dr. Zhimin Xu of Louisiana State University Agricultural Center as quoted by the American Chemical Society:

> 10 spoonfuls 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. Anthocyanins are water-soluble, unlike other antioxidants in black rice which are fat-soluble. This means the antioxidants in black rice can reach many different parts of our body. I think the black rice bran has an advantage over blueberries, because blueberries still contain a high level of sugar.
>
> Black rice is rich in anthocyanin antioxidants, substances that show promise for fighting heart disease, cancer, and other diseases. Some antioxidants in black (and brown) rice are fat-soluble, while anthocyanins are water-soluble and can therefore reach different areas of the body

Says Joe Vinson, PhD, a Professor of Chemistry at the University of Scranton in Pennsylvania. White rice has been stripped of the healthful anthocyanin rich bran that makes black rice so nutritive. The bran of brown rice has been shown to contain higher concentrations of gamma-oryzanol antioxidants that lower LDL "bad" cholesterol and help prevent heart disease.

Black rice contains biologically many active compounds. Black rice extracts attenuated oxidative insult by inhibiting cellular ROS and malondialdehyde MDA increase and by modulating antioxidant enzyme activities in HepG2 cells (Lee et al. 2014). Tang et al. (2015) reported that greater phenolics and antioxidant capacities are detected in non-waxy rice rather than waxy one. The black variety shows the highest antioxidant capacity and phenolic content among the analyzed varieties in terms of quantity and type of molecules containing anthocyanins, flavonols and phenolic acids (Zaupa et al. 2015).

5.5 Difference in Black and Brown Rice

Some major differences in black and brown rice are described here in detail.

5.5.1 Difference in Calories

A 1/3-cup serving of dry black rice contains 200 calories while the same serving of brown rice contains 226 calories. Twenty six calories may not seem like much of a difference but consuming an extra 26 calories a day over one year can lead to a 2.7 pound weight gain. One cup of cooked black rice (1 cup = 201 g = 7.1 oz) contain 200 calories.[2] The calorie content of one cup of cooked rice varies from a high of 241.8 kcals for medium- or short-grain white rice to 218.4 kcals for medium grain brown rice, 216.5 kcals for long-grain brown rice, 205.4 kcals for regular long-grain white rice to a low of 165.6 kcals for wild rice (Ricepedia).

5.5.2 Differences in the Carbohydrates, Protein and Fat

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 43 g of carbohydrates, 3 g of fiber, 6 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.

[2]www.blackrice.com Retrived 23 June 2015.

5.5.3 Difference at the Minerals

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. Zinc is a mineral that supports immune health, phosphorus is needed for the formation of teeth and bones and iron helps transport oxygen throughout the body.

5.5.4 Difference in Antioxidant Power

A major difference between the black rice and brown rice is its color. The color of black rice also makes it a better source of antioxidants according to the American Chemical Society. Anthocyanin, a pigment found in the rice grain creates its dark hue is an antioxidant that may aid in fight against heart disease and cancer. Cyanidin-3-glucoside and peonoidin-3-glucoside are confirmed as the dominant anthocyanins in black rice varieties with contents ranging from 19.4 to 140.8 mg/100 g DM and 11.1–12.8 mg/100 g DM respectively (Sompong et al. 2010). The predominant anthocyanins are cyanidin-3-glucoside (572.47 μg/g, 91.13 % of total) and peonidin-3-glucoside (29.78 μg/g, 4.74 % of total). Minor constituents include three cyanidin-dihexoside isomers and one cyanidin hexoside. The antioxidant activity of all rice bran extracts indicates high antioxidant efficiency in the following order: red > black > white color rice brans (Pakistan Journal of Biological Sciences 2010, 13: 170–174).

> One spoonful of black rice bran or 10 spoonfuls of cooked black rice contains the same amount of anthocyanin as a spoonful of fresh blueberries

According to a new study presented at the American Chemical Society in Boston.

Black rice bran possesses strong scavenging activities for reactive oxygen species (ROS). Identified candidate scavengers are cyanidin-3-glucoside (Cy-3-glu) and cyanidin. Although ferulic acid is known to be an antioxidative component of bran in currently available common white rice varieties but it is not found in the black rice bran extracts. These anthocyanin compounds are found to possess both strong ROS scavenging activities and to suppress cell-damaging effects of UVB, indicating that both Cy-3-glu and cyanidin are the active components involved in the antioxidative activity of black rice bran extracts (Kaneda et al. 2006). The Boston based Whole Grains Council refers on its site that a team of researchers at Cornell University found antioxidants are about six times higher in black rice than in common brown and white rice. The researchers looked 12 varieties of black rice and analyzed the phenolic content and antioxidant activity also.

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