

Colourful harvest: Unveiling the nutritional bounty and functional applications of coloured rice varieties

Anubhuti Dwivedi¹, Dr. Saloman Behera¹, Dr. Binata Nayak²

¹ Department of Food Science Technology and Nutrition, Sambalpur University, Odisha, India

² School of Life Sciences, Sambalpur University, Odisha, India

Abstract

There are numerous varieties of rice, including white, red, black, and brown. White and brown rice are the most prevalent types of rice on the market. Red and black rice are not accessible to the general public due to limited production. Black rice is a super food due to its strong antioxidant activity, and its use as a component in other food products can result in very nutritious dishes. Coloured rice is a kind of rice that offers a number of intriguing health advantages. Anthocyanin, the major pigment in coloured rice, has piqued the interest of scientists due to its strong antioxidant activity, health advantages, and natural colouring capabilities for usage in various culinary applications. Consuming coloured rice has been proven to be advantageous for those who experience allergic reactions to other cereal grains and also lowers the chance of acquiring diabetes, obesity, and cardiovascular illnesses. To fully explore its advantages, coloured rice must be used as a unique component in food processing.

Keywords: karpooravalli, overripening, nutribars, tray dries, control panel

Introduction

In many developed countries, rice is one of the most commercially significant cereal crops and is a staple food on global scale. Around the world, there are numerous varieties of rice, including white, red, black, and brown. White and brown rice are the most prevalent types of rice on the market out of those. However, due to limited production, not cost effective and lack of information about its nutritional worth, red and black rice are not accessible to the general public (Mahalik G., 2022) [14]. White rice is nevertheless readily available to all socioeconomic classes and is produced at a relatively low cost. Black rice is a variety of the rice species *Oryza sativa* L. that is grown mostly in Asia. This rice is sticky and has high amount of nutrients (Kumar N., 2020) [9]. It also comes in a form of short grain, long grain, and glutinous kinds with a flavour that is somewhat nutty, texture is smooth and firm. It is similar to brown rice in flavour and texture. Numerous other types of dark coloured rice, such as forbidden rice, purple rice, black rice from Japan, China, Indonesia and Thailand, are also seen (Saha S., 2016) [20].

Red rice (or red-kernelled rice) having scientific name *Oryza punctate* is a kind of rice containing tannin pigments, giving the hulled rice a red or brownish red appearance. This rice has a great potential to be marketed as a health based food product which includes baby food product due to its valuable nutritional contents especially antioxidant properties. Red rice is valued for its antioxidant properties (Mazumdar A., 2022) [11]. It is used in breads, colored pasta, vinegar, alcoholic beverage, drugs, and cosmetics. Procyanidins are the main compounds with antioxidant activity of red rice (Masni, Z 2019) [10].



Species: *Oryza longistaminata*

Fig 1: Varieties of Red Rice

The frequency of mastication affects the strength of oropharyngeal muscles and brain activity in addition to the functional impacts of the components in brown rice. The younger population in Japan has recently become fond of soft-textured fast food, which has caused the frequency of mastication to decline proportionately. Compared to meat or fish meals, brown rice requires more chewing. (Takei N., 2018) [24].

The frequency of mastication affects the strength of oropharyngeal muscles and brain activity in addition to the functional impacts of the components in brown rice. The younger population in Japan has recently become fond of soft-textured fast food, which has caused the frequency of mastication to decline proportionately. Compared to meat or fish meals, brown rice requires more chewing. (Takei N., 2018) [24].



Short Grain brown Rice



Large Grain brown Rice



Light brown Rice

Fig 2: Varieties of Brown Rice

Species: *Oryza sativa* L. Poaceae

Black rice classification

Black rice is divided into many groups based on its various sizes, forms, nutritional values, and colours. Black forbidden rice, black glutinous rice, black emperor's rice, and black jasmine or Chak Hao rice are just a few of the variations available (Rahim M.A., 2022) [16]. The several varieties of black rice are categorised as follows.



Fig 3: Varieties of Black Rice

Species: *Oryza sativa* L. indica

Black rice, often known as "Emperor's rice," has a long cultural history. In ancient China, it was kept exclusively for the Emperor and served as a tribute dish. It has subsequently maintained its appeal in some parts of China and is now highly appreciated for its strong antioxidant content (Oikawa *et al.*, 2015) [13]. It may be used to make porridge, dessert, bread, noodles, and the classic Chinese black rice cake. According to a recent research by (Rahim *et al.* (2022) [16], coloured rice is becoming increasingly well-known as a consequence of its photochemistry, functional attributes, nutritional uses, and possible health benefits (Oikawa *et al.*, 2015) [13]. In India, today black rice is becoming more popular and is beginning to appear in more food stores. Today coloured rice is only grown in a tiny portion of the country, mostly in the north-eastern state of Manipur and small amount in Chhattisgarh (Google search) [3]. Black & Red rice is often grown in rain fed conditions between June and July, and it is harvested in late November. Black rice may thrive in difficult environments where other white rice cultivars cannot due to inadequate soil nutrients and limited water supplies. Black rice may thrive on higher slope hillocks as well as on marginal rainfed soils (Mazumdar *et al.*, 2022) [11]. Coloured rice has the highest nutritional content of any type of rice. This rice is minimal in sugar, salt, and fat and devoid of gluten and cholesterol. It is a

whole grain, incredibly nutrient-dense kind of rice that is rich in fibre, anthocyanin, antioxidants, vitamins B complex and E, iron, zinc, thiamine, magnesium, niacin, phosphorus, and other minerals. According to estimates, 50 g of black rice provide 35% of the daily RDA for selenium, copper, zinc, and magnesium and 50g of red rice provide 15% magnesium, 14% copper, 14% niacin. Protein content and quality are higher than in any other rice variety (Saha *et al.* 2016) [20].

Scientific Classification of Rice

- **Kingdom** – Plantae
- **Division** – Magnoliophyta
- **Class** – Liliopsida
- **Order** – Poales
- **Family** – Graminae/Poaceae
- **Tribe** – Oryzae
- **Genus** – Oryza
- **Species** – sativa



Fig 4: Different varieties of rice

The varieties of rice with the greatest nutrients are red and black rice. These grains have more fibre, protein, and antioxidants than white rice. The prevalence of obesity and dietary-related chronic diseases such type 2 diabetes, hypertension, cardiovascular disease, cancer, and celiac disease is increasing on a global scale. Food that is healthy is getting more and more popular. People's habits are changing in favour of healthy eating as a result of the food paradigm shift (Thanuja & Parimalavalli, 2018) [26]

Consumers now perceive food as having an impact on their future health rather than as a survival essential. The term "concept of functional food" refers to this idea. The phrase "functional food" became well-known in Japan around 1984. Food that provides nutrients and good for health is referred to as functional food. Functional foods are said to be good for both physical and mental health, according to different sources (Kim H., 2013) [6]. Functional foods have developed further since their debut. The functional food category covers anything from locally sourced food to probiotic-containing meals (Valencia 2019) [28]. Pigmented rice is a meal that is becoming more and more popular as a healthy eating option. Rice that contains colour pigment from anthocyanin content is known as pigmented rice (Rathna *et al.*, 2019) [17]. Coloured rice is used as a functional super food, in which black & red rice is used for baked goods, extruded goods, which is very popular now a days from the health point of view and people are more interested in providing functional and value added products, which gives some extra benefit to their health value added goods of black and red rice is one of the best option which is still underutilized because of lack of knowledge about nutritional benefits and there not been underutilize in the market, brown rice has still its bran layer, which contains vitamins, minerals, and fibre (Ravichandran *et al.*, 2019) [17]. Both the semi-polished and unpolished kinds of coloured

rice exist. The iron and zinc content of red rice variants is well recognised, whereas black rice species are particularly high in protein, fat, and crude fibre. Anthocyanin pigments, recognised for their antioxidant and free radical-scavenging properties as well as other health advantages. Incredibly brown rice is nutrient-dense (Sangma *et al.*, 2023) ^[21]. It is high in fibre and low in calories. It also contains significant amounts of manganese and is a strong source of magnesium, phosphorus, selenium, thiamine, niacin, and vitamin B6 because vitamins are restricted to the bran and husk of the paddy (Kumar N., 2020) ^[9]. Higher concentrations of calcium, zinc, and iron can be found in rice bran and husk (Rahim M.A., 2022) ^[16].

Red and purple/black rice are two examples of cereal grains with pigmentation that contain greater levels of phytochemical components than non-pigmented types. More research is being done on phytochemicals since they may be easily taken into the body and can be broken down by digestive enzymes and gut micro biota, such as cell wall-bound phenolics and flavonoids (Rathna Priya. T 2019) ^[17].

2. Commercial Value

The traditional black rice will soon be available in high-yielding varieties by the effect of the Regional Agricultural Research Station of the Assam Agricultural University. Twelve lines of highyielding black rice have already been created, and assessment is now taking place. Within a year or two, the created kinds will be accessible on the market (Goswami, K 2020) ^[4]. Due to restricted supply and increased acknowledgment of its nutraceutical advantages, red rice and black rice both command premium prices of Rs.300-500/- per kg. Both are available through a variety of online retailers (Wuryandani 2018) ^[31]. India mart sells red rice under several brand names, including Himalayan Red Rice and Organic Red Rice. Internet suppliers of red rice include Sainj Valley Exotic Growers in Shimla (Red Rice), Himalayan Grassroot Organics in Kullu (Himalayan Red Rice), Sauhta Apples in Shimla (Red Rice from Himachal Pradesh), Spankil in Shimla (Himalayan Red Rice), and others (Thakur *et al.*, 2020) ^[25]. Black rice is also available on numerous ecommerce sites such as Amazon and India mart under various brand names such as Swabhimani, Organics Black rice, Weefa organic black rice, and so on, all in varying amounts and pricing.

3. Coloured rice used in food processing ingredient

The presence of the black pigment "Anthocyanin" and the numerous beneficial health effects of coloured rice make it a wonder ingredient in food preparation (Wuryandani, S 2021) ^[30]. The use of coloured rice in food processing can improve the nutritional content of the rice-based food products and also turn them into functional foods that are marketed to specific populations, such as diabetics, obese people, or those with heart disease and high blood pressure (Saha, S. (2016) ^[20]. The use of coloured rice in food processing will be unique and a healthy replacement for other widely available foods for the coming generation because it is not well known among the general populace (Kumar N., 2020) ^[9]. The nutritional value of brown rice has recently been acknowledged, and intake has been promoted. Brown rice should be used as the primary ingredient in ricebased products to boost the nutritious richness of these foods. For the development of value-added goods in particular, brown rice is crucial to the rice business. Brown

rice has been used to make a variety of items, including popped, extruded, bread, cakes, noodles, cookies, etc. Brown rice may also be used in mixtures with other flours. Value-added brown rice products are thought of as functional foods that promote excellent health and have a strong chance of being accepted by consumers. Brown rice-based products would broaden the market's selection of functional goods and, more crucially, functional foods that are safe for those with celiac disease (Mir S. A 2017) ^[12].

Value added products made from coloured rice

1. Bread
2. Cookies/Biscuits, Crackers
3. Noodles, Pasta
4. Cake
5. Vinegar, Beverage (Rice Milk), Alcohol

3.1 Coloured rice in bakery goods

Over a 250% rise in output indicates that bakery goods are growing more and more popular in India. Due to their wide availability, readiness for consumption, convenience, distinctive flavor, and affordable price even in rural places, baked goods are in high demand all throughout the world. Products that are baked include a variety of foods including buns, bread, cakes, cookies, puff pastries, and biscuits (Kumar N., 2020) ^[9]. The market has been experimenting with novel ingredients for fortification, enrichment or value added bakery items to meet the hunger of health aware customers, who currently seek innovative choices for existing baked goods as a wholesome substitute for other popular cuisines for the next generation (Mahalik G., (2022) ^[14].

3.2 Cake with coloured rice powder

Without cake, baking would be impossible since cake is shaped with the aid of wheat gluten. Colored rice can replace wheat in the preparation of cakes since it has different types of proteins (Mahalik, G. (2022) ^[14]. Due to its antioxidant activity, colored rice will increase the nutritional value of cake goods.

3.3 Coloured rice powder in bread

Bread pieces are created by fermenting utilizing yeast in the baking sectors. There are several ingredients used in bread, including wheat flour, salt, yeast, and water. When yeast interacts with the sugar and carbohydrate in wheat flour during the fermentation process, CO₂ is released, which helps bind the protein network and promotes digestion (Kumar, N 2020) ^[9]. Recently, bread has been made using a little proportion of coloured rice flour together with wheat flour (Mahalik, G. (2022) ^[14]. Black rice flour can be used to fortify bread due to its high nutraceutical activity. Because it digests slowly, coloured rice can be used in place of wheat flour. Anyone can benefit from ingesting it, even diabetics.



Fig 5: Brown Rice Bread



Fig 6: Black Rice Bread

3.4 Coloured rice powder in cookies/biscuits

The addition of coloured rice powder to cookies appears to increase the moisture content of the biscuits. Because of its sticky nature, black rice powder absorbs more water, but the texture of the cookies remains the same (Kumar, N 2020). Purple rice powder also has a faster rate of protein digestion (Mahalik, G. (2022) [14]. Purple rice powder has been demonstrated to slow the rate at which starch is absorbed allowing diabetics to enjoy the cookies. During the current inquiry, the creation of gluten-free crackers using two types of brown rice flour and apple pomace was explored. Brown rice flour was mixed with 0%, 3%, 6%, and 9% apple pomace to create pomace flour mixes. Except for the pasting temperature, which increased with an increase in pomace content, the viscosity profile revealed a reduction in pasting capabilities. Pomace-based rice crackers are thought to be a functional diet that promotes health, especially for those with celiac disease, according to the results of the study (Shabir Ahmad Mir 2014) [22].

3.5 Brown rice ice cream sandwich

Agriculture goods gain value by processing, which also increases their economic viability and nutritional worth. While buffalo's milk has higher protein and calcium content and lower cholesterol than other dairy milks, brown rice includes significant levels of protein, dietary fibre, minerals, and vitamins due to the bran that is left on the grain. These elements might be used to create a healthful, high-value product. Brown rice flour (BRF) replaced at 0, 40, 50, and 60% (wt/wt), together with fresh buffalo's milk, were used to create an ice cream sandwich. A customer survey (n=100; aged 15 to 30) was used to assess the product's acceptability. Consumer sensory testing revealed that an ice cream sandwich made with a cracker replaced with 50% BRF and paired with ice cream made with buffalo's milk was tolerable. A brown rice cracker ice cream was created as a consequence. This led to the creation of a brown rice cracker ice cream sandwich (BRICS), which provides 164 calories, 8 grammes of fat, 5.7 grammes of protein, 20 grammes of carbs, and important minerals (Riza abilgos-ramos, 2019) [18].

4. Extruded products with coloured rice supplementation

These meals are more often consumed since they are flavorful and easy to make (Mahalik G., 2022) [14]. The food items are created from cereal flour and high starch, as well as from other raw materials with high protein content, including vegetables, pet food, etc (Mazumdar A., 2022) [11].

4.1 Pasta

Pasta is widely accepted and consumed across the world due to its simple preparation, distinct flavor, and several health advantages. Most pasta is made from durum wheat, which has higher protein content than other types of wheat (Mahalik, G. 2022) [14]. When coloured rice flour was added to durum wheat flour during pasta preparation, the pasta's water absorption capacity enhanced (Sompong R., 2010) [23].



Fig 10: Red Rice Pasta



Fig 11: Brown Rice Pasta

4.2 Noodle

Extrusion is the process used to create noodles from a variety of ingredients, including wheat flour, salt, oil, and water. Noodles are always ready to make since all they need is water (Sompong R., 2010). Numerous elements, including protein, fiber, and vitamins, are lost during the making of noodles as a result of the wheat refining process, which has a substantial negative influence on the nutritional value of the meal (Mahalik G., 2022) [14]. Due to the expanding worldwide population and the ensuing need for functional meals, several research have examined the use of coloured rice powder in the preparation of noodles (Kumar N., 2020) [9].

The next two parts (T3 and T4) received additions of pasteurised papaya pulp at rates of 10 and 20 percent, respectively. Fruit-flavored fermented rice milk drinks were kept at 40C for 15 days, and their physical, chemical, rheological, microbiological, antioxidant, and sensory properties were assessed when they were first made and at 5, 10, and 15-day intervals thereafter (Atwaa 2019) [2].



Fig 7: Red Rice Noodle



Fig 8: Brown Rice Noodle



Fig 9: Black Rice Noodle

4.3 Rice milk beverage with fruit pulps as an additive

Based on earlier research (Bernat *et al.*, 2014 and 2015) [29], rice milk submitted for fermentation was enhanced with 1.5% (w/w) glucose-fructose prior to the inoculation procedure to enhance the growth and acidity of the mixed culture employed. After being heated to 90°C for 20 minutes and then cooled to 37°C, rice milk was inoculated with 5% of the ABT-5 culture and incubated at that temperature for 16 hours (until pH 4.6). The beverages were then stirred and divided into 5 equal portions; the first portion served as a control (C) and was left without any additives.

5. Health benefits of Coloured Rice

For health benefits People pick various types of rice depending on the tastes, culinary requirements, availability, and potential health advantages. Rice has the capacity to deliver quick and immediate energy Anthocyanins are colorants that shield your cells from damage and may be found in a number of blue and purple meals (Rozee 2020) [19]. Additionally connected to a decrease in inflammation and a decreased risk of cardiovascular disease are these pigments. You may enhance your general fitness and heart

health by eating black rice (Rathna *et al.*, 2019) [17]. Brown rice releases sugars gradually than white polished rice, which helps to regulate blood sugar levels over time. Because of this quality, it is a preferable choice for those with diabetes mellitus. Preventing the activity of hydrolytic enzymes in the small intestine on food, and raising the viscosity of food in the gut, dietary fibers decrease the absorption of carbs. This is crucial in lowering food's GI and lowering the risk of type 2 diabetes (Thanuja B., 2018) [26]. Red rice's proanthocyanidin content protects against type 2 diabetes. Similar to this, black rice's anthocyanin content is reported to have a hypoglycemic impact. Brown rice has high levels of selenium and manganese, both of which are essential to fight against free radicals; a key cancer-causing factor because of this brown rice is linked to a decreased risk of cancer because it contains these substances as well as having high dietary fiber content (Thakrar R., 2007) [25]. Red rice contains proanthocyanins, which control the inflammatory response and offer modest cancer protection. Similar to this, anthocyanins, which are prevalent in black rice have been shown in epidemiological, in vivo animal and human studies to have anti-carcinogenic characteristics (Ravichandran *et al.*, 2019) [17].

Consumption of brown rice may reduce the chance of developing the metabolic syndrome, which is a significant indicator of cardiovascular disease (Kumar.D 2020) [8]. Magnesium in red rice lowers the risk of heart attacks. Anthocyanin-rich extracts from black rice is effective in reducing a number of high-fat diet-related cardiovascular disease risk factors in rat models (Pratiwi R., 2017)[15]. Cholesterol, naturally occurring in bran oil is found in brown rice which aids in lowering LDL cholesterol. These studies clearly show that whole grains can reduce the risk of arterial plaque development, which lowers the risk of heart disease Red and brown rice both have more magnesium than white rice which is a significant element for maintaining healthy blood pressure and salt levels in the body. Brown, red, and black rice are examples of rice varieties that are high in fiber and can support good bowel and metabolic function. Red rice contains anthocyanins, which have qualities that can aid in controlling weight (Rathna P., 2019) [17]. Brown rice that has been germinated has been proposed as an alternate strategy to reduce the risk of serious illnesses by supplying nutrients and biologically active substances. Vitamin, mineral, fibre, and phytochemical levels are often increased during the germination process, including ferulic acid, gamma-aminobutyric acid, and -oryzanol. Scientific research showing the health benefits of consuming germinated brown rice, which lowers the risk of illnesses including obesity, cardiovascular disease, type 2 diabetes, and neurodegenerative disorders, is gaining more and more attention. A natural and affordable alternative to traditional white rice, germinated brown rice has been found to improve the nutritional and health condition of a wide population (Mir S.A., 2017) [12].

Table 1: Nutritional value of coloured rice

Components	Black Rice (100 g)	Red Rice (100 g)	Brown Rice (100g)
Moisture	11.07±0.2	12.51	12.00
Proteins	8.16 ±0.3	10.53	4.88
Fats	0.07 ±0.2	1.49	1.17
Total fiber	8.47 ±0.2	1.19	3.32
Carbohydrate	78.26 ±0.6	74.40	49.7
Anthocyanin	0.0795-0.4737	0.0079-0.0343	0.075-0.4673
Calcium	0.395	0.02	0.05
Phosphorus	0.264	0.21	142
Iron	0.387	0.004	0.006
Zinc	3.16 ± 0.05	0.005	1.05
Energy (kJ)	1425±0.7	1457.72	1438.34

Thomas *et al.*, 2013; Thakur *et al.*, 2020

6. Phytochemical composition

The phytochemicals found in rice may be broken down into the following sub-groups: carotenoids, phenolics, alkaloids, nitrogen, and compounds containing organo-sulfur. The subgroups of phenolic substances include tannins, phenolic acids, flavonoids, and coumarins. The primary pigment that gives red and black rice their colours, anthocyanins, is a kind of flavonoid (Goswami, K 2023) [4]. Among red rice varieties from Sri Lanka, China, and

Tamil Nadu, Maapillai Samba has the greatest levels of anthocyanin and total polyphenolic chemicals.

Red and purple/black rice are two examples of cereal grains with pigmentation that contain greater levels of phytochemical components than non-pigmented types. More research is being done on phytochemicals since they may be easily taken into the body and can be broken down by digestive enzymes and gut microbiota, such as cell wall-bound phenolics and flavonoids (Chen C-H 2014) [32].

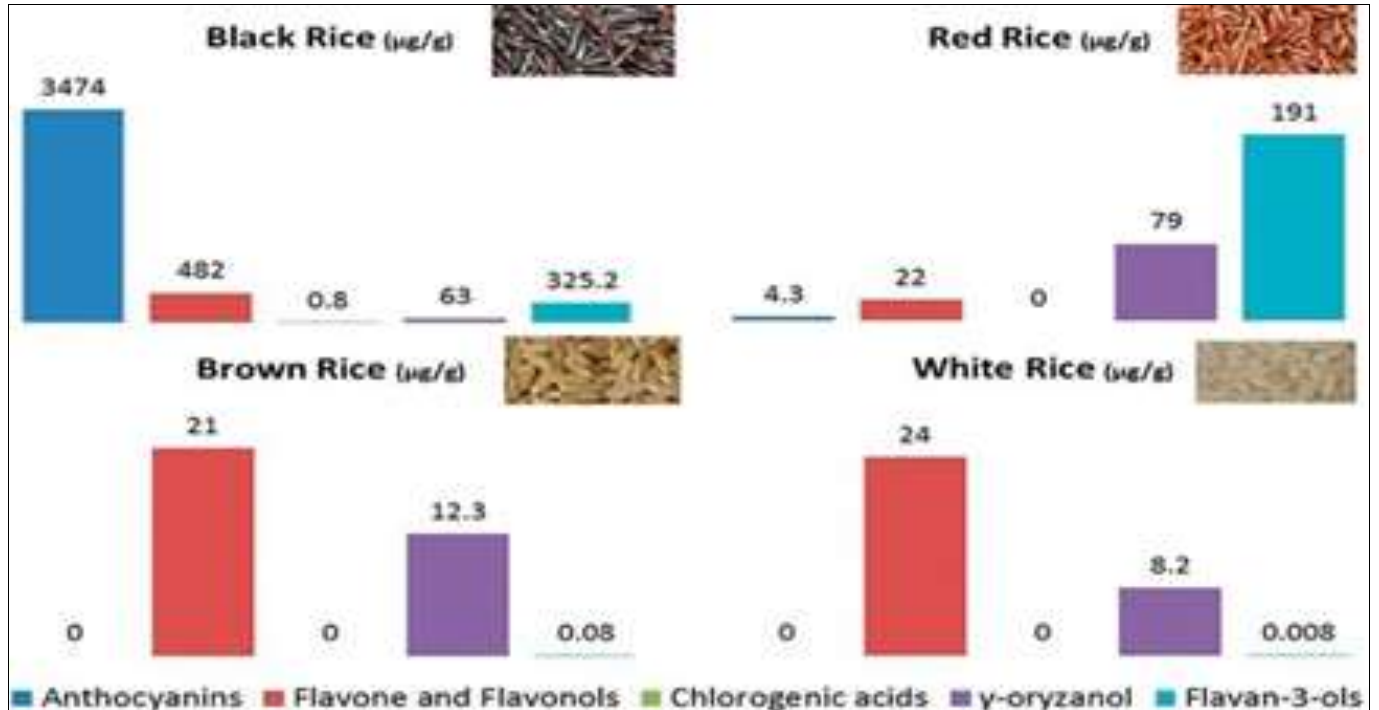


Fig 12: Phytochemical Composition of coloured rice

Medicinal use of Coloured Rice

Some variations of the many different forms of rice are utilized as medicines. Since each type of rice has distinctive qualities, more than one variety can be used to cure different disorders. Due to their unique features and traits, many distinct rice cultivars are used in the treatment of diseases. According to Ayurvedic practitioners, rice balances the body's humors (Rathna *et al.*, 2019) [17]. By eliminating harmful metabolites, rice strengthens, revitalizes, and energizes the body. It also controls blood pressure, prevents skin disorders, and has anti-aging properties. A kind of red rice called raktasali is effective for taming the body's unbalanced humors helpful for fevers and ulcers, enhances voice, skin and eye health, and boosts fertility. Sali, Sashtika, and Nivara rice are used in Ayurveda to treat haemorrhoids (piles), burns, and fractures (Kowsalya P., 2022) [7]. Nivara rice is also used to make weaning food for underweight babies and to treat conditions like cervical spondylitis, paralysis, rheumatoid arthritis, neuromuscular disorders, psoriasis, skin lesions, and stomach ulcers. Ayurvedic remedies include rice varieties like Mahagandhak, Kamdudha, Sutsekhar, Amritanav, Pradraripu, Laghumai, Dughdavati, Pradaknasak, Pushpnag, Sangrahat, and Mukta sukta that are used to treat conditions like vaginal and seminal discharges, diarrhoea, constipation, and dysentery. It is well known that red rice types may be used to cure conditions including diarrhoea, vomiting, fever, bleeding, chest discomfort, wounds, and burns. In Himachal Pradesh, matali and lal dhan are used to treat high blood pressure and fever (Lacerda L. G., 2019) [5]. Leucorrhoea and problems following abortion are treated with a different red rice variety called Kafalya from the Himachal Pradesh and Uttar Pradesh. While Neelam Samba from Tamil Nadu is utilized for breastfeeding mothers, Kari Kagga and Atikaya from Karnataka are used for cooling and as tonics (Ravichandran *et al.*, 2019) [17]. Kuruvi Kar is drought-resistant and is enjoyed by the natives for its

nutritional value. Raktasali is effective in taming twisted humor. It was also thought to be a successful therapy for conditions including fevers and ulcers. Additionally, it is thought to be antitoxic, diuretic, spermatophytic, cosmetic, and tonic, as well as improving vision and voice (Rathna P., 2019) [17].

Brown rice is high in minerals, vitamins B and E, fibre, and nutraceuticals such as oryzanol, phytosterols, and polyphenols. Brown rice contains phenolic components such as phenolic acids, proanthocyanidins, flavonoids, anthocyanins, and others, with a larger concentration in coloured kinds (Tian, X.2023) [27]. They are advantageous to health because of their antioxidant, anti-inflammatory, and lipid-lowering characteristics. Brown rice is also said to protect against anaemia, hyperglycemia, diabetes, hypercholesterolemia, atherosclerosis, and other diseases. As a result, the chapter focuses on global interest in brown rice research on nutraceuticals, bioactivity, and health consequences (Mir S. A., 2017) [12].

Conclusion

Coloured rice is a kind of rice that offers a number of intriguing health advantages. Colour rice is a super food due to its strong antioxidant activity, and its use as a component in other culinary products can result in very nutritious dishes. Anthocyanin, the major pigment in coloured rice, has piqued the interest of scientists due to its strong antioxidant activity, health advantages, and natural colouring capabilities for usage in various culinary applications. Consuming coloured rice has been proven to be advantageous for those who experience allergic reactions to other cereal grains and also lowers the chance of acquiring diabetes, obesity, and cardiovascular illnesses. To fully explore its advantages, coloured rice must be used as a unique component in food processing.

References

- Ahuja U, Ahuja SC, Chaudhary N, Thakrar R. Red rices—past, present and future. *Asian Agri-History*,2007:11(4):291304.
- Atwaa EH, Elmaadawy AA, Awaad EA. Production of fruit flavored probiotic rice milk beverage. *Journal of Food and Dairy Sciences*,2019:10(12):453-458.
- Google Scholar
- Goswami K, Thapa DB, Sandilya J, Deka N. An assessment of economic profitability of black rice (*Oryza sativa* L. indica) production in Assam, India. *Journal of Applied Research on Medicinal and Aromatic Plants*,2023:34:100488.
- Ito VC, Lacerda LG. Black rice (*Oryza sativa* L.): A review of its historical aspects, chemical composition, nutritional and functional properties, and applications and processing technologies. *Food chemistry*,2019:301:125304.
- Kim H. Functional foods and the biomedicalisation of everyday life: a case of germinated brown rice. *Sociology of health & illness*,2013:35(6):842-857.
- Kowsalya P, Sharanyakanth PS, Mahendran R. Traditional rice varieties: A comprehensive review on its nutritional, medicinal, therapeutic and health benefit potential. *Journal of Food Composition and Analysis*, 2022, 104742.
- Kumar D, Kiran DK, Koli GK, Tiwari PK, Kumar B. Pigmented rice: A miracle food for Modern-day world.
- Kumar N, Murali RD. Black Rice: A novel ingredient in food processing. *J Nutr Food Sci*,2020:10(2):771.
- Masni Z, Wasli ME. Yield performance and nutrient uptake of red rice variety (MRM 16) at different NPK fertilizer rates. *International Journal of Agronomy*, 2019.
- Mazumdar A, Aswin GA, Bhatt D. Utilization of black rice and red rice in value added products: A review. *Proteins*, 2022:8:0-3.
- Mir SA, Bosco SJD, Shah MA, Santhalakshmy S, Mir MM. Effect of apple pomace on quality characteristics of brown rice based cracker. *Journal of the Saudi Society of Agricultural Sciences*,2017:16(1):25-32.
- Oikawa T, Maeda H, Oguchi T, Yamaguchi T, Tanabe N, Ebana K, Izawa T. The birth of a black rice gene i. and its local spread by introgression. *The Plant Cell*,2015:27(9):24012414.
- Panda DK, Jyotirmayee B, Mahalik G. Black rice: A review from its history to chemical makeup to health advantages, nutritional properties and dietary uses. *Plant Science Today*, 2022:9(sp3):01-15.
- Pratiwi R, Purwestri YA.
- Black rice as a functional food in Indonesia. *Functional Foods in Health and Disease*,2017:7(3):182-194.
- Rahim MA, Umar M, Habib A, Imran M, Khalid W, Lima C MG, Emran TB. Photochemistry, Functional Properties, Food Applications, and Health Prospective of Black Rice. *Journal of Chemistry*, 2022.
- Rathna Priya TS, Eliazer Nelson ARL, Ravichandran K, Antony U. Nutritional and functional properties of coloured rice varieties of South India: a review. *Journal of Ethnic Foods*,2019:6(1):1-11.
- Riza _____ABILGOS-RAMOS, El _____Shaira
- LABARGAN, Josefina
- BALLESTEROS, Amelia
- MORALES, Rosaly MANAOIS 2019
- Roze V, Upadhyay S, Gururani P, Singh B. Black Rice *Oryza sativa* L and their traditional Products:
- Saha S. Black rice: the new age super food (an extensive review). *Int. J. A Res. Formal, Appl. Nat. Sci*,2016:16(1):51-55.
- Sangma RR, Manpoong C, Sharma A, Devadas VS, Singh D, Pandey H. Performance of black rice (*Oryza sativa*) varieties grown in Namsai district of Arunachal Pradesh, India. *Research on Crops*,2022:23(1):11-14.
- Shabir Ahmad Mir, Sowriappan John Don Bosco, Manzoor Ahmad Shah, Swaminathan Santhalakshmy, Mohammad Maqbool Mir b 2014 23. Sompong R. Siebenhandl-Ehn S, Berghofer, E., & Schoenlechner R. Extrusion cooking properties of white and coloured rice varieties with different amylose content. *Starch-Stärke*,2011:63(2):5563.
- Takei N, Kodama S, Hirakawa A, Mizuno S, Saika K, Watanabe S. Medical rice: brown rice for health and low protein rice for preventing CKD. *EC Nutrition*,2019:14:7-10.
- Thakur AK, Kumari N. Red Rice in Himachal Pradesh: History, Tradition and Uses. *International Journal of Economic Plants*,2020:7(2):060-065.
- Thanuja B, Parimalavalli R. Role of black rice in health and diseases. *Int. J. Health Sci. Res*,2018:8:241-248.
- Tian X, Wu F, Zhou G, Guo J, Liu X, Zhang T. Potential volatile markers of brown rice infested by the rice weevil, *Sitophilus oryzae* (L.)(Coleoptera: Curculionidae). *Food Chemistry: X*,2023:17:100540.
- Valencia, Erica and Purwanto, Maria Goretti Marianti. Artificial Rice As an Alternative Functional Food to Support, 2020.
- Food Diversification Program. In: The 2019 International Conference on Biotechnology and Life Sciences: Biotechnology in the Era of 4th Industrial Revolution (IC-BIOLIS), 89 Oktober 2019, Jakarta.
- Vanga SK, Raghavan V. How well do plant based alternatives fare nutritionally compared to cow's milk?. *Journal of food science and technology*,2018:55(1):10-20.
- Wu X, Guo T, Luo F, Lin Q. Brown rice: a missing nutrient-rich health food. *Food Science and Human Wellness*, 12(5), 1458-1470.
- Wuryandani S. Prioritized Attributes on Black Rice Product Development: Kano Model Application. *Agroindustrial Journal*,2023:8(2):581-590.
- Wuryandani S, Ismoyowati D, Nugrahini AD. STP analysis in marketing pigmented rice as functional food. *KnE Life Sciences*, 2018, 128-135.
- Zhou Z, Chen X, Zhang M, Blanchard C. Phenolics, flavonoids, proanthocyanidin and antioxidant activity of brown rice with different pericarp colors following storage. *Journal of Stored Products Research*,2014:59:120-125.