ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Qualitative Characteristics of Red Rice and White Rice Procured from Local Market of Uttarakhand: A Comparative Study

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Received: 4th April, 2017 Accepted: 5th May, 2017

Abstract

The present study was undertaken with the objective to evaluate and compare the physical characteristics, nutritional quality, antioxidant properties and glycemic index of indigenously grown raw red rice grown in Udham Singh Nagar district of Uttarakhand and white rice (Sarbati) procured from local market of Uttarakhand, India. Of the thirteen physical quality parameters evaluated, red rice proved to be superior to white rice in all parameters barring seed length. Red rice was found to have a higher iron, magnesium, calcium, and zinc content than white rice. Regarding other nutrients the study revealed that red rice has a higher crude protein (10.49%) and crude fiber (2.71%) content as compared to white rice. The nutritional quality of red rice was found to be comparable to many millets, fruits and vegetables. It showed excellent antioxidant properties too such as total phenolic content (143.38 mg GAE/100g of phenol), total flavonoid content (120.0 mg R.E. /100 gm of flavonoid) and DPPH scavenging activity (25 per cent). Red rice was found to have a lower glycemic index (63.15 ± 2.63mg/dl) than white rice due to which it can be a part of the diets of diabetics as well as persons suffering from other non-communicable diseases. Red rice is a storehouse of nutritional excellence and is a healthier alternative to white or polished rice.

Keywords: Red rice, Antioxidants, Glycemic index, Nutritional composition, Physico-chemical characteristics.

Abbreviations: DPPH:2, 2 Diphenyl 2 picryl hydrazyl hydrate;TFC:Total flavonoid content; TPC:Total phenol content; R.E:Retinol equivalent; GAE:Gallic acid equivalent

Introduction

Rice (*Oryza Sativa L.*) is one of the most popular and important cereal crops. It is the staple food of more than three billion people (Bhattacharjee *et al*.**,** 2002) in 39 countries,that comprises of nearly half of the world's population. Commercially more than two thousand varieties of rice are grown throughout the world. Over 2 billion people in Asia derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7–8% crude protein, 3% crude fat, and 3% crude fiber (Juliano, 1985). Champagne *et al.,* (2006) stated that rice is mainly composed of starch. Vandeputte *et al.,* (2004) mentioned rice starch as the major constituent of rice grain**.** Moldenhauer *et al*.**,** (2006) added that the same level of starch is the base of determining the quality that the cooked rice would depict.

Rice is widely consumed as white rice in milled and parboiled form. There are many special cultivars of rice that contain colour pigments, such as black rice, red rice and brown rice. Their name refer to the kernel colour (black, red or purple) which is formed by deposition of anthocyanin in different layers of the pericarp, seed coat and aleurone (Chaudhary *et al*,. 2001). The origin of coloured rice is as old as rice itself. Rice with a red bran layer is called red rice. Though, the colour is confined to the bran layer, a tinge of red remains even after a high degree of milling. Unmilled rice has a higher nutrient content than milled or polished white rice. Red rice contains 7g/100g protein, 5.5mg/100g iron, 3.3mg/100g zinc, and 2g/100g fibre respectively. Red rice has a nutritional value more than that of milled and or polished rice FAO (2004).

Rice was known to the civilization 5000 BC. However the Chinese, Southern and East Asians are believed to have learnt the practice of growing rice around 2000 BC (Chaudhary *et al*., 2001).

De candolle (1886) and Watt (1892) believed that rice was originally cultivated in South India. India is one of the rice producing country with larger area involved in the cultivation of rice. Historians believe that the well-known variety of rice was first domesticated in the area covering the foothills of the Eastern Himalayas. Rice seems to have appeared around 1400 BC in southern India after its domestication in the northern plains. Some say that the word rice is derived from the Tamil word "*Arisi"* (Hiziroglu *et al.,* 2007). The rice crop forms the basic economic activity directly or indirectly for about 150 million rural households in India (Krishnaiah *et al*., 2000).

Ancient Indian literature Charaka Samhita, authored by great Charaka mentioned rice with red husk and grain as the best which is efficacious and subdues the diseases (Kumar, 1988; Krishnamurthy, 1991). Eaten as a whole grain, Red rice is commonly consumed in Himachal Pradesh, Uttar Pradesh and South India, especially Karnataka and Tamil Nadu and is predominantly known for its aroma and taste. But rice consumers often prefer to have polished white rice despite the valuable food content of coloured rice which is lost when bran is removed while polishing**.**

The choice of carbohydrate-rich foods in the habitual diet should take into account not only their chemical composition but also their ability to influence postprandial glycemia (glycemic index) (Riccardi *et al*., 2008). Polyphenol and flavonoid which have antioxidant capacity present in many foods and vegetables are regarded as the functional materials. Regular intake of these phytochemicals can reduce many chronic diseases such as cardiovascular diseases, heart diseases, diabetes, obesity and certain cancers, and improve endothelial function and reduce blood pressure (Liu, 2007; Yawadio *et al.,* 2007; Jonathan *et al.,* 2006).

Little or no information is available on nutritive value of red rice grown in tarai region of Uttarakhand. Therefore, the study is aimed to estimate and analyse the physical characteristics, nutritional quality, antioxidant properties and glycemic index of white rice and red rice.

Materials and Methods:

Procurement of sample: Samples of two types of rice (*Oryza Sativa L.*) *viz.* indigenously grown raw red rice from Udham Singh Nagar district of Uttarakhand, and white rice (Sarbati) were procured from Uttarakhand Agricultural Production Board and the local market respectively.

Estimation of nutritional quality: Dehusked red rice and milled, polished white rice samples were analysed in triplicate for proximate composition such as percent moisture, crude protein, total ash, crude fat and crude fibre. Proximate composition was determined by the method given by AOAC (2000). The carbohydrate percentage was determined by the difference method as reported by **(**Onyeike *et al.,* 1995). The calorific value (Kcal/100g) of sample was calculated by summing up the product of multiplication of per cent crude protein, crude fat and carbohydrate present in the sample by 4, 9 and 4 respectively.

Minerals: Calcium, iron, zinc, and magnesium in the sample were estimated using atomic absorption spectrophotometer. Ash solutions were prepared using wet-ashing procedure as described by Raghuramulu (2003).

Physical properties: The physical properties of white rice and red rice such as Seed volume, seed weight, seed density, hydration capacity, swelling capacity, length of grains, bulk density, and kernel elongation were estimated by the procedure reported by (Williams *et al.,* 1983). Alkali spread value was calculated by method described by (Little *et al.,* 1958) and the kernel elongation was calculated as described by (Azeez *et al.,* 1966).

The hydration capacity of the grain is an important attribute which affects the cooking quality and in turn organoleptic qualities of product Potty (1996). The author also reported that large sized particles have low bulk density; progressive size reduction increases the bulk density significantly.

Cooking quality: Different grain samples take different time for cooking therefore the rice samples were soaked for a constant period of 60 minutes and cooked for 3 different timing *viz.* 20, 30 and 40minutes. The number of cooked grains were counted and put in 500ml of boiling water and timed from the time the water started boiling again. After specified period remaining water was drained off and the softness of the grain was gauged manually by pressing them between the thumb and index finger. The cooked grains were counted and recorded in percentage.

Antioxidant properties: Total flavonoid content (TFC), total phenol content (TPC) and DPPH scavenging activity were determined.

Total flavonoid content - Total flavanoid content was determined according to the method given by Zhishen *et al.,* (1999).

Total Phenol content: The Total Phenol content was determined according to the method given by Singleton *et al.,* (1999) using Folin- ciocalteu reagent.

DPPH scavenging activity: The total antioxidant activity was determined according to the method given by Brand *et al.,* (1995) using 1,1- diphenyl-2-picryl hydrazyl (DPPH)**.**

Glycemic Index: The glycemic index of white rice and red rice was determined using the procedure described by (Brouns *et al.,* 2005).

Statistical Analysis: The data obtained on the proximate composition, mineral content, physical properties and antioxidant content of white and red rice were further analysed statistically. Mean ± S.D. was calculated for chemical composition of white and red rice.

Results and discussion

Nutritional composition of white rice and red rice: The results of proximate composition and minerals are presented in Table 1. White rice was found to have 12.7% moisture, 7.6% crude protein, 0.46% ash, 0.62% fat, 0.23% fibre, and 78.34% carbohydrate. On the other hand, red rice was found to have 12.75% moisture, 10.49% crude protein, 1.53% ash, 1.815 fat, 2.7% fibre and 70.19% carbohydrate content. The protein content of red rice is comparable to other cereals and millets such as Whole wheat (11.8%),

Barley (11.5%), Bajra (11.6%) and Jowar(10.4%). The ash content of Red Rice was higher than that of White Rice. Red rice is a rich source of fibre as compared to whole wheat (1.2%), Bajra (1.2%) and many vegetables such as amaranth, spinach, cucumber and carrot (Gopalan *et al.,* 2007). The total physiological energy was recorded as 349.34 kcal in white rice and 341.29 kcal in red rice.

Red rice was found to be a rich mineral source. It had 13.45mg iron, 192.27 mg magnesium, 8.71 mg calcium, and 1.91 mg zinc while white rice was found to have 7.65 mg iron, 46.45 mg magnesium, 7.94 mg calcium and 1.49 mg zinc. Red rice has an iron content more than whole wheat (5.3mg) (Gopalan *et al.,* 2007). Thus, it can be recommended for the people suffering with iron deficiency as rice forms a major part of the diet. A high magnesium content in red rice seeks its importance in the diet of individuals suffering with various heart disorders, especially those related to elevated cholesterol level and hypertension.

Physical properties of white rice and red rice: The Physical properties of red rice are presented in table 1 compared to white rice sample. Red rice was found to have a higher 1000 kernel weight (18.3g), seed weight (1.827g), seed density (1.59 g/ml), seed volume (1.1 ml), hydration capacity(0.347 g/100 seeds), hydration index (0.19), swelling capacity (1.6 ml/100 seeds), swelling index (1.41), kernel elongation (1.32 cm) and bulk density (0.82 gm/l). Also it has a high gelatinization temperature and cooking time. However, the length of the red rice grain is less than white rice. The physical properties of red rice suggest that it has more density than the white rice.

Table 1. Proximate composition and physical properties of white rice and red rice

Nutritional parameters	White rice	Red rice
Moisture Content (g/100 gram)	12.75±0.15	12.7±0.13
Crude Fat Content (g/100 gram)	0.62±0.015	1.81±0.011
Crude Fiber Content (g/100 gram)	0.23±0.02	2.71±0.1
Crude Protein Content (g/100 gram)	7.6±0.23	10.49±0.43
Total Ash Content (g/100 gram)	0.46±0.04	1.53±0.01
Carbohydrate Content (g/100 gram)	78.34±1.5	70.19±1.0
Energy Content (kcal/100 gram)	349.34±2.5	341±1.2
Thousand kernel weight (g)	14.2±0.51	18.3±0.83
Seed weight (g)	1.42±0.02	1.827±0.02
Seed volume (ml)	1.16±0.05	1.1±0.05
Seed density (g/ml)	1.22±0.072	1.59±0.083
Hydration capacity (g/100 seeds)	0.179±0.03	0.347±0.02
Hydration index	0.125±0.02	0.19±0.009
Swelling capacity (ml/100seeds)	0.85±0.35	1.6±0.1
Swelling index	0.72±0.34	1.41±0.11
Length of grain(cm)	0.7±0.1	0.56±0.057
Bulk density of 1g of sample(g/l)	0.703± 0.005	0.82±0.017
Kernel elongation	1.28 cm± 0.127	1.32cm± 0.096
Gelatinization Temp (Alkali spread value)	1-5scale point	High (1-2 scale point)
Cooking quality	30- 40 min	more than 60 min

Antioxidant property of white rice and red rice: The results of antioxidant properties are presented in Table 2. The total phenolic content and total flavonoids content of red rice was found to be 143.38 mg GAE/100 gm and 120 mg R.E./100 gm respectively. The DPPH scavenging activity was found to be 25%. Sompong *et al.,* (2011) found the total phenolic content of ten red rice varieties ranging between 79.2 and 691.4 mg FA equivalent/ 100 gm. Shen *et al.,* (2009) recorded 147.2 mg RE/100 gm as the mean flavonoid content of red rice varieties. On the other hand, the total phenol and flavonoids content of white rice was found to be 24.26 mg GAE/100 gm and 166.23 mg R.E./100 gm. The DPPH scavenging activity was found to be 20%. Yafang *et al.,* (2011) found the phenolic content of white rice to be ranging between 42.57 mg GAE/100 g to 100.7 mg GAE/100 g and flavonoid content ranged between 62.1 mg RE/100 g to 182.6 mg RE/100 g.

Table 2. Mineral and Antioxidant properties of white rice and red rice

II. Minerals and Antioxidant properties	White rice	Red rice
Calcium Content (mg/100g)	7.94±0.17	8.71±0.65
Iron Content(mg/100g)	7.65±0.22	13.45±0.60
Magnesium Content (mg/100g)	46.45±0.649	192.27±5.98
Zinc content(mg/100g)	1.49±0.039	1.91±0.036
Total flavonoid content (mg R.E./100 gm of flavonoid)	166.23±0.25	120.0 ±0.38

Total phenolic content (mg GAE/100g of phenol)	24.26±1.05	143.38 ±1.5
DPPH scavenging activity%	20%	25%

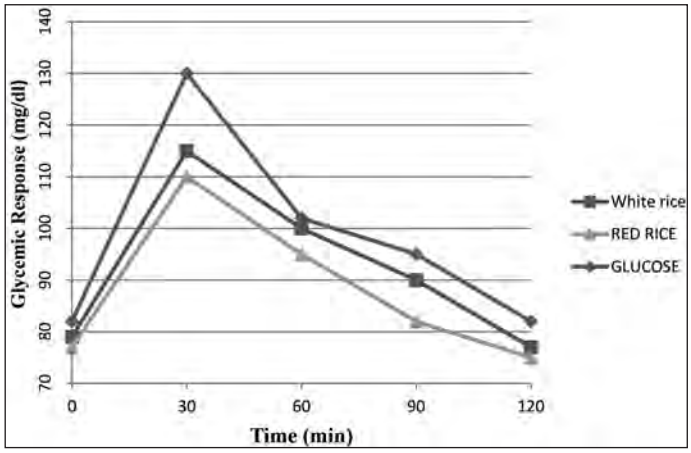

Figure 1. Blood glucose response curve for White and Red rice

Glycemic Index: The glycemic index of white rice and red rice was recorded as 71.7±0.91 and 63.15±2.63 respectively. White rice has 8 per cent more carbohydrate and 2.5 per cent less crude fibre relatively**.** Fiber rich foods like red rice generally have a low glycemic index (GI) (Radulian *et al.,* 2009). As red rice is relatively rich in crude fibre, it may be eaten in small quantities by the diabetic individuals and incorporated in daily diet by the healthy people too.

Conclusion

In the present study it was found that red rice has a higher content of crude fiber, crude protein, minerals and antioxidants than white rice. It has a higher nutrient density and lower glycemic index which makes it comparatively superior than white rice. Red rice has multifaceted nutritional values which make it a highly beneficial superfood. However, red rice has been relegated from plates and fields due to the emergence of white rice as a predominant staple food since the advent of green revolution. Although the scientific community is totally aware of its wonders as a source of minerals, protein and antioxidants, y*et al*one they cannot make a significant mark without an immense market demand. The red rice must evolve onto its journey as a gift of nature rather than ending as weedy and wild rice. Looking onto its health properties, it will be desirable to have processed food items such as puffed and flaked rice, coloured noodles and snack items prepared from red rice adding to its popularisation and commercialisation as an important food grain.

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