

Black rice anthocyanin content increases with increase in altitude of its plantation

Abstract

Black rice is the most nutritious heirloom rice landraces. A G60 black rice variety was grown in both terai and hill region of Nepal at 79meters and 1360meter altitude from mean sea level in 2015. The important rice qualities such as total anthocyanin content, caryopsis color, Calcium, and iron content were analyzed. It was observed that the anthocyanin content of black rice increased significantly with increase in altitude of its plantation site. The increase in anthocyanin content may be due to favorable environment and environment genotype interaction. This finding also indicates that some other rice quality may also increase with an increase in altitude of its plantation.

Keywords: black rice, anthocyanin, rice quality, genotype x environment, quality rice

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Introduction

Black rice is an heirloom rice landrace mostly grown in China, Korea, Japan, Thailand, Philippines and India.¹ This rice is highly rated in the market because of its huge nutritional value.² The main peculiarity of black rice is its anthocyanin which is both fat and water soluble. Earlier, it was believed that this rice enhance the longevity of life hence this rice is also known as long life rice. General people were forbidden to consume black rice except for emperors and nobles in China, thus this rice is popularly known as forbidden rice. There exists no other rice with a higher nutritional spectrum near black rice. This rice is free of gluten, free of cholesterol, low in sugar, salt, and fat. Black rice is a whole grain, super nutritious type of rice that is high in fiber, anthocyanin, antioxidants, vitamins B and E, iron, thiamine, magnesium, niacin and phosphorous. A huge number of scientific studies show that black rice powder is one of the nature's most well-balanced superfood and its abilities are truly remarkable. Black rice anthocyanins (BRACs) are extracted from the aleurone layer of black rice which is a major cereal crop existing since ancient times in China and other Eastern Asia countries.³ American Health Association, the American Cancer Society and the 2005 Dietary Guidelines for Americans recommended an increase in the consumption of black rice to prevent heart disease and certain kinds of cancers.⁴ Black rice contains many vitamins and minerals, including iron, vitamin A, and vitamin B, which are beneficial for overall health and the prevention of heart disease.⁵ The health benefits of black glutinous rice have recently been reported by several investigators. A recent report showed that anthocyanin supplementation in humans improves LDL and HDL levels⁶ and can delay cancer development in rodents models of carcinogenesis.⁷ The main purpose of this study was to compare the black rice quality in different altitudes.

Materials and methods

Black rice G60 variety was grown in both terai and hill region of Nepal maintaining different altitudes at summer season of 2015. First place was selected as Ramban Sarlahi located at 26°52'0N 85°34'0E with an altitude of 79meters (262 feet) in terai region and the second place was chosen as Khumaltar Lalitpur at an altitude of 1360meter above mean sea level on 27°40' N latitude and 85°20' E longitudes.

25-28 days old seedlings were transplanted in a 5mX2m area with a spacing of 15cmX15cm in normally irrigated condition of July 2015. Fertilizer was recommended @10:40:30kg/ha and @80:30:30kg/ha NPK for both terai and hill regions respectively. The basal dose was applied as 50% of total nitrogen content, full dose of phosphorus and potassium and the remaining was applied in split dose as a top dress after 1st wedding and at rice booting stage. Agronomic practices were done as per the recommended practices. Different major traits were measured such as days to maturity, plant height, panicle length and grain yield. Rice quality analysis was done in Food and Technology Division, NARC, Khumaltar, Nepal.

Determination of minerals

The total contents of calcium (Ca) and iron (Fe) were determined in extracts obtained upon mineralization in nitric acid (HNO₃ p.a.) with a concentration of 1.40 g·cm⁻¹ in a MARS 5 microwave oven (CEM Corporation, USA), in HP500 Teflon vessels (the parameters of the process, i.e., weight of analytical samples, volume of nitric acid, and temperature of the mineralization process complied with the US-EPA3051 Protocol). Total concentrations of the six analyzed metals were determined by using an inductively coupled plasma (ICP) atomic emission spectrometer (IRISIntrepidXSP11, Thermo, USA). The analysis by use of an ICP atomic emission spectrometer (ICP-AES) was conducted after preparing the standard calibration curves corresponding to each element. Mean and SD were calculated.

Results and discussion

The average days to rice heading and maturity of black rice were 83days and 129days at 1360meter height whereas days to heading and maturity at 79m were 7 days and 116days. The longer days to maturity in hill region may be due to low solar radiation and low growing degree days compared to terai region. Some other rice parameters like plant height and tiller number did not differ significantly from both sites. Similarly, the grain yield of different rice varieties also varies with different locations. Grain yield was found higher in high altitude compared to low altitude. The increase in grain yield in high altitude is due to longer duration of photosynthesis uptake by plants compared to terai region. Similar results were also found by Kushwaha et al.⁸

and Khakwani et al.,⁹ who suggested that highest paddy yields are obtained in early transplanting. The reason could be that this might be due genotype genetic superiority, an appropriate temperature for growth and development, nutrients absorption, the proper root system of the genotype and proper time of transplanting which leads to providing optimum duration for seed filling. The mineral content (Ca and Fe) of black rice from different two locations were analyzed and no significant difference was found from both altitude of plantations. But black rice possessed more Ca and Fe than other rice varieties. Kushwaha⁸ also reported that black rice contains a huge amount of minerals than other rice varieties. Chen et al.,¹⁰ reported that red and black rice both contained higher total phenols content than white rice. Therefore, it is reasonable to presume that the higher amounts of minerals in red and black rice derive from a phenolic compound

that promotes accumulation of divalent and trivalent minerals, such as Cu, Fe, Mg, and Zn. The color of black glutinous rice is caused by anthocyanins which are a group of reddish purple water-soluble flavonoids¹¹ located on pericarp, seed coat, and aleurone layer.¹² Major rice grain quality like total anthocyanin content and caryopsis color were also analyzed. It was found that Khumaltar (1360m) location (3.39) had significantly higher anthocyanin content than Ramban-Sarlahi (69m) location (2.03) (Table 1-4). The grain color was also visually observed and caryopsis color of high altitude rice was found darker than low altitude rice (light black) (Figure 1). Similar results were also reported by Kushwaha⁸ and Finocchiaro et al.,¹³ who reported that on average, the pigmented rice had a TAC four times higher than the white ones.

Table 1 Rice different parameters are taken during rice growing season of 2015 at 1360meter under high hill observation nursery trial at Agriculture Botany Division, Khumaltar, Nepal

S.No	Genotypes	Days to heading	Days to maturity	Plant height	Tiller number	Grain yield
1	Karo	99	140	118.8	11.2	6.07
2	Darmali	99	141	114.8	13	6.33
3	Salidhan	94	131	124	11.8	5.77
4	chandannath-3	89	131	125	13.6	4.56
5	Lekali-3	90	133	122.2	0	6.11
6	Black rice (G60)	83	129	57.6	0	3.81
7	98046-TR196-2-1-1	88	133	86.2	19	6.8

Table 2 Rice different parameters are taken during rice growing season of 2015 at 79meter level at Ramban Sarlahi Nepal

S.No	Genotypes	Days to heading	Days to maturity	Plant height	Tiller number	Grain yield
1	Karo	80	125	115.5	10	4.05
2	Darmali	82	122	110.8	11	4.33
3	Salidhan	85	118	112	10	5
4	chandannath-3	84	120	115	12	4.5
5	Lekali-3	83	116	121	14	6
6	Black rice (G60)	78	116	67	11	3
7	98046-TR196-2-1-1	82	119	89	13	4.8

Table 3 Content of two mineral elements in different locations with different varieties

Cultivars	Khumaltar (1360 meter)		Ramban (79 meter)	
	Ca (mg /100 g)	Fe (mg /100 g)	Ca (mg /100 g)	Fe (mg /100 g)
Blackrice G60	53.01±1.82h	5.90±1.43d	52.60±0.19a	5.02±4.41e
Karo	20.29±1.49c	10.35±2.15f	19±1.24b	8.35±4.03f
Darmali	53.27±54.74g	3.67±0.95c	51.80±0.21b	3.00±7.08g
Salidhan	20.34±1.33b	4.24±1.40b	18.02±0.38d	4.45±2.32b
Chandannath-3	20.56±3.16a	8.56±2.61e	19.21±3.37d	7.30±2.41h
Lekali Dhan-3	30.47±2.41f	4.24±0.97a	30.37±0.82bc	4.54±4.56c
98046-TR196-2-1-1	26.69±3.02e	1.44±0.76a	25.24±0.79b	1.04±1.30a

Table 4 Total anthocyanin content and caryopsis color of different rice varieties at different altitudes

Khumaltar (1360 meter)		Ramban (79 meter)		
Cultivars	Total Anthocyanin Content	Caryopsis Colour	Total Anthocyanin Content	Caryopsis Colour
Blackrice756	3.93±0.12a	Dark black	2.03±0.12a	Light Black
Karo	0.81±0.76d	White	0.81±0.76d	White
Darmali	0.76±0.69a	White	0.76±0.69a	White
Salidhan	0.69±0.71bc	White	0.69±0.71bc	White
Chandannath-3	0.02±0.34b	White	0.02±0.34b	White
Lekai Dhan-3	0.87±1.06c	White	0.87±1.06c	White
98046-TR196-2-1-1	0.38±0.03bc	White	0.38±0.03bc	White

**Figure 1** Black rice caryopsis color (1-light dark and 2-heavy dark) from 79m and 1360m altitude from mean sea level respectively.

Conclusion

Black rice is packed with high nutrition. Among several rice quality, anthocyanin is the one which causes black rice color black.

The results reveal that black rice anthocyanin content increase with an increase in altitude of its plantation with a favourable environment.

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None.

Conflict of interest

The author declares no conflict of interest.

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