



Research Article

ANALYSIS OF NUTRITIONAL AND COOKING QUALITY PARAMETERS OF RED RICE CULTIVARS USING SCANNING ELECTRON MICROSCOPE WITH EDAX

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Abstract- In Department Nano Science and Technology of Tamil Nadu Agricultural University and Department of Food Science and Nutrition a laboratory analysis was carried out to assess the cooking quality and elemental composition of four red rice cultivars. The red rice cultivars of Chandikar, Norungan, TKM 9 and TPS 1 grain samples were collected in Agricultural College and Research Institute Madurai and analyzed for its cooking quality and elemental composition. All the four-rice variety are short grains and medium slender in L/B ratio. Among the four varieties the two TNAU improved varieties had recorded the maximum hulling and milling percentage than the land races. The TNAU improved varieties recorded lower grain volume and bulk density than land races. Among the varieties, TPS 1 get cooked rapidly. Higher grain elongation and volume expansion ratio was observed with Chandikar variety. Higher carbohydrates, protein, fibre, fat, iron and zinc per cent of land races was noticed compared to improved red rice varieties. All the four varieties were with elements of C, N, O, K, M and Mo. Cultivar Norungan was had a special element namely Gd and in TPS 1 with Sm.

Keywords- Red rice, Cooking quality, Scanning electron Microscope and Nutritional rice

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Introduction

Rice has been the most important staple food for more than 60 per cent of the Indian population, who are also highly vulnerable to inflationary pressure due to rising rice price. More than half of the world populations use this cereal as staple food, mainly in developing countries. In Asia, rice is the main dietary source for energy, protein, thiamine, riboflavin, niacin, iron and calcium. Rice, one of the world's leading sources of nutrition for centuries, comes in hundreds of varieties and in many other colors besides the expected shades of brown. Several varieties of rice are an appealing red color. Red rice grain has a more complex taste and contains more nutritious, fiber-filled bran than many lighter-colored rice. Rice varieties with a red bran layer are called red rice. Red rice grain has a more complex taste and contains more nutritious, fiber-filled bran than many lighter-colored rice. Rice varieties with a red bran layer are called red rice. The colour is confined to the bran layer, a tinge of red remains even after a high degree of milling. The colour of the bran ranges from light red to dark red. The red bran layer contains polyphenols and anthocyanin, and possesses antioxidant properties. The inner portion of red and white rice is alike and white (Rood, 2000) [9]. The zinc and iron content of red rice is 2-3 times higher than that of white rice (Ramaiah and Rao, 1953) [8]. The change in food habits from traditional foods to junk foods has increased the risk of lifestyle-related health issues and diseases such as diabetes, cancer and heart problems. Red rice meets most of the requirements of a good and healthy food. Red rice is considered to be highly nutritive and medicinal without knowing the elemental composition of the red rice. To find out the elemental composition of this red rice the present study was carried out in Tamil Nadu Agricultural University.

Materials and Methods

The laboratory experiment was carried out in Department of Nano Science and Technology Laboratory, Tamil Nadu Agricultural University, Coimbatore during 2015. The four red rice Races of two traditional cultivars (Chandikar and Norungan) and two improved red rice varieties (TKM 9 and TPS 1) grain were collected from field of Agricultural College and Research Institute, Madurai and samples were analyzed for its surface features and elemental composition using SEM and SEM with EDXA. Here, a wide range of magnifications is possible, from 10 times (equivalent to that of a powerful hand-lens) to more than 5, 00,000 times. For taking images of sample, about 0.5 to 1.0 mg of sample was placed on the carbon conducting tape. Energy Dispersive X-Ray Spectroscopy (EDAX) is a chemical micro analysis technique used in conjunction with scanning electron microscopy (SEM). The EDAX technique detects X-Rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analyzed volume. The X-ray energy is characteristic of the element from which it was emitted. For recording the chemical composition of sample, about 0.5 to 1.0 mg of sample was dusted on the carbon conducting tape. Then the tape was mounted on the sample stage and the elemental composition of the samples was recorded using EDAX attached in the FEI ESEM model "QUANTA 250" available in the Department of Nano Science and Technology, Tamil Nadu Agricultural University, Coimbatore. The morphological, milling characteristics of grain and cooking quality parameters were analyzed from one hundred gram of dried (12 per cent moisture) paddy grain samples were dehulled in Satake dehulser and characterized by the methods described by Ali *et al.*, 1993 [1]. Cooking quality parameters was estimated by the method outlined by Juliano and Bechtel (1985) [3]. After harvest, Red rice grains were powdered by using pestle and mortar and made into a fine powder or rice flour. From the flour, Carbohydrate (Anthrone method), Protein (Micro kjeldahl), Fibre (Acid and alkali

titration), Fat (Soxhlet apparatus method), Iron and Zinc (Atomic Absorption Spectrophotometer) were analyzed.

Result and Discussion

The surface morphology of all four red rice varieties was examined. The grain shape was determined on the basis of the length to breadth ratio of the milled rice samples, while the grain appearance was ascertained on the basis of the kernel size, translucency and chalkiness of the rice kernels. The L/B ratio of above 3 is generally considered as slender. All the four red rice varieties had L/B ratio of less than 3 (Chandikar - 2.64, Norungan - 2.59, TKM 9 - 2.66 and TPS 1 - 2.66). Based on the observations of the selected rice varieties for shape reveals that all four varieties are medium slender. Similar results also reported by Saravanan (2014) [10] in red rice TPS 1 and TKM 9 and Thomas *et al.* (2013) [12] reported in brown rice land races [Table-1].

According to length, the grains of Chandikar (6.83 mm) and Norungan (6.57 mm) classified as long grains. The improved variety TKM 9 (5.35 mm) and TPS 1 (5.11 mm) classified as medium or intermediate rice grains. As per the kernels width all the four varieties are classified as short grains. This result was in conformity with Srivastava and Jaiswal (2013) [11] and Saravanan (2014) [10].

Table-1 Hulling and grain characteristics of selected red rice varieties

Varieties	Grain Length (mm)	Grain Width (mm)	L/B ratio
V ₁ -Chandikar	6.83	2.59	2.64
V ₂ - Norungan	6.57	2.42	2.59
V ₃ - TKM 9	5.35	2.01	2.66
V ₄ - TPS 1	5.11	1.90	2.68

Milling characteristics (per cent) of selected red rice varieties

The highest hulling per cent of 76.52 and milling per cent of 69.21 was noted in variety TPS 1 (V₄). Followed by variety TKM 9 (V₃) recorded the hulling per cent of 72.44 and milling per cent of 60.28. Among the two traditional varieties, Chandikar (V₁) recorded the maximum hulling (65.25 per cent) and milling percentage (57.35 per cent). The least hulling and milling per cent of 61.42 and 53.45, respectively, was recorded with Norungan (V₂). Higher whole grain recovery of 73.18 and 68.43 per cent was recorded with TPS 1 (V₄), and TKM 9 (V₃), respectively. Among the land races, the variety Chandikar (V₁) recorded the higher whole grain recovery of 63.92 per cent compared to Norungan (V₂) (60.42 per cent). The lowest milling loss of 10.31 and 13.16 per cent was recorded in variety TPS 1 and TKM 9, respectively. The traditional land race Norungan (V₂) found to have higher milling loss of 17.32 per cent when compared with Chandikar (15.85 per cent) [Table-2].

Table-2 Milling characteristics (per cent) of selected red rice varieties

Varieties	Hulling percentage	Milling percentage	Whole grain recovery (%)	Milling loss (%)	Grain volume (mm ³)	Bulk density (g ml ⁻¹)
V ₁ - Chandikar	65.25	57.35	63.92	15.85	3.86	2.04
V ₂ - Norungan	61.42	53.45	60.42	17.32	3.22	1.71
V ₃ - TKM 9	72.44	60.28	68.43	13.16	2.14	0.98
V ₄ - TPS 1	76.52	69.21	73.18	10.31	2.31	1.01

Among the improved varieties least grain volume of 2.14 mm³ was recorded in TKM 9 (V₃) and in TPS 1 (V₄) with 2.31 mm³. Among the land races, Norungan recorded the lower grain volume (3.22 mm³) compared to Chandikar (3.86 mm³). In general higher bulk density was recorded with land races. Among the red rice varieties the least bulk density of 0.98 and 1.01 g ml⁻¹ was recorded with TKM 9 (V₃) and TPS 1 (V₄), respectively. The land race Norungan recorded a bulk density of 2.04 g ml⁻¹ and Chandikar with 1.71 g ml⁻¹. This resulted in reduction of milling loss and higher whole grain recovery. Among the land races Chandikar recorded higher hulling and milling per cent than Norungan. This influenced on whole kernel recovery and reduction in milling loss of Chandikar. Pandey and Gupta (2000)

observed the milling characteristics of eighteen varieties of paddy grown in India. Variation in grain volume and bulk density was observed in all four red rice varieties. When compared to land races, improved varieties recorded lower grain volume and bulk density. This might be due to reduced grain length, width and L/B ratio of grains. Similar results were also reported by Saravanan (2014) [10] in red rice and Elsy *et al.* (1992) [2] in medicinal red rice variety Njavara.

Cooking quality parameters of selected red rice varieties

The variation in cooking quality parameters like, cooking time (minutes), water uptake (ml g⁻¹), loss of solids (per cent) volume expansion ratio and grain elongation ratio were also studied in all four red rice. The results revealed that higher cooking time of 45 and 40 minutes was taken by variety Chandikar (V₁) and Norungan (V₂), respectively. Among the improved varieties from TNAU, TKM 9 (V₃) required 35 minutes to get cooked completely and TPS 1 (V₄) with 33 minutes. Land races found to uptake more quantity of water during cooking and loss of solids. Land race Chandikar (V₁) observed with higher water uptake of 4.12 ml g⁻¹ and Norungan (V₂) with 4.03 ml g⁻¹ and solids loss of 4.07 and 3.71 per cent in Chandikar and Norungan. The lowest water uptake of 3.12 and 3.31 ml g⁻¹ was recorded in TPS 1 (V₄) and TKM 9 respectively and TKM 9 (3.03 per cent) found with higher loss of solids when compared with TPS 1 (3.17 per cent). Volume and grain expansion ratio was higher in land races compared to improved varieties. The maximum volume and grain expansion ratio of 7.12 and 2.26, respectively recorded in Chandikar (V₁). Variety Norungan (V₂) registered with volume expansion ratio of 6.68 and grain expansion ratio of 2.10. This might be due to longer cooking time resulted in higher water uptake for cooking. During cooking all the four cooked red rice kernels were split because of longer cooking time and fibre presence in red rice. Due to this splitting nature and longer cooking time both the land races found with increased loss of solids than TNAU improved varieties. The grain elongation ratio after cooking was higher in land race Chandikar than improved TPS 1. This might be due to higher uncooked grain length, width and L/B ratio. Similar results were also reported by Thomas *et al.* (2013) [12] [Table-3].

Table-3 Cooking quality parameters of selected red rice varieties

Varieties	Cooking time (min)	Water uptake (ml g ⁻¹)	Loss of solids (%)	Volume expansion ratio	Grain elongation ratio
V ₁ - Chandikar	45	4.12	4.07	7.12	2.26
V ₂ - Norungan	40	4.03	3.71	6.68	2.10
V ₃ - TKM 9	35	3.31	3.03	5.38	1.76
V ₄ - TPS 1	33	3.12	3.17	5.62	1.78

Biochemical Properties

The data relating carbohydrates, protein, fiber, fat, iron and zinc per cent of selected red rice varieties was studied [Table-4].

Table-4 Biochemical Properties of selected red rice

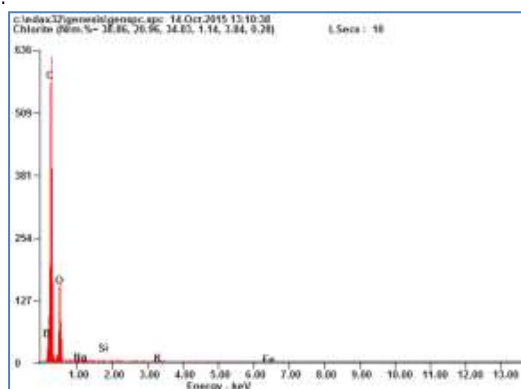
Varieties	Carbohydrates (%)	Protein (%)	Fiber (%)	Fat (%)	Iron (%)	Zinc (%)
V ₁ - Chandikar	71.08	6.75	2.12	2.31	5.41	3.54
V ₂ - Norungan	66.54	3.52	0.81	1.24	4.51	2.61
V ₃ - TKM 9	61.46	5.61	1.40	0.64	5.24	3.13
V ₄ - TPS 1	58.51	4.51	0.92	0.72	5.12	2.91

Among the red rice varieties higher carbohydrates, protein and fiber per cent of 71.08, 6.75 and 2.12 per cent was found in traditional red rice variety Chandikar (V₁). The lowest carbohydrates per cent of 58.51 was observed in TPS 1 (V₄). The lowest protein and fibre per cent of 3.52 and 0.81 per cent was recorded in variety Norungan (V₂). The variety TKM 9 (V₃) observed moderate per cent of carbohydrates (61.46 per cent), protein (5.61 per cent) and fibre (1.4 per cent). The higher fat per cent of 2.31 and iron per cent of 5.41 and zinc per cent of 3.54 was recorded in land race Chandikar (V₁). The lowest fat per cent of 0.64 was recorded in TKM 9 (V₃) followed by TPS 1 (V₄) with 0.92 per cent. Among the

varieties lower iron content (5.12 per cent) was recorded in TPS 1 and zinc (2.61 per cent) in Norungan (V_2). The moderate iron content of 5.24 per cent in TKM 9 and 4.51 per cent was recorded in Norungan. Similarly Krishnaprabu 2013 [4] and Rajalakshmi 2014 [7] were also reported the higher biochemical properties in eleven and five traditional red rice varieties, respectively. However, all the biochemical results the presence of iron and zinc was reported by several scientist, whereas SEM with EDAX not observed with iron and zinc peaks irrespective all the varieties.

Energy dispersive X-ray spectroscopy (EDAX)

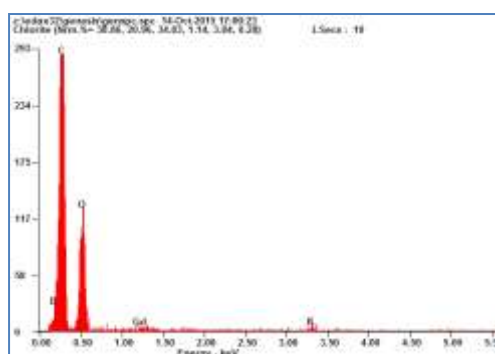
The EDAX data further confirmed the elemental composition of four red rice varieties [Fig-1, 2, 3 and 4]. The variety, Chandikar with maximum amount of carbon (68.87 per cent), oxygen (18.25 per cent) and also minimum amount of boron (12.88 per cent), Norungan with higher amount of carbon (65.59 per cent), oxygen (18.36 per cent) boron (13.36 per cent), potassium (1.41 per cent) and a special element gadolinium (0.78 per cent), TKM 9 with carbon (69.83 per cent), oxygen (13.66 per cent) boron (15.77 per cent), potassium (0.54 per cent), sodium (0.12 per cent) and silicon (0.08 per cent) and TPS 1 with carbon (69.80 per cent), oxygen (22.44 per cent), samarium (4.61 per cent), molybdenum (1.37 per cent), potassium (1.11 per cent), and copper (0.67 per cent). This indicates the nutrient richness of all the four red rice varieties. Besides the macro and micro elements, the variety Norungan contain a special element namely Gd and in TPS 1 with Sm. These two elements (Gd with an atomic number of 64 and atomic mass of 157.25) and Sm with (atomic number of 62 and atomic mass of 150.36) don't have any biological role but it's derivatives plays an important role in biomedicine research.



KV:10.00 TILT: 0.00 TAKE-OFF:37.86 AMPT:25.6 DETECTOR TYPE :SUTW-SAPPHIRE RESOLUTION :132.67

Element	Wt %	At %
B K	12.88	14.77
C K	68.87	71.09
O K	18.25	14.14
K K	00.00	00.00

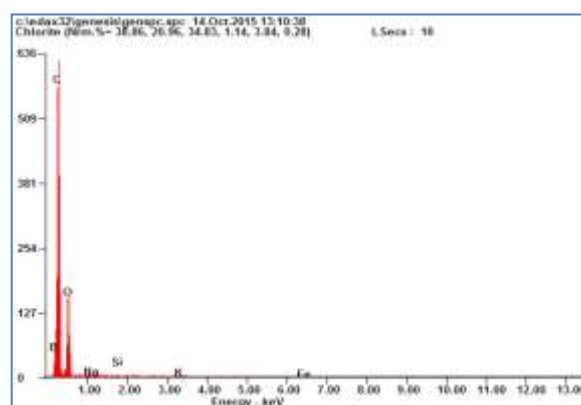
EDAX ZAF quantification standard less sec table : default
Fig-1 SEM-EDAX analysis report of red rice Chandikar grain



KV:10.00 TILT: 0.00 TAKE-OFF:37.75 AMPT:25.6 DETECTOR TYPE :SUTW-SAPPHIRE RESOLUTION :132.67

Element	Wt %	At %
B K	13.86	16.17
C K	65.59	68.85
O K	18.36	14.47
SmM	00.00	00.00
GdM	00.78	00.06
AlK	00.00	00.00
P K	00.00	00.00
MoL	00.00	00.00
K K	01.41	00.46

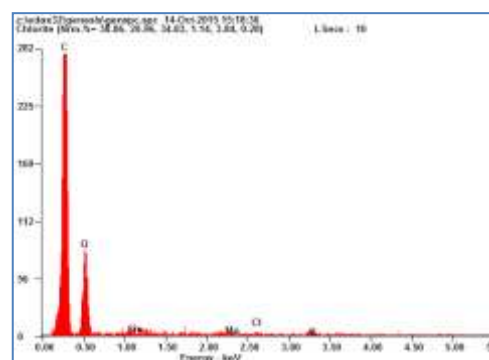
EDAX ZAF quantification standard less sec table : default
Fig-2 SEM-EDAX analysis report of Norungan grain



KV:10.00 TILT: 0.00 TAKE-OFF:35.03 AMPT:25.6 DETECTOR TYPE :SUTW-SAPPHIRE RESOLUTION :132.67

Element	Wt %	At %
B K	15.77	17.90
C K	69.83	71.35
O K	13.66	10.48
NaK	00.12	00.06
SiK	00.08	00.03
K K	00.54	00.17

EDAX ZAF quantification standard less sec table : default
Fig-3 SEM-EDAX analysis report of TKM 9 grain



KV:10.00 TILT: 0.00 TAKE-OFF:35.05 AMPT:25.6 DETECTOR TYPE :SUTW-SAPPHIRE RESOLUTION :132.67

Element	Wt %	At %
C K	69.80	79.54
O K	22.44	19.20
SmM	04.61	00.42
MoL	01.37	00.20
ClK	00.67	00.26
K K	01.11	00.39

EDAX ZAF quantification standardless sec table : default
Fig-4 SEM-EDAX analysis report of TPS 1 grain

Summary

The analyzed four red rice cultivar which was resulted 1.5 times in higher nutritional (carbohydrates, protein, fiber, fat, iron and zinc) than normal white rice, thus these traditional rice variety process some new important elements like Gd and Sm which was not found in other white rice varieties.

Application of research: The research of traditional red rice nutritional properties is much uses in discovering potential of our local cultivars and also the nutritional values of these cultivars. The resulted new elements of Gd and Sm importance and role food diet and other applications maybe studied in future for better utilisation of red rice cultivars

Research Category: Nutritional and cooking quality

Abbreviations:

TPS: Thiruppathisaram

TKM: Tirurkuppam

EDAX: Energy Dispersive X-Ray Spectroscopy

SEM: Scanning electron microscopy

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Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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