RESEARCH ARTICLE

Variability of Mineral Composition of Rice Landraces Collected from Maharashtra, India

V.K. Kauthale, S.M. Patil, A.D. Nalawade

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Abstract

Micronutrient malnutrition is one of the burning issues in the rice-based diet area throughout the world. The present study aimed at evaluation of the mineral composition of 77 rice landraces collected from various agro-climatic zones of Maharashtra. The hand-mill processed rice grains were analyzed for eight (Na, Mg, K, Ca, Mn, Fe, Co, Cu, and Zn) mineral content. Among the mineral contents, the iron content ranged from 2.05 to 12.2 mg/100g, calcium content from 39.2 to 238.47 mg/100g, manganese content from 1.53 to 7.54 mg/100g, copper content from 0.54 to 3.03 mg/100g and zinc content ranged from 2.65 to 11.62 mg/100g.The other minerals, like magnesium content in studied landraces, ranged from 81.72 to 278.56mg/100g, sodium content from 4.73 to 274.34 mg/100g, and potassium content from 148.05 to 670.74 mg/100g. Most of the studied landraces had wide range of variation, rich in minerals and could be a valuable source for bio-fortification of minerals through the breeding method.

Keyword: Landraces, Malnutrition, Mineral content, Rice.

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Introduction

Rice (*Oryza sativa* L.) is the most important cereal in the world, cultivated in a large area. It is a staple food for nearly half of the world's seven billion people (IRRI, 2013). Rice is low in fat and high in starchy carbohydrates, packed full of vitamins and minerals, and provides an excellent source of vitamin E, B vitamins (thiamine, niacin) and Potassium (Renuka *et al*., 2016). Unfortunately, rice is lacking many essential minerals as iron, zinc and vitamin A. Thus, a rice-based diet is the primary cause of micronutrient malnutrition throughout much of the developing world. Iron, zinc, and vitamin A deficiencies are common in rice-consuming regions (http://www.goldenrice.org/Content2-How/how6_mn.php). Micronutrient malnutrition resulting from the consumption of diets deficient in minerals, vitamins, and essential amino acids affects more than one-half of the world's population, especially women and children in developing countries (UNSCN, 2004, Datta *et al*., 2006). These deficiencies result in decreased work productivity, reduced mental capacity, stunting, blindness, increased child mortality, and elevated morbidity and mortality in general (http://www.goldenrice.org/Content2-How/how6_mn.php). One of the interventions against micronutrient malnutrition is the breeding of crops through conventional or genetic engineering to accumulate micronutrients in the edible portion (Stein, 2010). Various workers pointed out that the identification of genetic resources with high levels of targeted micronutrients is a necessary step to enhance micronutrient levels through conventional plant breeding (Ortiz-Monasterio *et al*., 2007; Bouis, 2000). The collection and characterization and screening for desirable characters become fundamental steps towards the genetic improvement of crops. The crop landraces are being served as a valuable gene pool as they contain locally adapted alleles and represent an irreplaceable bank of highly co-adapted genotypes (Qualset *et al.,* 1997).

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However, with the introduction of an industrial production system, crop diversity is the major victim. Therefore, conservation of this valuable gene pool is need of the hour. The objective of present work was to determine the mineral content of rice landraces collected from tribal areas of Maharashtra, India, which will reveal nutritive properties of these unexplored rice landraces and their possible use in breeding programs. Additionally, this study will contribute to the enrichment of food nutrition database.

Materials and Methods

The 77 landraces of rice have been collected from native farmers in Jawhar (Palghar), Akole (Ahmednagar), Junner (Pune), and Etapalli (Gadchiroli) blocks in Maharashtra. The field experiments were conducted during Kharif 2017 at village level *in-situ* conservation centers of BAIF Development Research Foundation, and seed samples were collected at crop harvest. The hand-mill processed seed samples collected from these *in-situ* centers were used for analysis. Grain samples were analyzed at the National Agri-Food Biotechnology Institute (NABI), Mohali, Chandigarh. Samples of 0.1 g were digested with 10 mL of ICP-MS grade nitric

acid and diluted to 50 ml with MQ water. After digestion, the solution was examined for eight elements (Na, Mg, K, Ca, Mn, Fe, Co, Cu, and Zn) content using Agilent 7700 series Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

Results and discussions

Results of the present study on eight mineral contents in 77 rice landraces showed that many rice landraces are with a wide range of minerals; the result of the analysis is given in Annexure 1. Figure 1 shows the landraces with higher levels of Fe (5 to 12.51 mg/100g), Na (50 to 274.34 mg/100g), Mg (140 to 278 mg/100g), K (350 to 670 mg/100g), Ca (85 to 238.47 mg/100g), Mn (4 to 7.53 mg/100g), Cu (1 to 3 mg/100g) and Zn (5 to 11.62 mg/100g) among studied 77 landraces.

The calcium content in studied landraces ranged from 39.2 to 238.47 mg/100g, and 31 landraces showed more than 85-mg/100g calcium. Among those landraces, *Khadkya* (238.47 mg/100 g), *Mahadi* (197.05 mg/100 g), *Hali kolpi* (194.98 mg/100 g), *Dangi–red* (180.82 mg/100 g) and *Varangal* (179.92 mg/100 g) were found with the highest calcium content. Thomas *et al*. (2015) reported 12.42 to 21.38 mg/100 g calcium in different rice varieties. The iron content in studied landraces ranged from 2.05–12.2 mg/100g. About 55 landraces found with more than 5 mg/ 100g of iron content. *Kalbhat* (12.21 mg/100 g), *Khadkya* (11.51 mg/100 g), *Jay-shriram* (11.37 mg/100 g), *Tornya* (9.64 mg/100 g) and *Masala* (8.98 mg/100 g) were found with highest iron content. Iron deficiency is the most common nutritional disorder in the world, affecting over 4 billion people, with more than 2 billion people, mainly in developing countries, actually being anemic [http://www.who.int/nut/ida.htm]. Improved rice varieties developed for higher iron, contains 19.8 to 37.5 ppm (1.98 to 3.75 mg/100g) iron (Ravindra Babu 2013). Among the transgenic lines developed by Krishnan *et al*. (2009), Fe content was recorded 21 mg/kg in the unpolished IR68144 and 15 mg/kg in BR29 and polished rice grains of IR68144 and BR29 it was 15 and 8.9 mg/kg, respectively. The results clearly showed that most of the studied landraces are superior in the matter of iron content.

The magnesium content in studied landraces ranged from 81.72 to 278.56mg/100g. The landraces *Tulshya* (278.56 mg/100g), *Lalkabara* (269.87 mg/100g), *Hali Kolamba* (268.94 mg/100g), *Ambemohar* (253.52 mg/100g) and *Gandha* (239.12 mg/100g) were found highest magnesium content. Out of studied 77 landraces, 42 landraces contained magnesium more than 140 mg/100g. The sodium content in studied landraces ranged from 4.73 to 274.34 mg/100g. Thirty-two landraces found more than 50 mg/100g sodium content. *Khadkya* (274.34 mg/100g), *Dhavalbhat* (193.18mg/100g), *Kamod* (173.48mg/100g), *Kirtibhat* (172.10 mg/100g) and *Varangal* (170.46mg/100g) landraces found with highest sodium content. The potassium content in studied landraces ranged from 148.05 to 670.74 mg/100g. *Tulshya* (670.74 mg/100g), *Ambemohar* (624.45 mg/100g), *Namoku* (608.12 mg/100g), DRK-2 (596.42 mg/100g) and *Lalkabara* (577.55 mg/100g) landraces found with highest potassium content. The 38 landraces were contained more than 350 mg/100g potassium. The manganese content in studied landraces ranged from 1.53 to 7.54 mg/100g. *Noon* (7.54 mg/100g), *Pitris* (7.52 mg/100g), *Tulshya* (7.43 mg/100g), *Kirtibhat* (6.65 mg/100g) and *Salbhat* (6.57 mg/100g) landraces found with highest manganese content. The 39 landraces contained more than 4 mg/100 g manganese.

The copper content in studied landraces ranged from 0.54 to 3.03 mg/100g. The 45 landraces contained more than 1 mg/100 g copper. *Sonphal* (3.03 mg/100g), *Hali kolpi* (2.25 mg/100g), *Raibhog* (2.06 mg/100g), *Kalbhat*(2.05 mg/100g) and *Garikolapi* (1.95 mg/100g) landraces found with highest copper content. Renuka *et al*. (2016) reported vast variation in 39 rice varieties in respect to zinc content (25µg/g to165 µg/g).

The zinc content in studied landraces ranged from 2.65 to 11.62 mg/100g. *Khadkya* (11.62 mg/100g), *Noon* (10.57 mg/100g), *Sonphal* 9.57 mg/100g), *Kirtibhat* (9.32 mg/100g) and *Varangal* (7.68 mg/100g) landraces found with highest zinc content. The 49 landraces contained more than 5 mg/100g zinc. Deb *et al*., (2015) reported 2.4 to 44.9 mg/kg (0.24 to 4.49 mg/100g) zinc content in 130 rice landraces except *for Garibsaal*, which is known for its medicinal properties in gastro-intestinal ailments, contains extraordinary amount (155 mg/kg) of zinc. In the present study, also few landraces like *Khadkya* (11.62 mg/100g) *Noon* (10.57 mg/100g) and *Sonphal* (9.57 mg/100g) contain higher zinc. The rice landraces with overall higher mineral contents are depicted in Table 1. *Tulashya* and *Khadkya* contain an overall

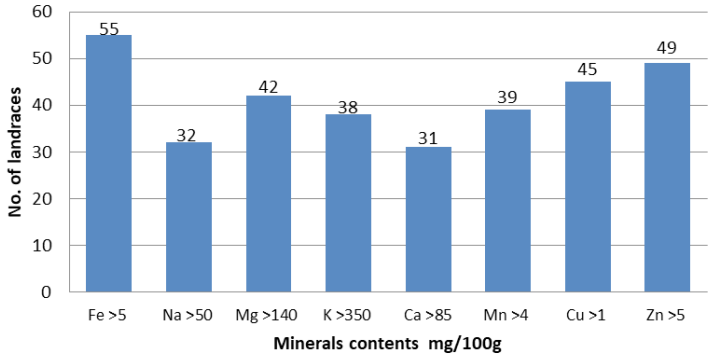

Figure 1: Number of rice landraces with high levels of minerals in grains

Table 1: Selected rice landraces with highest mineral contents in studied samples (mg/100g)

Landraces	*Iron*	*Sodium*	*Magnesium*	*Potassium*	*Calcium*	*Manganese*	*Copper*	*Zinc*
Ambemohar	7.24	156.81	253.52	624.45	109.55	6.14	1.61	6.50
Hali Kolamba	5.90	136.74	268.94	560.47	102.80	5.00	1.80	7.08
Kirtibhat	5.16	172.10	198.52	476.46	138.24	6.65	1.58	9.32
Sonphal	7.73	21.84	237.76	531.05	79.18	3.50	3.03	9.57
Tulshya	8.08	144.28	278.56	670.74	94.88	7.43	1.79	7.25
Khadkya	11.51	274.34	228.51	517.83	238.47	5.30	1.87	11.62
Kalbhat	12.21	125.21	205.80	524.31	92.94	5.16	1.70	5.45
Varangal	4.20	170.46	169.30	311.38	179.92	3.90	1.72	7.68
Malghudya	8.52	137.67	147.51	290.64	139.41	2.54	0.93	5.23
Kalbhat	12.21	125.21	205.80	524.31	92.94	5.16	1.70	5.45

higher amount of most of the minerals among the studied landraces.

Several traditional rice varieties are considered in folk medicine to have high nutritive and therapeutic value and found rich in minerals (Deb *et al*., 2015). The indigenous traditional knowledge indicated that collected landraces are being utilized for various purposes like diet for nursing mothers (*Malgudya*, *Rajgudya*, *Dhavul*), fracture recovery (*Mahadi*), weakness recovery (*Dangi-red*, *Kasbai*) etc. However, these community claims need to be scientifically validated.

Conclusions

The present study reported a wide range of mineral accumulation, including Cu, Fe, Mn, Zn and Mg in hand-milled seeds of 77 rice landrace. This has indicated that there is a good scope to locate and promote such high mineral-rich varieties for cultivation and human consumption. The outcome of the study will also facilitate plant breeders to choose desired parents for a breeding program to articulate the nutrient-rich varieties and address the malnutrition aspect in regards to most of the cereal crops.

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Annexure 1: Mineral contents in studied rice landrace samples (mg/100g)

Landrace name	Fe	Na	Mg	K	Ca	Mn	Cu	Zn
Chimansal	3.10	9.75	119.08	252.42	42.83	4.62	0.73	2.65
Zini (midlate)	2.73	52.35	100.31	213.97	76.19	2.26	0.67	3.10
Zini early	3.95	58.35	83.93	148.05	96.70	1.65	0.76	3.43
Ehawanji	3.85	5.20	121.20	334.02	42.05	2.52	0.60	3.61
Sapari	3.54	6.06	93.11	359.61	49.19	2.50	0.94	3.66
DRK-1	3.73	7.09	101.34	296.45	64.64	3.13	0.76	3.81
Kasbai	5.22	7.83	141.28	329.71	71.00	4.39	0.94	3.89
DRK-2	4.40	12.23	184.97	596.42	61.26	5.58	0.92	3.89
Yeremalunchi	3.60	7.53	110.79	455.25	48.41	3.37	0.71	4.07
Katewanji	4.31	5.69	139.65	446.14	39.20	4.42	1.08	4.08
Kasvel	3.64	33.37	123.22	240.57	75.54	3.08	0.77	4.09
Karaj	4.77	5.02	141.18	405.62	53.74	4.43	0.90	4.18
Wada zini	2.42	80.00	107.11	195.20	139.02	3.03	0.54	4.18
Lalya	2.83	125.02	153.94	257.67	131.36	2.83	0.79	4.26
Mothilunchi	5.11	8.89	135.79	348.10	53.61	4.03	0.84	4.28
Yerkusuma	3.27	7.22	82.14	223.21	39.98	2.06	0.71	4.29
Dhndhune	2.05	100.18	121.80	208.77	103.84	2.71	1.44	4.33
Sagg	3.79	101.02	132.80	231.26	133.44	5.24	0.86	4.36
Kavala	5.83	71.47	110.17	192.06	117.08	3.47	1.09	4.38
Vakvel	8.53	19.10	148.02	328.70	61.52	2.83	1.54	4.49
Javyachi gundi	3.40	9.67	131.63	323.04	42.18	3.55	1.31	4.56
Kolpi(mid late)	3.50	160.04	103.85	186.48	119.42	3.28	0.89	4.60
Godal	4.58	5.19	183.91	518.34	53.09	6.50	0.91	4.63
Pandharilunchi	5.59	6.77	116.47	284.47	60.87	3.45	0.84	4.88
Padarvanji	4.34	6.42	119.55	317.53	59.19	3.37	1.12	4.90
Lalluchi	3.89	6.53	133.79	304.20	54.39	3.35	0.76	4.94
Tornya	9.64	8.15	160.88	360.15	48.15	4.32	1.40	4.97
Suratikolam	5.64	12.25	141.80	340.73	77.23	4.32	1.44	4.98
Juna 57	4.69	121.05	201.96	530.02	65.55	4.45	1.82	5.01
Masala	8.98	80.50	136.23	252.71	100.86	3.94	1.00	5.05
Ashvini	3.67	119.72	180.93	466.63	74.25	4.90	1.70	5.19
Kalbhat	6.30	134.54	114.99	358.25	86.45	3.80	2.05	5.23
Malghudya	8.52	137.67	147.51	290.64	139.41	2.54	0.93	5.23
Selkavanji	4.18	4.73	108.59	264.11	47.89	3.36	1.34	5.24
Masura	5.63	84.79	172.47	367.33	107.09	4.20	0.74	5.27
Raatbhat	4.06	17.33	98.71	213.72	55.16	3.61	1.04	5.28
Kate chenur	5.99	14.67	188.68	502.70	76.84	5.55	0.94	5.30
Garikolapi	5.07	135.94	126.47	334.84	89.82	1.53	1.95	5.34
Nanded chennur	6.29	20.93	150.65	337.43	98.65	5.12	0.79	5.34
Rajghudya	8.02	18.80	149.62	356.50	106.96	4.06	0.99	5.36
Raibhog	8.43	127.79	153.58	407.05	78.92	2.66	2.06	5.38
Khodakhuri	5.03	8.32	135.27	274.29	74.76	3.92	0.78	5.38
Jiri zini	3.89	120.25	135.65	346.55	83.07	6.05	1.63	5.41
Kalbhat	12.21	125.21	205.80	524.31	92.94	5.16	1.70	5.45
Dhavalbhat	3.05	193.18	143.00	215.03	162.00	2.49	0.77	5.46
Kokade	5.31	4.88	120.86	326.21	52.57	3.57	0.87	5.61
HMT	3.95	13.11	81.72	221.57	56.46	3.33	1.39	5.69
Reganal lunchi	5.04	10.77	108.06	385.84	62.04	2.71	0.74	5.77
Juna kolam	4.50	11.55	113.84	291.80	71.00	5.60	1.25	5.89

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Jaymahadev	4.27	10.81	151.16	452.47	60.75	5.62	0.98	5.90
Jirvel	7.90	135.33	165.38	434.71	111.50	2.50	1.69	5.97
Sodui	4.15	15.58	182.79	411.74	66.07	4.00	0.96	6.14
Kamal bhat	5.45	140.60	156.97	396.10	83.20	3.96	1.53	6.16
Kamod	4.35	173.48	181.68	411.51	91.25	4.10	1.39	6.19
Sadhana bhat	3.52	124.49	134.48	325.73	62.69	3.58	1.52	6.22
Mahadi (midlate)	6.00	44.66	139.44	262.61	197.05	4.20	1.27	6.27
Dula-2	4.74	24.85	150.93	362.58	56.33	5.26	1.48	6.28
Nanded-92	4.49	15.90	128.21	382.08	91.38	4.24	1.16	6.30
Vijay Nanded	4.37	16.79	121.47	324.14	78.14	3.73	1.04	6.35
Goti	7.20	7.34	212.83	517.56	69.96	4.97	1.27	6.42
Ambemohar	7.24	156.81	253.52	624.45	109.55	6.14	1.61	6.50
Gandha	4.57	7.00	239.12	564.77	61.78	5.87	1.36	6.57
Dangi (red)	3.00	136.99	143.90	293.41	180.82	4.46	1.33	6.59
Lalkabara	6.60	5.12	269.87	577.55	50.88	6.06	1.18	6.63
Salbhat	8.91	10.03	185.27	409.15	54.12	6.57	1.18	6.76
Namoku	6.14	5.99	210.69	608.12	71.13	5.43	1.23	6.78
Pacheki	6.52	125.20	185.85	316.66	146.94	3.84	0.97	7.00
Pitris	5.12	6.95	221.42	496.03	80.61	7.52	1.20	7.02
Hali kolamba	5.90	136.74	268.94	560.47	102.80	5.00	1.80	7.08
Tulshya	8.08	144.28	278.56	670.74	94.88	7.43	1.79	7.25
Jayshriram	11.37	40.18	189.98	481.45	136.17	5.67	1.12	7.39
Hari kolpi	5.26	117.41	187.46	385.69	194.98	2.75	2.25	7.58
Varangal	4.20	170.46	169.30	311.38	179.92	3.90	1.72	7.68
Kirtibhat	5.16	172.10	198.52	476.46	138.24	6.65	1.58	9.32
Sonphal	7.73	21.84	237.76	531.05	79.18	3.50	3.03	9.57
Noon	7.73	7.03	204.11	487.97	88.52	7.54	1.18	10.57
Khadkya	11.51	274.34	228.51	517.83	238.47	5.30	1.87	11.62
Range	2.05 -12.21	4.73-274.00	81.71-278.00	148.04-670.00	39.19-238.47	1.53-7.53	0.53-3.03	2.65-11.62