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Assessment of genetic pameters for Yield and nutrional traits in rice (*Oryza sativa* L.)

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Abstract

The present investigation was undertaken with 30 rice genotypes to study the variability, heritability and genetic advance as per cent of mean for yield and nutritional traits. Analysis of variance revealed presence of significant variability among the germplasm. High estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was recorded for number of productive tillers plant^{-1}, yield plant^{-1}, 100 grain weight, kernel length/breadth ratio, zinc content, iron content, amylose content, total antioxidant activity and total soluble phenol content indicating large amounts of variation among the set of germplasm. High heritability coupled with high genetic advance as percent of mean was observed for plant height, number of productive tillers plant^{-1}, panicle length, yield plot^{-1}, 100 grain weight, kernel length/breadth ratio, protein content, Zn content, Fe content, amylose content, total antioxidant activity, total soluble phenol content and phytate content revealing that these traits are mostly under the control of additive gene action and these characters may be improved by simple phenotypic selection. High heritability with moderate genetic advance was recorded for days to 50% flowering, spikelet fertility, total starch content and glycemic index appear to be under the control of non-additive gene action.

Keywords: variance, heritability and genetic advance, glycemic index, phytate

Introduction

Rice is the world's most important food crop and a primary food source for more than one third of world's population. It is the crucial dietary and food security source for people of many Asian countries. The essence of plant breeding lies in the creation of genetic variation which is a prerequisite for any crop improvement programme. India has a rich and wide range of genetic wealth of rice. It has been estimated from various surveys that nearly 50,000 of rice is still being grown in the country (Patra, 2000) [12]. With the introduction of high yielding varieties and new technologies become a great threat to the security of the age-old practice of growing traditional varieties and landraces which may have immense potential for different important traits (Raut, 2003) [4]. Increased health consciousness among the rice consumers has resulted in greater attention to the genotypes containing higher levels of bioactive compounds, such as antioxidants and phenols. Nowadays, whole grain pigmented rice has been categorized as one of the potent functional foods since, it contains high amounts of phenolic compounds (Yawadio *et al.,* 2007) [24]. In addition, colored rice contains higher levels of proteins, vitamins and minerals compared to common white rice. Red rice is reported to be a good source of fibre, antioxidants, magnesium and iron. A thorough knowledge on nature and magnitude in the genetic variability and association of characters of a species is a pre-requisite for an effective breeding programme. In this context, the present study was takenup to assess the genetic parameters for the yield and nutritional content of traditional coloured as well as white rice genotypes collected from the farmers of different districts of Telangana.

Materials and Methods

The 30 genotypes used in the present study were collected from farmers of different districts of Telangana. Among the 30 genotypes, 17 genotypes (Narayana kamini, Sammel bhog, Chintaluri sannalu, Arakuloya, Ambemohar, Kalajira, Badsha bhog, Ghani, Parimala sanna, Tulasi baso, Ramsri, Doddiga, Sannajajulu, Ramyagali, Bahurupi, Ratnachudi, Mysore malliga) were of white pericarp type and remaining 13 were coloured, of which three were light brown (Ranikanda, seelamsanna, Illapaipu samba), two were light red (Mappillaisamba, Madumurangi), five were red (Pancharatna, Poongar, Kulakar, Navara, Pathariya) and three were dark purple (Kalabhatt, Burma black, Karuppu kavuni). All the 30 genotypes were grown at Agricultural College Farm, Bapatla during *Kharif* 2018 on separate raised nursery beds. Thirty days old seedlings were transplanted in the main field laid out in Randomized Block

Design (RBD) with three replications. Each genotype was transplanted separately in 5 rows of 3 m length by adopting a spacing of 20 cm between rows and 15 cm between plants. All the necessary precautions were taken to maintain uniform plant population of each genotype per replication. The intercultural operations were done at regular intervals and necessary plant protection measures were adopted during the crop growth. Observations were recorded on five randomly chosen plants of each genotype per replication for plant height (cm), days to 50% flowering**,** number of productive tillers plant $^{-1}$**,** panicle length (cm), spikelet fertility (%), yield plot^{-1} (Kg), 100 grain weight (g), kernal length/breadth ratio, protein content (%), Zn content (µgg^{-1}), Fe content (µgg^{-1})**,** total starch content (%)**,** amylose content (%)**,** total antioxidant activity (mg AAE 100g^{-1})**,** total soluble phenol content (mg 100g^{-1}), glycemic index and phytate content (mg 100g^{-1}). Phenotypic and genotypic coefficients of variation (GCV and PCV) were computed according to Burton and Devane (1953) [2]. Heritability in broad sense was estimated as per Allard (1960) [1] and genetic advance was estimated as per the formula proposed by Johnson *et al.* (1955) [7]. GCV and PCV were categorized into low: less than 10%, moderate: 10-20% high: More than 20%, as suggested by Subramanian and Menon (1973) [18]. Heritability estimates were categorized according to Johnson *et al.* (1955) [7], low :0–30%, moderate: 31-60% and high :Above 60%, The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al.* (1955) [7] Low : Less than 10% Moderate :10- 20% and high : More than 20%.

Results and Discussion

Analysis of variance (Table 1) revealed significant differences among the genotypes for all the characters indicating presence of sufficient variability among the genotypes, thus, the possibility genetic improvement through selection is highly promising. High variability of breeding materials will increase the probability of producing desirable recombinants in successive generations. Similar results were reported by Rashid *et al.* (2017) [13]. Mean performance of the 30 genotypes studied for yield and nutritional traits are presented in Table 2. Among the 17 characters studied, wide range of variation was observed for plant height (81.4 to 184.2), total soluble phenols (52.6 to 252.9) total antioxidant activity (20.09 to 122.40), phytate content (308.96 to 572.87) and amylose content (4.73 to 34.6).

In the present study all the coloured rice genotypes exhibited high amount of total soluble phenol content and antioxidant activity than white rice genotypes. Among the coloured rice genotypes, dark purple genotype Kalabhatt (109.43 mg), and red colour genotypes Pancha ratna (122.4 mg), Poongar (112.12 mg), Kulakar (114.33 mg) exhibited high amount of total antioxidant activity. Similarly, Tian *et al*., 2004 [21] reported high total antioxidant activity in red and black rice genotypes than light brown rice genotypes. The phenolic compounds are mainly associated with the pericarp in rice and the grains with darker pericarp colour such as red and black contain higher amount of polyphenols (Itani and Ogawa, 2004) [5]. The concentration of total phenolics in the grain is positively associated with antioxidant activity (Itani *et al.*, 2002) [6] with potential beneficial effects on health, such as reduction of oxidative stress (Hu *et al*., 2003) [14] Since, high amount of total soluble phenolic compounds is a desirable trait, the dark purple genotypes in the present study, Kalabhatt (252.99 mg), Burma black (243.59 mg), Navara (236.56 mg), and Karuppu kavuni (204.26 mg), and red colored genotypes Pancharatna (139.84 mg) Mappillai samba (128.35 mg) and Poongar (124.10 mg), recorded high amount of phenolic compounds than brown pericarp and white coloured genotypes. Among coloured genotypes, high iron content was reported in Seelam sanna (40.79 µg g^{-1}) and Panch ratna (38.73 µg g^{-1}) while, high zinc content was reported in Ranikanda (31.45 µg g^{-1}).

Phytic acid is an anti-nutritional factor which bounds to micronutrients like Fe and Zn and prevent their absorption. This results in nutritional deficiencies. Hence, the genotypes with low phytate content are desirable because of its anti-nutritional property. In the present study, Badsha bhog is a white coloured genotype recorded lowest phytate (308.96 mg) content. Whereas, Madumurangi is a red coloured rice genotype exhibited low phytate content (341.73 mg). Further, Kulakar is red coloured rice recorded low amylose content (21.07%). Similarly, intermediated amylose content (24.81%) coupled with high protein content (14.13%) was recorded in Mappllai samba, which is also light red coloured genotype.

Foods with Glycemic Index (GI) lower than 55 are called as low GI foods. Low GI foods are safe for diabetic patients, as they result in a gradual and steady rise in blood sugar. Among the coloured rice genotypes, low glycemic content was recorded in the red pericarp genotype Kulakar (52.28%), dark purple coloured genotype Karuppu kavuni (52.29%) and brown pericarp genotype Badsha bhog (54.19%).

Among the coloured rice genotypes, Mappllai samba (4.29 Kg; 3.41g) and Karuppu kavuni (4.16 Kg; 2.95g) and Madumurangi (3.62 Kg; 2.66g) recoreded high yield per plot and 100 grain weight whereas, the genotypes Navara (96.51%) and Pancha ratna (92.63%) recorded high per cent of spikelet fertility.

Among white rice genotypes, Ramyagali recorded high protein (12.39%), Badshabhog recorded high zinc (35.45 µg g^{-1}), Tulasibaso has high iron content (61.68 µg g^{-1}). Further the genotype Badshabhog recoreded low glycemic index (54.19) as well as low phytate content (308.96 mg). In case of yield related traits Arakuloya (20.8), Chintaluri sannalu (18.56) recorded high no of productive tillers; Sammelbhog (32.33 cm) and Sannajajulu (31.00 cm) recorded high panicle length. Among the grain quality traits, Mysore malliga (23.74%), Ambemohar (23.65%), Badshabhog (20.5%), Ramyagali (20.07%) recorded intermediate amylose content which, is very desirable, since amylose content determines the texture of cooked rice and rice varieties with intermediate amylose content have a fluffy texture after cooking which is highly preferred by the consumers.

The genetic parameters namely PCV, GCV, heritability and genetic advance as percent of mean for the 17 yield and nutritional traits studied are presented in Table 3. A perusal of these results revealed highest phenotypic and genotypic coefficient of variation for total antioxidant activity (55.25 and 50.83 respectively), while glycemic index manifested the least values (7.83 and 7.72 respectively). The estimates of heritability ranged from 68.00 (spikelet fertility) to 99.40 (Days to 50% flowering). The maximum value for genetic advance as percent of mean was observed for Iron content (83.28) followed by yield per plot (72.75), amylose content (66.55) and 100 grain weight (64.42).

High PCV and GCV was recorded for the traits *viz*., number of productive tillersplant^{-1}, yield plant^{-1}, 100 grain weight, kernel length/breadth ratio, zinc content, iron content, amylose content, total antioxidant activity and total soluble phenol content indicating that large amount of variation is present among the germplasm. Whereas, low PCV and GCV was recorded for the characters days to 50% flowering, starch content and glycemic index representing less variation among the germplasm with respect to these traits. The coefficient of variability studies indicated that the estimates of PCV were slightly higher than the corresponding GCV for all the characters, indicating that these characters were less influenced by the environment. Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits. Similar estimates of slightly higher PCV than GCV were reported earlier by Ravindrababu *et al.* (2012) [15], Tiwari *et al.* (2019) [22], Sudeepthi *et al.* (2020) [19] and singh *et al.* 2020 [17].

In general, the characters that show high heritability with high genetic advance are controlled by additive gene action (Panse and Sukhatme, 1957) [11] and can be improved through simple or progeny selection methods. Selection for the traits having high heritability coupled with high genetic advance is likely to accumulate more additive genes leading to further improvement of their performance. High heritability combined with high genetic advance as per cent of mean was observed for plant height, number of productive tillers plant^{-1}, panicle length, yield plot^{-1}, 100 grain weight, kernel length / breadth ratio, protein content, Zn content, Fe content, amylose content, total antioxidant activity, total soluble phenol content, phytate content. Thus, these traits are mainly under the control of additive gene action and hence these characters may be improved by following simple selection. High heritability with moderate genetic advance was recorded for days to 50% flowering, spikelet fertility, total starch content and glycemic index appear to be under the control of non-additive gene actions. Hence, instead of simple selection, other methods like heterosis breeding or recurrent selection could be better alternative methods for improvement of these traits. Similar results were also reported by Umesh *et al.* (2015) [23], Nandini *et al.* (2017) [9], Devi *et al.* (2017) [3] and Mamata *et al.* (2018) [8], High GCV and PCV coupled with high heritability and high genetic advance as percent of mean were observed for number of productive tillersplant^{-1}, yield plot^{-1}, 100 grain weight, kernel length/breadth ratio, zinc content, iron content, amylose content, total antioxidant activity and total soluble phenol content suggesting an additive type of gene action. Hence, good response to selection can be attained for improvement of these traits. The findings are in conformity with the reports of Sri Devi *et al.* (2019) [10] for test weight, Sundaram *et al.* (2019) [20] zinc and iron content; and Sangamithra *et al.* (2018) [16] for total phenol content and total antioxidant activity.

Conclusion

Genotypes with high nutritional content as well as good yield potential reported in the present study are Mappillai samba, high yield (4.29 Kg), protein content (14.13%), antioxidant (98.37 mg 100g^{-1}) and high phenol contents (128.35 mg 100g^{-1}); Parimalasanna and Tulasi baso recorded high Zn and Fe contents (47.45µg g^{-1}, 61.68 µg g^{-1}) respectively. Pancharatna is a red pericarp coloured genotype recorded high antioxidant activity (122.40 mg 100g^{-1}) and phenol content (139.84 mg 100g^{-1}). Karuppukavuni a dark purple coloured genotype recorded high yield (4.16 Kg), along with low glycemic index (52.29) and high phenol content (204.26 mg 100g^{-1}). Kulakar is another red rice genotype recorded low glycemic index (52.28), intermediate amylose content (21.07%), high phenol content (121.65 mg 100g^{-1}) and antioxidant activity (114.33 mg 100g^{-1}). Hence, hybridization between the above genotypes may be carried out to obtain desirable seggregants with good nutritional properties coupled with high yield potential. Further, the characters number of productive tillersplant^{-1}, yield plot^{-1}, 100 grain weight, kernel length/breadth ratio, zinc content, iron content, amylose content, total antioxidant activity and total soluble phenol content controlled by an additive type of gene action suggesting that these characters can be improved by simple selection.

Table 1: Analysis of variance for yield, yield components and nutritional characters among 30 genotypes of rice (*Oryza sativa L.*)

	Source	Mean sum of squares		
		Replications	Treatments	Error
	Degree of freedom	2	29	58
1	Plant height (cm)	15.175	1402.364*	5.3602
2	Days to 50% flowering	0.8111	163.6077*	0.3054
3	Number of productive tillers plant^{-1}	2.574	25.569*	1.07605
4	Panicle length (cm)	0.506	55.8669*	0.4211
5	Spikelet fertility (%)	16.526	189.7612*	25.718
6	Yield per plot (Kg)	0.045	2.0217*	0.0157
7	100 grain weight (g)	0.000502	1.1219*	0.00019
8	Kernal length/breadth ratio	0.001023	1.1017*	0.00854
9	Protein content (%)	0.0362	13.5387*	0.01234
10	Zn content (µg/g)	3.957	138.0167*	1.5314
11	Fe content (µg/g)	15.148	333.6802*	6.5261
12	Total starch content (%)	0.0487	92.094*	0.0828
13	Amylose content (%)	0.0823	147.4006*	0.0331
14	Total antioxidant activity (mg AAE/100 g)	0.0429	3194.148*	0.0669
15	Total soluble phenol content (mg/100g)	0.169	9827.0916*	0.0547
16	Glycemic Index	1.777	64.573*	0.5797
17	Phytate content (mg/100g)	4.549	12637.314*	1.5164

* Significant at 5% level

Table 2: Mean performance of rice (Oryza sativ a L.) genotypes for yield and nutritional characters

S.No.	Character	Plant height (cm)	Days to 50% flowering	Number of productive tillers per plant	Panicle length (cm)	Spikelet fertility (%)	Yield per plot (Kg)	100 grain weight (g)	Kernal Length / Breadth ratio	Protein content (%)	Zn content (μgg^{-1})
1	Narayanakamini	139.26	96.00	12.63	19.86	80.71	2.16	1.60	3.27	10.13	30.54
2	Ranikanda	147.50	98.00	10.43	26.56	55.35	1.68	1.81	3.05	11.02	31.45
3	Sammelbhog	145.10	86.00	11.43	32.33	84.46	1.89	1.44	2.00	11.98	11.51
4	Chintalurisannalu	81.40	85.00	18.56	22.76	94.81	1.62	1.30	3.60	8.18	20.23
5	Selamsanna	145.13	89.00	10.40	22.53	88.39	1.86	1.35	3.03	6.45	20.83
6	Arakuloya	145.46	79.00	20.80	19.46	76.63	2.18	2.01	2.62	11.44	21.11
7	Ambemohar	143.63	85.00	10.46	27.46	85.99	1.19	1.30	2.69	12.30	25.62
8	Pancharatna	134.60	81.00	8.96	20.66	92.63	2.53	2.13	2.75	10.40	22.54
9	Kalajira	143.63	85.00	10.96	25.26	80.48	2.05	1.85	3.30	10.33	34.32
10	Kalabhatt	147.50	94.00	12.80	23.76	85.35	2.31	2.04	2.28	8.80	23.00
11	Badshabhog	124.86	95.00	11.30	26.86	73.21	1.72	1.40	1.90	7.92	35.45
12	Poongar	121.86	82.00	12.50	24.00	87.89	2.72	2.81	2.31	4.74	20.22
13	Ghani	119.40	80.00	11.76	23.83	90.69	2.04	1.85	1.81	12.07	19.73
14	Parimalasanna	159.40	97.00	13.90	27.46	79.30	1.23	1.10	1.96	11.84	47.45
15	Tulasibaso	146.00	93.00	12.86	27.00	87.34	1.73	1.25	2.09	11.93	24.10
16	Ramsri	102.43	76.00	11.83	17.20	80.62	1.53	1.70	2.56	6.39	21.31
17	Doddiga	155.40	87.00	7.73	26.96	90.09	3.30	2.55	1.62	11.13	19.68
18	Mappillai samba	170.50	86.00	9.26	26.46	87.97	4.29	3.41	2.01	14.13	20.92
19	Sannajajulu	121.06	93.00	10.03	31.00	82.87	1.94	1.65	4.50	7.53	21.50
20	Illapaipu samba	118.10	90.00	10.40	26.00	82.68	1.43	1.35	2.80	10.01	23.10
21	Burma black	157.53	95.00	9.63	27.33	87.06	3.56	2.75	2.42	10.18	20.49
22	Ramyagali	131.93	80.00	10.30	16.40	92.17	2.68	2.75	2.50	12.39	27.74
23	Karuppukavuni	172.23	105.00	14.83	25.33	87.93	4.16	2.95	2.53	9.06	29.13
24	Kulakar	117.76	77.00	12.60	16.00	81.38	1.38	1.74	2.21	11.58	21.13
25	Bahurupi	164.13	76.00	12.10	23.23	71.95	2.33	2.05	2.37	11.33	17.58
26	Ratnachudi	145.46	89	17.2	24.26	84.47	2.43	1.80	2.64	7.58	22.26
27	Madumurangi	184.26	90.00	11.76	33.90	81.40	3.62	2.66	2.50	11.02	18.16
28	Navara	135.73	85.00	12.30	22.26	96.51	2.15	1.90	2.34	9.35	28.83
29	Mysore malliga	125.33	96.00	16.13	28.10	88.48	1.88	1.31	3.38	11.32	20.56
30	Pathariya	134.86	83.00	15.60	20.96	88.11	2.98	2.75	2.33	10.63	26.46
	Mean	138.60	88.00	12.38	24.51	84.23	2.28	1.95	2.58	10.10	24.23
	C.V	1.67	0.62	8.37	2.64	6.02	5.48	0.69	3.57	1.09	5.10
	C.D.5%	3.78	0.90	1.69	1.06	8.28	0.20	0.02	0.15	0.18	2.02
	C.D.1%	5.03	1.20	2.25	1.41	11.02	0.27	0.029	0.20	0.24	2.69
	Range lowest	81.40	76.00	7.73	16.00	55.35	1.19	1.10	1.62	4.74	11.51
	Range highest	184.26	105.00	20.80	33.90	96.51	4.29	3.41	4.50	14.13	47.45

S.No.	Character	Fe content (μgg^{-1})	Total starch content (%)	Amylose content (%)	Total antioxidant activity (mg AAE/100g)	Total soluble phenol content (mg/100g)	Glycemic Index	Phytate content (mg/100g)
1	Narayanakamini	32.43	68.61	24.58	33.49	74.10	57.80	432.63
2	Ranikanda	29.76	69.03	24.81	35.19	86.95	60.31	406.20
3	Sammelbhog	27.31	62.42	15.15	30.88	130.45	69.62	457.06
4	Chintalurisannalu	18.15	62.67	27.28	35.38	54.40	56.76	466.53
5	Selamsanna	40.79	71.26	11.84	50.58	70.67	60.58	468.38
6	Arakuloya	24.66	61.40	27.08	40.21	88.23	57.65	407.80
7	Ambemohar	29.90	74.79	23.65	33.30	90.18	65.78	452.49
8	Pancharatna	38.73	68.68	25.26	122.40	139.84	59.88	548.89
9	Kalajira	19.30	65.63	24.32	48.64	74.77	55.08	545.10
10	Kalabhatt	22.50	70.73	4.73	109.43	252.99	68.75	571.92
11	Badshabhog	15.66	57.12	20.50	49.36	102.39	54.19	308.96
12	Poongar	32.95	74.93	25.34	112.12	124.10	59.93	403.68
13	Ghani	15.63	63.27	24.29	32.70	80.22	60.21	436.30
14	Parimalasanna	15.65	64.07	25.14	57.4	63.19	60.69	446.35
15	Tulasibaso	61.68	61.64	26.11	34.57	81.12	59.13	487.32
16	Ramsri	13.33	73.51	28.36	42.32	76.72	56.96	454.79
17	Doddiga	17.47	74.56	17.02	43.39	74.37	57.58	361.74
18	Mappillai samba	17.2733	60.58	24.81	98.37	g128.35	68.75	389.08
19	Sannajajulu	23.58	66.61	29.58	32.52	102.35	59.34	403.13
20	Illapaipu samba	32.73	55.67	15.75	26.60	88.36	56.80	466.94
21	Burma black	15.52	69.67	7.90	96.39	243.59	68.73	413.45
22	Ramyagali	21.90	68.19	20.07	26.51	52.62	57.74	495.21
23	Karuppukavuni	28.47	69.57	19.59	75.21	204.26	52.29	512.02

24	Kulakar	19.02	67.69	21.07	114.33	121.65	52.28	475.56
25	Bahurupi	15.85	55.66	17.11	25.50	64.31	57.04	414.13
26	Ratnachudi	35.29	65.75	12.62	20.09	73.45	55.72	447.87
27	Madumurangi	34.35	62.75	14.43	103.14	90.33	61.29	341.73
28	Navara	16.41	68.40	33.73	87.64	230.56	62.84	572.87
29	Mysore malliga	15.21	60.39	23.74	58.24	57.51	60.41	417.19
30	Pathariya	21.06	58.51	34.60	95.67	187.50	59.03	545.83
	Mean	25.08	65.78	21.68	59.05	110.32	59.77	451.71
	C.V	10.18	0.43	0.83	0.43	0.21	1.27	0.27
	C.D.5%	4.17	0.47	0.29	0.42	0.38	1.24	0.71
	C.D.1%	5.55	0.62	0.39	0.56	0.50	1.65	2.67
	Range lowest	13.33	55.66	4.73	20.09	52.62	52.28	308.96
	Range highest	61.68	74.93	34.60	122.40	252.99	69.62	572.87

Table 3: Estimates of variability, heritability and genetic advance as per cent of mean for yield, quality and nutritional parameters in rice (*Oryza sativa* L.)

S. No.	Character	Mean	Range		Coefficient of variation		Heritability (%) (broad sense)	Genetic advance as per cent of mean (5% level)
			Minimum	Maximum	PCV %	GCV %		
1	Plant height (cm)	138.60	81.40	184.26	15.65	14.90	95.20	31.89
2	Days to 50% flowering	88.00	76	105	8.40	8.38	99.40	17.21
3	Number of productive tillers per plant	12.38	7.73	20.80	24.54	23.06	93.90	44.66
4	Panicle length (cm)	24.51	16.00	33.90	17.73	17.54	97.80	35.72
5	Spikelet fertility (%)	84.23	55.35	96.51	10.64	8.77	68.00	14.91
6	Yield per plot (Kg)	2.28	1.19	4.29	36.14	32.7	90.50	72.75
7	100 grain weight (g)	1.95	1.10	3.41	31.28	29.38	93.50	64.42
8	Kernal Length / Breadth ratio	2.58	1.62	4.50	23.64	23.37	97.70	47.60
9	Protein content (%)	10.10	4.74	14.13	21.05	19.03	90.40	43.21
10	Zn content ($\mu g g^{-1}$)	24.23	11.51	47.45	28.29	27.83	96.70	56.39
11	Fe content ($\mu g g^{-1}$)	25.08	13.33	61.68	42.85	41.62	94.40	83.28
12	Total starch content (%)	65.78	55.66	74.93	8.43	8.21	97.30	17.31
13	Amylose content (%)	21.68	4.733	34.60	32.33	31.30	96.80	66.55
14	Total antioxidant activity (mg AAE/100g)	59.05	20.09	122.40	55.25	50.83	92.00	62.82
15	Total soluble phenol content (mg/100g)	110.32	52.62	252.99	51.87	50.28	96.00	45.87
16	Glycemic Index	59.77	52.28	69.62	7.83	7.72	97.40	15.70
17	Phytate content (mg/100g)	451.71	308.96	572.87	14.37	13.75	95.60	29.59

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