Nutrient Content for Newly Improved Breeding Rice Lines from Parentage of the Kavuni and CO 50

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of the study was determining the physical properties and minerals composition in the twenty three breeding lines and two parent rice varieties. Physical properties found that no significant difference in terms of shape and size of the grain. The calcium, iron and zinc content of rice samples in the ranged from 7.56 to12.72 mg/100g, 0.73 to 2 mg/100g and 2.29 to 3.39 mg/100g, respectively. Results showed that the cultures 144-5 (12.72 mg/100g)>155-3(12.62 mg/100g)>144-2(12.61 mg/100g) =148-2 (12.61 mg/100g) contained higher levels of calcium content. Among the rice lines accessions, the samples: 144-2 (2.04 mg/100g)>32-2 (2 mg/100g)>145-2 (1.67 mg/100g)>145-3 (1.57mg/100g) had higher contents of iron. The zinc content of rice lines ranked in the following decreasing order; 144, 144-1,144-2, 144-3, 145-3, 145-6, 143-1,148-2,271-2. From the twenty three rice lines, some of the rice lines contained more minerals than of parent kavuni. The finding indicated that the cross breeding technique may increases not only the yield and also nutrient content of rice.

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1. INTRODUCTION

Cultivated rice (*Oryza sativa L.*), belongs to the Gramineae or grass family (Genus: *Oryza*), and it has been consumed by humans for almost 5000 years. It has adapted to diverse environments and currently sustains two-thirds of the world's population. Over 2 billion peoples in Asia alone obtain 80 percent of their energy needs from rice, which contains 80 percent carbohydrates, 7 to 8 percent protein, 3 percent fat, and 3 percent fiber.

Rice is a rich source of carbohydrate, moderate protein and fat content and also a source of B vitamins [1] along with some traces elements as calcium, magnesium, phosphorus, iron, copper, zinc and manganese [2]. Although the numerous factors affect the nutritional content of rice, varies within the rice genotype, agronomic and cultivation condition, storage and processing method [3,4].

The consumption of milled and polished white rice contains, very low level of essential micronutrients, which leading factor for formulation of the micronutrient deficiency from the continuous consumption [5]. WHO estimate globally 42 percent of children which were five years of age and 40 percent of pregnant women were anemic. WHO, FAO and UNICEF have partnered together to reduce the malnutrition through achieve the zero hunger goal mission on 2025, which will achieve a "50 percent reduction in the rate of anemia in women of reproductive age" [6,7].

Rice is a major vehicle for nutrient delivery to populations [8,9]. Black rice is widely considered as a 'super food' by researchers and scientists. The term 'super food' is used to describe the food items with extremely high nutritional content of black rice. In connect this super nutritious rice is high in fiber, antioxidants, thiamine, B and E vitamins, iron, magnesium, niacin and phosphorous [10].

Kavuni is a one of the traditional black rice genotype of Tamil Nadu. It is rich in micronutrient especially iron, zinc, calcium, copper, sodium, potassium and magnesium with health features due to low levels of total soluble sugars, fat and high levels of dietary fiber and phytochemical as beta-carotene, lutein, polyphenols [11]. Even though the mentioned favorable nutritional quality, kavuni is not cultivated widely among the farmers, due to phonological properties like photosensitivity, long duration, poor tillering and low yield than the present varieties.

There is need to conserve the traditional variety, so improvement of the traditional kavuni strain was made by cross breeding. Therefore, achieving the high yield new rice variety with good nutritional quality character are expected through the breeding between traditional pigmented rice variety (kavuni) and high yield rice variety (CO50). Recently, 23 breeding lines have been developed from cross breeding techniques between the kavuni and C050. The objective of this study was to investigate and physical properties and minerals content of new improved breeding rice lines from parentage of kavuni*CO50.

2. MATERIALS AND METHODS

2.1 Materials Collection and Sample Preparation

The twenty three lines and two parents were obtained from the Department of Crop Breeding and Molecular Biology, Tamil Nadu Agricultural University, Coimbatore. The dehulled and unpolished grains of 23 breeding lines and the one pair of parent samples could be divided into three classes according to L* (lightness), a* (redness) and b* (brightness) color values by Tinto meter: White colour rice lines are (Co50, 131-4, 31-3, 13-3, 13-5 and 13-2), light black colour rice lines are (31-6, 35-2, 144, 144-1, 144-5, 145-2 and 163-5) and dark black colour rice lines are (143-1, 32-2, 35-3, 144-2, 144-3, 39, 40, 145-3, 145-6, 148-2 and 271-2) selected for this study.

2.2 Kernel Length, Breadth, Length/Breadth Ratio and Grain Classification

Ten randomly selected whole kernels of rice lines from the three sets were taken and length of each grain was measured by placing on a micro-scale. Breadth of each grain was measured using a vernier caliper. The average of observations was taken for final reading of length and breadth of rice kernels in millimeter (mm). The L/B ratio was calculated by dividing the average length by the average breadth of rice kernel. The grain size was classified based on the method suggested by IRRI 1980.

Based on the L/B ratio, grains were classified [12] into long slender (LS), short slender (SS), medium slender (MS), long bold (LB) and short bold (SB). Kernel length measurements on the basis of average length (mm), kernels were classified as follows: Extra long (> 7.50), Long (6.61-7.50), Medium (5.51-6.60) and Short (< 5.50).

2.3 Thousand Grain Weight

The thousand grain weight was measured by the method [13]. It involved the counting and weighing of 1000 randomly selected unpolished black rice lines and white rice lines.

2.4 Determination of Proximate Composition

The proximate composition of grain samples were determinate by standard method used for protein (AOAC, 1990), fat (AACC, 2000) and carbohydrate [14].

2.5 Micronutrient Estimation

The minerals such as iron, calcium and zinc contents were estimated with elemental Analysis by energy X-ray fluorescence by taking the optimum weight identified during the above experiment.

2.6 Statistical Analysis

All measurements were carried out in triplicate for each of the sample. All statistical analyses were carried out using SPSS 20.0 for the analysis of variance (ANOVA) and the Pearson correlation coefficients. Significance of the differences was described at the 0.05 level for ANOVA, and the 0.05 and 0.01 levels for Pearson correlation.

3. RESULT AND DISCUSSION

The agronomical characteristics of parent rice varieties black kavuni and white CO50 rice are presented in Table 1. Black kavuni is black colored traditional pigmented rice in Tamil Nadu. It was considered a ware house of novel genes for valuable nutritive and therapeutic properties. It had a poor agronomic attributes like photo-sensitivity (one season/crop per year), low yield (1 to 1.5t/ha), bold grain and poor cooking quality. The CO50 is a hybrid variety with a parentage of CO43×ADT 48. It is a dehushked rice, white in colour, it was consumed a staple food grains in Tamil Nadu. It is a one of high yielding non pigmented variety. Following Tables 2 and 3 was mentioned about the physical properties and cooking quality of twenty three rice lines from the parent of Kavuni ×CO50.

3.1 Grain Size

The length of culture rice ranged from 5.52mm to 6.4mm. The highest grain and kernel length was recorded in 163-5 culture followed by kavuni parent that was 6.4mm and 6.1mm respectively. The lowest grain length was observed in 13-2 culture (5.52mm). In white colour rice varieties the 131-4 culture (6.03mm) and 13-3 (6.03mm), where 163-5 (6.40mm) light black colour culture, and 40 (6.01mm) dark black colour culture had highest grain length.

In light black colour cultures, the 163-5 rice line had highest length than the kavuni parent variety. Based on the grain size classification the twenty three rice lines were medium in size. [15] found that the grain length varied from 5.13 mm to 6.38mm in selected white and black rice varieties. Similar result found by Devaraj *et al.,* 2020 [16] where the length and breadth of black kavuni rice 6.12 mm and 2.14mm respectively.

The thousand kernel weight ranged from 17.95g of kavuni to 14.31g of 13-5 for kernel, whereas in dark black group rice lines the values ranged from12.66g to 16.17 g for 35-3 and 40 rice cultivars, respectively. According to [17], the waxy pigmented rice had 16.52 g of thousand kernel weight. The cultivar having highest length and width ratio possess higher values of thousand kernel weight. As shown in table, the thousand kernel weight in different rice lines was in the order: kavuni (17.95mm)>145-2(17.23mm)>131-4 (16.51mm)>163-5(15.96mm) =143-1(15.96mm).

3.2 Kernel Breadth

Kernel breadth revealed highest in 271-2 (2.26mm) culture followed by 143-1 (2.26) cultures and lowest 144-2 (1.98mm) followed by 145-3 (1.98) culture. It was observed that among dark black colour rice lines the following culture rice such as 35-3,144-3,145-6 and 148-2 on par to CO50 parent.

3.3 Grain Shape

The shape of the rice grains were determined by examining the length/ breadth ratio of the grains, which is an important factor for quality of rice. Length to width of rice varieties ranged

Table 1. Agronomical features of parent rice varieties (CO 50, Kavuni)

S. No	Name	Variety/ Origin	Crop maturation (days)	Species/subtype/Parentage	Agronomical features
			White rice		
1.	CO 50 (Parent)	TNAU variety, Coimbatore, India	130-135 days	*Oryza sativa*/ Indica/ CO 43×ADT 48	High yielding variety, tolerant , Bacterial Leaf blight, photo insensitive and white kernel (non pigmented)
			Black rice		
2.	Black-Kavuni (Parent)	Traditional variety, Tamil Nadu	135-140 days	*Oryza sativa*/ Indica/ Not known	Low yielding ,poor tillering, long duration photosensitive, brownish black kernel (pigmented)

[11]

Table 2. Physical properties of rice samples

S. No	Name	Length (mm)	Grain Size	Breadth (mm)	L/W (mm)	Grain shape	1000 Kernel Weight(g)
			Parent rice				
1.	CO 50	5.62±0.28[d]	Medium	2.17±0.15[abc]	2.60±0.00[fg]	Bold	15.40±0.09[e]
2.	Kavuni	6.1±0.43[ab]	Medium	2.25±0.18[ab]	2.71±0.05c[d]	Bold	17.95±0.13[a]
			White rice- rice lines				
3.	13-2	5.52±0.09[f]	Medium	2.23±0.15[ab]	2.47±0.07[j]	Bold	15.42±0.40[e]
4.	13-3	6.03±0.51[bc]	Medium	2.24±0.09[ab]	2.69±0.03[cde]	Bold	15.44±0.02[e]
5.	13-5	5.79±0.47[bcde]	Medium	2.11±0.06[abc]	2.74±0.09[cd]	Bold	14.31±0.39[g]
6.	31-3	5.92±0.49[bcde]	Medium	2.16±0.09[abc]	2.74±0.05[cd]	Bold	13.48±0.34[h]
7.	131-4	6.03±0.56[bc]	Medium	2.21±0.06[ab]	2.72±0.04[cd]	Bold	16.51±0.36[c]
			Light black colour –rice lines				
8.	31-6	5.63±0.40[ef]	Medium	2.06±0.15[abc]	2.73±0.07[cd]	Bold	15.13±0.13[ef]
9.	35-2	5.76±0.39[bcde]	Medium	2.08±0.08[abc]	2.77±0.01[bc]	Bold	15.03±0.16[ef]
10.	144	5.68±0.29[cdef]	Medium	2.22±0.30[bc]	2.56±0.01[ghi]	Bold	15.17±0.28[ef]
11.	144-1	5.67±0.170[cdef]	Medium	2.11±1.06[abc]	2.69±0.06[cde]	Bold	15.16±0.41[ef]
12.	144-5	5.57±0.290[ef]	Medium	2.24±0.07[ab]	2.49±0.0[ij]	Bold	16.05±0.17[d]
13.	145-2	5.99±0.20[bcd]	Medium	2.04±0.09[abc]	2.94±0.09[a]	Bold	17.23±0.33[b]
14.	163-5	6.4±0.50[a]	Medium	2.2±0.10[ab]	2.83±0.08[b]	Bold	15.96±0.51[cd]

S. No	Name	Length (mm)	Grain Size	Breadth (mm)	L/W (mm)	Grain shape	1000 Kernel Weight(g)
			Dark black colour- rice lines				
15.	143-1	5.59±0.40[ef]	Medium	2.26±0.11[ab]	2.47±0.05[j]	Bold	15.96±0.08[cd]
16.	32-2	5.61±0.08[ef]	Medium	2.30±0.20[a]	2.44±0.02[j]	Bold	15.07±0.14[ef]
17.	35-3	5.55±0.10[ef]	Medium	2.15±0.08[abc]	2.58±0.02[gh]	Bold	12.66±0.27[i]
18.	144-2	5.63±0.290[d]	Medium	1.98±0.30[bc]	2.84±0.03[b]	Bold	15.21±0.37[ef]
19.	144-3	5.74±0.245[bcdef]	Medium	2.14±0.07[abc]	2.68±0.06[def]	Bold	12.84±0.40[i]
20.	39	5.9±0.26[bcde]	Medium	2.16±0.10[b]	2.73±0.01[cd]	Bold	14.79±0.33[f]
21.	40	6.01±0.28[bc]	Medium	2.22±0.08[ab]	2.71±0.06[cd]	Bold	16.17±0.52[d]
22.	145-3	5.89±0.43[bcdef]	Medium	1.98±0.14[bc]	2.97±0.09[a]	Bold	14.15±0.03[g]
23.	145-6	5.63±0.40[d]	Medium	2.16±0.08[abc]	2.61±0.01[efg]	Bold	15.35±0.07[e]
24.	148-2	5.69±0.166[cdef]	Medium	2.11±0.18[abc]	2.70±0.07[cd]	Bold	15.46±0.44[e]
25.	271-2	5.69±0.09[cdef]	Medium	2.26±0.04[a]	2.52±0.01[hij]	Bold	15.12±0.00[ef]

Table 3. Minerals compositions of rice samples

S. No	Name	Calcium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
		Parent		
1.	CO 50	8.32±0.11^{l}	1.28±0.02^{jk}	3.10±0.07^{fghji}
2.	Kavuni	13.43±0.08^{ab}	1.79±0.03^{di}	3.11±0.10^{efghji}
		White rice		
3.	13-2	7.56±0.14^{i}	1.44±0.01^{de}	2.94±0.09^{lk}
4.	13-3	8.27±0.04^{k}	0.73±0.02^{m}	2.90±0.04^{l}
5.	13-5	8.04±0.05^{k}	1.22±0.04^{hij}	3.11±0.07^{efghji}
6.	31-3	8.36±0.26^{k}	1.16±0.02^{sjk}	3.01±0.0.10^{lkji}
7.	131-4	11.57±0.08^{def}	0.94±0.03^{l}	3.15±0.10^{cdefgh}
		Light black colour –rice lines		
8.	31-6	10.27±0.07^{i}	1.47±0.02^{d}	3.03±0.08^{hlkji}
9.	35-2	11.5±0.37^{ef}	1.16±0.03^{jk}	2.99±0.02^{lkji}
10.	144	12.05±0.33^{bcd}	1.31±0.03^{f}	3.40±0.08^{a}
11.	144-1	12.54±0.24^{ab}	1.13±0.01^{k}	3.39±0.05^{a}
12.	144-5	12.72±0.14^{a}	1.4±0.00^{e}	2.98±0.01^{lkj}
13.	145-2	11.90±0.21^{cde}	1.67±0.05^{b}	3.00±0.07^{hkji}
14.	163-5	12.42±0.02^{ab}	1.49±0.03^{d}	3.12±0.02^{defghi}
		Dark black colour- rice lines		
15.	32-2	9.25±0.16^{j}	2±0.05^{a}	3.09±0.07^{ghji}
16.	35-3	10.85±0.01^{gh}	0.94±0.03^{l}	3.00±0.09^{lkji}
17.	144-2	12.61±0.01^{a}	2.04±0.07^{a}	3.22±0.03^{bcdef}
18.	144-3	12.62±0.14^{a}	1.23±0.01^{hi}	3.33±0.01^{ab}
19.	39	10.64±0.35^{hi}	0.74±0.01^{m}	3.18±0.02^{cdefg}
20.	40	11.20±0.37^{fg}	1.39±0.01^{e}	3.15±0.06^{cdefgh}
21.	145-3	11.85±0.13^{de}	1.57±0.03^{c}	3.28±0.08^{abc}
22.	145-6	12.04±0.17^{bcd}	1.27±0.04th	3.24±0.04^{bcde}
23.	143-1	12.36±0.21^{abc}	1.29±0.00^{f}	3.23±0.03^{bcdef}
24.	148-2	12.61±0.08^{a}	1.13±0.02^{k}	3.25±0.09^{bcd}
25.	271-2	12.05±0.12^{bcd}	1.25±0.01th	3.23±0.01^{bcdef}

from 2.47 to 2.97. L/B ratio was observed to be highest for 145-3 and 145-2 cultures as 2.97mm and 2.94mm respectively. The culture shows the lowest L/B was 13-2 (2.47mm). Selected rice varieties had bold shapes according to the grains shape classification used. Physical properties of six rice varieties were analyzed by Thomas et al., 2013. The L/B ratio was for brown rice 2.09mm.

Since rice a staple crop in world scenario thus for the rice breeding program its yield is considered an important parameters. Grain length, width and thickness are the three components of grain shape composed [18]. Grain weight also important dependent factor of rice yield [19].

3.4 Iron

The results pertaining for minerals contents during the study are presented in Table 3 on the basis of rice lines in colour differences. It found that collected rice lines in this study had iron content in the range of 0.73 to 2 mg/100g sample (Table 3). Among all the rice lines, the highest iron content was found in the order of 144-2 (2.04 mg/100g)>32-2 (2 mg/100g)>145-2 (1.67 mg/100g)>145-3 (1.57mg/100g). The iron content of this rice lines were confirmed with the results reported by [20] that iron content in the rice varieties in the ranged from 0.59 to 3.98 mg/100g. This results were matched by previous study by [11], that the black kavuni (1.86mg/100g) had higher amount iron than the CO50 (1.49mg/100g).

3.5 Calcium

The mean values of the calcium content for collected rice ranged from 7.56 mg/100g to12.72 mg/100g. Deepa *et al.,* 2008 reported that the calcium content of unpolished red rice (Niavara and Jyothi) and brown rice (IR64) in the range from 9.20 to 12.60 mg /100 gram. Among the rice line, the highest calcium content observed in 144-5 (12.72 mg/100g)>155-3(12.62 mg/100g)>144-2(12.61 mg/100g) =148-2 (12.61 mg/100g), where as mentioned cultures met appreciably highest or more than that of kavuni (12.43 mg/100g) parent. The cultures 144-1 (12.54 mg/100g) and 163-5 (12.42 mg/100g) rice

lines contained calcium content near to kavuni parent (12.43 mg/100g). Among the white rice colour lines, majority of the cultures had lowest calcium content than the desired range (12.43mg/100g). The pigmented rice had higher amount of calcium than the white rice [21].

3.6 Zinc

The zinc content for all the rice lines exhibited in fairly amount of desired range (3mg/100g). The 144 and 144-1 rice lines exhibited the highest calcium content on 3.40 mg /100g and 3.39 mg/100g respectively, followed by144-3 (3.33 mg/100g) and 145-3 (3.28 mg/100g), whereas 13-3 (3.28 mg/100g) contained the lowest calcium content (2.90 mg/100g). Among all accessions, the rice cultures such as 144, 144-1,144-2, 144-3, 145-3, 145-6, and 143-1,148-2,271-2 had highest or more than that of kavuni parent (3.11 mg/100g). In white rice group, the culture 13-5 had similar and near to zinc content for with kavuni parent. The zinc content of the rice lines as recorded in the present study was found to be similar with the findings of Pathak et al., 2017 [22].

Phenotypic correlation coefficient among physical characters of 25 rice samples has given in Table 4. Form the correlation relationship among the grain character; it was observed grain length has significant positive correlation (r=0.603**) with length and breadth ratio. Also negative correlation (r=-0.768**) between breadth and length and breadth ratio. This results supported the earlier observations such as [23] found that there was a significant positive correlation observed between the grain length and grain length–width ratio and negative correlation between grain breadth and length–width ratio.

The correlation coefficient for minerals content of 25 rice samples has given in Table 5. Form the correlation relationship among the rice sample minerals; it was observed it calcium has strongly significant positive correlated (r=0.553**) with zinc content of grain. It was full agreement with earlier results Jiang et al., 2007.

Table 4. Pearson correlation co-efficient among the physical properties and minerals compositions of rice lines

Compositions	Length	Breadth	L/B ratio	1000 gram weight
Length		0.037 (0.862)	0.603** (0.001)	0.366 (0.072)
Breadth			-0.768** (0.000)	0.253 (0.222)
L/B ratio				0.057 (0.787)
1000 gram weight				

Table 5. Pearson correlation co-efficient among the minerals compositions of rice lines

Compositions	Calcium	Iron	Zinc
Calcium		0.216 (0.300)	0.553** (0.004)
Iron			0.051 (0.810)
Zinc			

Significant at 0.05 and 0.01 probability level

4. CONCLUSION

Bio-fortification approach for reducing the micronutrient malnutrition and also aiming the improve yields for commercial production. Breeding in staple foods helps to reduce levels of malnutrition in poor women, children and infants. To solve this, in this research resulted 23 breeding lines from the parentage of nutritional richer for Kavuni and high yield for CO50. Form the point alleviating the micronutrient malnutrition, the mineral content of rice is one of the important considering factors for choosing best superior lines. Based on the data, in dark black color rice lines as 144-2, 144-3, 40, 145-3, 145-6, 143-1 and 271-2 were considering to be a superior lines. For light black colour rice lines the 144, 144-1, 145-2 and 163-5 as superior. The minerals content of rice lines provide the information to the rice breeders for screening the rice for better nutrition also offer opportunities to further increase the nutritional benefits of some food products from rice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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