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Standardization of Storage and Milling Time for Increasing the Retention of Iron (FE) and Vitamin A Content In Rice Grains

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ABSTRACT

Rice is the dominant cereal crop in many developing countries and is the staple food for more than half of the world's population and contributes over 20% of the calorie intake of the human population. The major nutritional problems common in rice consuming countries are protein energy malnutrition and iron, zinc, iodine and vitamin A deficiencies. The present study was conducted to standardization of storage and milling time for increasing the retention of Fe and Vitamin A content in rice grains. The experiment was conducted during September 2009 to August 2011 (Three years). In first year to standardization of rapid Screening method for grain iron content in rice was taken, Second year to take different boiling and storage studies were observed and last year to standardization of milling time and its retention content of different minerals and nutrients i.e. iron and vitamin A, respectively. It was found that retention of iron content was significantly influenced on 12th months but it was not significantly influenced in vitamin A. The genotype kosuvakathalai showed comparably high per cent of iron and vitamin A content than all other varieties under storage, milling and by cooking method.

KEYWORDS : Iron, Vitamin A, Milling, genotype and Screening

II. Introduction

Rice is the dominant cereal crop in many developing countries and is the staple food for more than half of the world's population and contributes over 20% of the calorie intake of the human population. More than 2 billion people in Asia alone derive 80% of their calories from rice. Ninety five per cent of world rice production and consumption is in Asia. In Europe and North America, rice has an increasingly important place in the market as a staple and gourmet food.

The major nutritional problems common in rice consuming countries are protein energy malnutrition and iron, zinc, iodine and vitamin A deficiencies. It is estimated that more than 3 billion people in the developing world are iron deficient. Similarly, four hundred million people are at risk for vitamin A deficiency. Being a staple diet and consumed in bulk in many of the developing countries, especially in India, even a small increase, in its nutritive value would be highly beneficial for human health. Because of the high per capita consumption of rice in these countries, improving its nutritive value by increasing iron and zinc levels in the grain can have significant positive health outcomes for millions of people.

Currently, polished rice contains an average of only 2 parts per million (ppm) iron (Fe) and 12 ppm of zinc (Zn). In many Asian countries, rice provides 50–80 percent of the energy intake of the poor but it does not provide enough essential micronutrients to eliminate "hidden hunger," in particular iron deficiency anemia (IDA) zinc and Vitamin A deficiency. In many of these same Asian countries, IDA affects nearly 60 percent of the population.

Minerals in rice, wheat, maize, and other cereals are concentrated in the aleurone; mineral concentration decreases sharply toward the center of the kernel and is much lower in the endosperm. The mineral-containing aleurone layer is removed by polishing or milling; small differences in polishing can thus have a dramatic effect on micronutrient concentration.

G. Barry, personal communication, (2005) An extensive studies at the International Rice Research Institute (IRRI) have revealed a poor association between mineral concentrations in brown rice and polished rice, while recent studies by Sison et al., (2006) resulted in a close correlation.

The effect of the milling process on the outcome of rice quality has been researched by examining the quality of the whitened rice product focusing on parameters such as degree of milling, transparency, whitening, and yield. In a study on milling characteristics for different kernel size fractions, the researchers examined different thickness fractions for several cultivars and found a linear relationship between head yield and degree of milling within each thickness fraction by Rohrer & Siebenmorgen, (2004).

Bautista & Siebenmorgen (2002) compared several laboratory scale mills and determined that yields decrease with increasing milling duration. In the 10 to 50 second range for the McGill mill, they found that yield decreased in an approximately linear fashion with increasing process time. They noted that yields were affected by other factors including moisture content and variety.

Milling has a profound effect on rice composition, as non-starch constituent's decrease from surface to core of the grain. In general, increasing degree of milling the nutritional value of protein content, crude oil content and ash content and all macro and micro elements decreased significantly. But the amylose content increased by the same treatments. On the other hand, the cooking properties of the different varieties also affected by the milling time. Cooking time was decreased by in-creasing milling time; however water absorption ratio and volume expansion ratio increased significantly by EL-Hissewy and EL-Kady, (1992). Parboiling under normal condition of time (30 min) has no effect on the minerals and trace element composition of rice by Ibukun., (2008).

The objective of this study was to effect of parboiling duration on Fe and Vitamin A content of different rice Varieties, to standardize the optimum milling and Storage time for Fe and Vitamin A content using different rice varieties and to determine the Fe and Vitamin A content in cooked rice of different rice varieties.

III. Materials and Methods

Experimental details:

The experiments were conducted at department of agricultural chemistry, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu during September 2009 to August 2011. The experiment duration was three year to determine the iron and vitamin A retention content in different genotypes by different methods and purpose i.e. screening, parboiling, storage, milling and cooking.

Year 1:
Screening

For Initial screening of high iron and Vitamin A content, 78 genotypes were collected from all over TamilNadu which included 31 land races, 4 Indian accessions, 9 foreign accessions and 34 adapted varieties. The initial screening is done by adopting both quantitative method (atomic absorption spectrophotometer) and qualitative rapid screening method (Perl's Prussian blue (Fe)).

Standardization of Rapid Screening method for grain iron content in rice:
To estimate the Fe content qualitatively the Perl's Prussian blue method was adopted with various concentration of Prussian blue solution (viz., 2 %, 3 %, 5 %, 10 %, and 15 %) to standardize the optimum concentration required for rice flour. The rice flour when treated with five percent Prussian blue solution incubated for 30 minutes produced various levels of blue colour intensity with high, medium and low Fe content.

Year II
Parboiling of Rice:
Raw paddy rice samples were soaked in water for 48 h after which they were steamed for a short period of 30 min for normal duration. The samples were sun dried at a temperature not more than 38oC (Chancellor, 1965). Then it was dehusked and grinds this into powder form for analysis.

Storage Study:
The high iron and Vitamin A content rice varieties were selected for storage study. The selected rice varieties were packed in jute bags and stor@gmail.com ed at room temperature for 360 days to see the effect of storage time.

Year III (Extension Period):
Standardization of milling time:
The high Fe and Vitamin A content rice varieties were selected and subjected to six milling times (10, 30, 40, 50 and 60 sec) for both raw and parboiled rice using a huller to determine the effect of milling time.

Standard conditions adopted for cooking rice:
The selected rice varieties were subjected to two different cooking treatments: i.e. boiling and pressure cooking method to see the effect of Fe and Vitamin A content during cooking. The standard condition adopted by Rashmi and Asna Urooj (2003) were given below.

Processing	Conditions
Pressure cooking	The samples (50 g) were pressure-cooked in enough water (75 -150 ml) for a period of time (4 -12 min),
Boiling method	The samples (50 g) were boiled in enough water (250 -700 ml) until done (15 - 35 min).

After cooking the rice varieties were cooled for 10 mins. Then the cooked rice varieties were oven-dried at 60°C, before being ground to pass through in a 45 mm mesh serve and used for Fe and Vitamin A analysis.

IV. Results and Discussion
The retention of iron content of rice genotype was not significantly influenced by different rice samples (i.e. raw rice and parboiled rice) except at third and twelth month, genotypes were significantly influenced by different intervals not at third months (Table 1). However, the interaction between cooking methods and genotypes was found to be significant only twelth months.

The maximum (3.88 and 2.08 ppm) and significantly different were observed under raw rice at third and twelth months, respectively, whose iron retention capacity was reduced with successive method of parboiled rice in different months interval with no significant difference between at 0^{th}, 6^{th} and 9^{th} months interval.

The genotypes differed significantly in their iron content retention at different intervals i.e. 0^{th}, 6^{th}, 9^{th} and 12^{th}, except 3^{rd} months. The maximum (7.37, 6.28 and 5.01 ppm) and significantly more iron content were recorded in kosuvakathalai at 0^{th}, 6^{th} and 9^{th} months interval, respectively, whereas 12^{th} month IC350429 (3.35 ppm) was observed more iron retention content. However, in 12^{th} month madhukar (0.40 ppm) and mapillaisamba (0.39 ppm) were at par with each other.

The minimum (0.42, 0.35, 0.28 and 0.07 ppm) and significantly lower retention of iron content was observed at 0^{th}, 6^{th}, 9^{th} and 12^{th} months interval in TKM 9, respectively. The interaction varying between rice samples and genotypes were found to be significant at 12^{th} month and the genotypes IC 350429 exhibited maximum iron content, not only under raw rice samples but also under parboiled rice samples. However, the variety TKM 9 was observed lower iron content under both the rice samples an interval of 12^{th} month.

The variety IC 354029 under raw rice was showed its superiority in iron retention capacity over all other combination of rice cooking samples and genotypes, while, the variety TKM 9 all under raw and parboiled condition has been significantly inferior in iron retention capacity to all other combination of rice cooking samples and varieties (Table 1a and Fig 1).

The results of this work show that storage of rice at ambient temperature (28 - 30^{0}C) from 3rt month onwards decreased its iron content. The rate of decrease in the iron content was observed to be dependent on genotypes. The storage time also decreased the functional properties such as amylase, swelling property and solubility of the rice genotypes. The rates of decrease in these functional properties were also dependent on the genotypes. Similar reported was given by Perdon et al, (1997).

The retention of iron content was significantly influenced by rice samples under normal boiling, genotypes under pressure cooking in different methods of cooking. However, the interaction between rice samples and genotypes was significantly influenced under pressure cooking method but it was not influenced under normal boiling.

The maximum (3.78 ppm) and significantly more iron retention content was observed in raw rice under normal boiling than parboiled rice but it was significantly not influenced under pressure cooking method. The genotypes differed significantly in their iron retention content at different methods of cooking (Table 1). The genotypes kosuvakathalai had maximum (7.16 and 7.09 ppm) and significantly higher iron content were retained under normal boiling as well as pressure cooking method. Whereas, the genotype IC 208793 (4.15 ppm) and IC 255787 (4.13 ppm) were at par with each other under pressure cooking method.

The minimum (0.12 and 0.14 ppm) and significantly lower iron content was retention TKM 9 under both the cooking method. The interaction between rice samples and genotypes was found to be significant under pressure cooking method (Table 1a and Fig 2. The variety kosuvakathalai found best and significantly high iron retention content than all other combination of rice samples under pressure cooking method, but it was at par with each other with genotypes IC 350429.

The minimum and significantly lower iron content retained was observed TKM 9 in both the rice samples i.e. raw rice and parboiled, under pressure cooking. Among the genotypes kosuvakathalai showed its superiority in iron content retention than all other combinations and genotypes. Whereas, the genotypes TKM 9 proved to be inferior most than all the other combination of rice samples and genotypes. It might be due to grain colour variation of genotypes.

Gregorio et al. (2000) reported a wide variation of iron contents in rice grains among rice varieties. In same varieties, apart from the effect of G x E interaction, milling process may also affect iron level in milled rice and cooked rice. Data from this study showed that samples with less whiteness percentage often resulted to higher iron levels in milled rice, but this correlation was not closely tight.

The retention of iron content in rice was not influenced by different rice samples under different milling time i.e. 20, 30, 40, 50 and 60 seconds, except 10 seconds of intervals, the genotypes were significantly influenced by iron retention content under different milling time (Table 1). However, the interaction under different milling time except 10 second of intervals.

The maximum (3.79 ppm) and significantly high iron retention content was observed under parboiled rice at 10 second interval than raw rice (3.18 ppm). Whereas, an each 10 second i.e. 20, 30, 40, 50 and 60 second, it was not significantly influenced. The genotypes differed significantly in their different interval of milling times. The maximum (7.26, 6.98, 6.75, 6.68, 6.61 and 6.21 ppm) and significantly more iron content were retained by genotype kosuvakathalai than all other genotypes.

The minimum (0.37, 0.35, 0.30, 0.21, 0.17 and 0.09 ppm) and significantly poorest iron content was retained by TKM 9 at different milling time i.e. 10, 20, 30, 40, 50 and 60 ppm, respectively. The interaction between rice samples and different genotypes in their iron retention content was found to be significant (Table 1a and Fig 3). While, the genotype kosuvakathalai accumulated maximum and significantly more iron retention content under both the rice samples (i.e. raw rice and parboiled) at 10 second intervals, than all other combinations of milling times, it might be due to brown rice colour.

The minimum and significantly lower amount of iron retention content was accumulated by TKM 9 under different rice samples, which was having poorest iron retention content than all other combination of rice samples and genotypes at 10 second intervals. Grain color also seemed to be associated with the amount of iron content. Maria Elinor Grace et al, 2006 reported that Genotypes with high iron in brown rice (0 sec milling time) also showed high iron in milled form, although there is a significant reduction as milling time increased (10 to 70 sec).

Three groups of genes associated with high grain iron content were also found on chromosomes 7, 8, and 9 as reported by Gregorio et al. (2000). Since the Rc gene, which is required for red pericarp is on chromosome 7 and genes associated with high iron in rice were also found in chromosome 7, it could be an explanation why rice grains with red pericarp have high grain iron content. Significant differences in mean iron content among varieties were observed for each milling time. Degree of reduction in iron content for each milling time also significantly differed among genotypes.

The retention of vitamin A content in rice samples was not influenced significantly by varying rice samples under different month's interval of storage period, except 3rd month. The genotypes were significantly influenced by rice samples under different month of intervals (Table 2). However, the interaction between rice samples and genotypes were not influenced significantly under different month intervals of storage periods.

The rice samples raw rice was obtained significantly higher (0.470 ppm) vitamin A retention content at 3rd months of interval of storage period than all other intervals. Whereas, parboiled rice showed its significant retention at only 3rd month intervals of storage period. The genotype showed significantly differed vitamin A retention under different month of intervals (i.e. 0th, 3rd, 6th, 9th and 12th).

The maximum (0.820, 1.100, 1.272, 1.250 and 1.210 ppm) and significantly higher vitamin A was retained by genotype kosuvakathalai at all the intervals of storage period. The minimum (0.050, 0.040, 0.027, 0.020 and 0.020 ppm) and significantly poorest vitamin A was retained by IC 255787 under all the intervals of storage period, it might be due to having more stability than other genotypes.

Food processing has the potential to alter the stability of vitamins in food. The use of stabilized, encapsulated forms of vitamins has greatly improved the resistance of vitamins to severe processing and storage conditions. The stability of vitamin A in fortified wheat and corn flour is excellent. De Gracia and Murillo, (1993), studies shows that wheat flour and yellow corn flour, stored under normal conditions, retain over 95 percent of their vitamin A after six months at room temperature. However, the stability of vitamin A under high storage temperatures is not as good. Wheat flour stored for three months at 45°C retained only 72 percent of vitamin A.

The retention of vitamin A content in rice was significantly influenced by different interval of milling time (i.e. 30, 50 and 60 second), but it was not significantly influence at 10, 20 and 40 second interval of milling time. The maximum (0.366, 0.326 and 0.277 ppm) and significantly more vitamin A were retained in raw rice samples at 30, 50 and 60 seconds interval of milling time, respectively (Table 2). The minimum vitamin A content was retained under parboiled rice samples of 30, 50 and 60 seconds intervals.

The genotypes differed significantly in their different milling time. The maximum (1.250, 1.162 and 1.107 ppm) and significantly higher vitamin A was retained genotype kosuvakathalai under 30, 50 and 60 seconds interval in milling time, respectively. The minimum (0.018, 0.091 and 0.006 ppm) and significantly lower vitamin A was recorded the genotypes IC 255787 under 30, 50 and 60 seconds of time interval, respectively. Whereas, the genotypes IC 255787 and IC 350420 were on par with each other in 60 seconds of time interval.

The interaction between rice samples and genotypes were significantly influenced under different time intervals. The genotypes kosuvakathalai retained more vitamin A content under raw rice as well as parboiled at 30, 50 and 60 seconds interval of time than all other combinations of rice samples and genotypes, which was superiority of having more vitamin A content then all other combinations. Whereas, the genotype IC 255787 was showed its inferior than all other combinations of rice sample and genotypes under different milling times.

In a study by Dellamonica (1978), vitamin A retentions were measured during boiling of a fortified whey-soy drink mix. In the study, the product was boiled for up to 5 minutes and showed approximately 50% loss of the original vitamin content. In another trial, the product was mixed with boiling water and allowed to stand at room temperature. The study demonstrated that vitamin A retention was 92% when first mixed with boiling water, 75% after 1 minute, 51% after the 2- and 4-minute intervals, and 40% after 5 minutes. This trend shows considerable vitamin loss due to heat treatment. Additionally, this study suggests that length of time of heat treatment is a crucial factor in determining vitamin degradation (Dellamonica, 1978).

The retention of vitamin A content in rice samples and interaction between rice samples and genotypes were not significantly influenced by different methods of cooking. Whereas, the genotypes were significantly influenced under different methods of cooking (Table 2). The maximum (0.603 and 0.958 ppm) and significantly higher amount vitamin A was retained by kosuvakathalai under normal boiling as well as pressure cooking method, respectively.

The minimum and lowest amount of vitamin was retained by IC 255787 under both the cooking methods. There was slight decrease in vitamin A content of the parboiled rice samples. This agreed with the findings of Gariboldi (1973) that it may be due to the fact that during steaming, water soluble vitamins are spread throughout the grain, thus altering their distribution and concentration.

Table 1 Retention of Iron content of selected rice genotypes at various storage periods, cooking methods and milling time

Treatments	Interval in months					Cooking methods		Interval in Seconds						
	Part per million (ppm)													
	0th	3rd	6th	9th	12th	Normal boiling	Pressure cooking	10 sec	20 sec	30 sec	40 sec	50 sec	60 sec
A. Rice samples													
Raw rice	4.09	3.88	3.49	2.80	2.08	3.78	3.83	3.18	3.49	3.18	2.87	2.61	2.45
Parboiled rice	3.87	3.42	3.30	2.61	1.78	3.74	3.61	3.79	3.67	3.58	3.41	3.16	2.98
SEd	0.003	0.25	0.003	0.003	0.035	0.005	0.051	0.004	0.02	0.005	0.001	0.007	0.039
CD at (5 %)	NS	0.10	NS	NS	0.147	0.023	NS	0.018	NS	NS	NS	NS	NS
B. Genotypes													

Kosuvakathalai	7.37	6.99	6.28	5.01	2.97	7.16	7.09	7.26	6.98	6.75	6.68	6.61	6.21
Madhukar	2.31	2.18	2.03	1.61	0.40	2.10	2.05	2.12	1.93	1.71	1.59	1.07	1.05
IC208793	4.42	4.20	3.76	2.98	2.34	4.23	4.15	3.98	3.59	3.36	2.84	2.65	2.59
IC255787	4.38	4.16	3.73	2.96	2.89	4.17	4.13	4.01	3.68	3.17	3.01	2.90	2.70
IC350429	7.04	5.65	5.97	4.75	3.35	6.83	6.79	6.89	6.66	6.39	6.30	5.75	5.40
TKM9	0.42	0.39	0.35	0.28	0.07	0.12	0.14	0.37	0.35	0.30	0.21	0.17	0.09
Mapillaisamba	0.79	0.75	0.67	0.54	0.39	0.47	0.53	0.77	0.71	0.71	0.54	0.31	0.28
IR68144	5.14	4.88	4.39	3.48	3.05	4.93	4.87	4.99	4.78	4.62	3.96	3.61	3.39
SEd	0.007	0.50	0.011	0.007	0.039	0.006	0.026	0.019	0.054	0.017	0.011	0.017	0.081
CD at (5 %)	0.014	1.03	0.022	0.014	0.08	0.013	0.053	0.041	0.111	0.022	0.022	0.035	0.166
Interaction	NS	NS	NS	NS	S	NS	S	S	NS	NS	NS	NS	NS

S – Significant NS – Non significant

Table 1a Influence of iron content in Raw and parboiled rice of selected genotypes at various storage periods, cooking methods and milling times and vitamin A content of Raw and Parboiled rice of selected genotypes at different milling times

B. Genotypes	A. Rice sample						A. Rice sample					
	12th months		Pressure cooking		10 seconds interval		Interval in Seconds					
							30 sec		50 sec		60 sec	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
Kosuvakathalai	3.17	2.77	7.21	6.98	7.31	7.21	0.186	0.132	0.169	0.012	0.110	0.100
Madhukar	0.45	0.34	2.17	1.93	2.10	2.14	1.287	1.214	1.147	1.177	1.047	1.168
IC208793	2.81	1.86	4.29	4.01	3.76	4.19	0.296	0.037	0.288	0.290	0.195	0.024
IC255787	3.03	2.75	4.25	4.01	4.04	3.98	1.900	0.017	0.008	0.032	0.003	0.008
IC350429	3.48	3.22	6.93	6.63	7.06	6.73	0.043	0.043	0.017	0.023	0.023	0.011
TKM9	0.07	0.07	0.17	0.12	0.40	0.33						
Mapillaisamba	0.45	0.32	0.57	0.49	0.78	0.75						
IR68144	3.16	2.94	5.01	4.73	4.99	4.99						
	SEd	CD at 5 %	SEd	CD at 5 %	SEd	CD at 5 %	SEd	CD at 5 %	SEd	CD at 5 %	SEd	CD at 5 %
*	0.056	0.113	0.037	0.076	0.004	0.018	0.0013	0.0027	0.0084	0.0179	0.041	0.087
**	0.062	0.17	0.037	0.083	0.019	0.040	0.0012	0.0028	0.0086	0.0224	0.046	0.132

S – Significant NS – Non significant *to compare means of two B of the same A ** to compare means of two A at the same (or) different B

Table 2 Retention of Vitamin A content of selected rice genotypes at various storage periods, different milling time and different methods of cooking

Treatments	Interval in months					Interval in months						Cooking methods	
	Part per million (ppm)					Part per million (ppm)						Part pe million (ppm)	
	0th	3rd	6th	9th	12th	10 sec	20 sec	30 sec	40 sec	50 sec	60 sec	Normal boiling	Pressure cooking
A. Rice samples													
Raw rice	0.250	0.470	0.417	0.400	0.380	0.438	0.380	0.366	0.357	0.326	0.277	0.244	0.197
Parboiled rice	0.310	0.220	0.292	0.280	0.270	0.305	0.299	0.288	0.281	0.307	0.262	0.089	0.227
SEd	0.0004	0.120	0.0001	0.0009	0.0005	0.0005	0.0004	0.0004	0.0004	0.0041	0.028	0.0002	0.0005
CD at (5 %)	NS	0.504	NS	NS	NS	NS	NS	0.0017	NS	0.0173	0.013	NS	NS
B. Genotypes													
IR68144	0.280	0.260	0.244	0.220	0.210	0.273	0.163	0.159	0.153	0.198	0.107	0.123	0.140

Kosuvakathalai	0.820	1.100	1.272	1.250	1.210	1.310	1.284	1.250	1.233	1.162	1.107	0.603	0.958
TKM9	0.170	0.170	0.169	0.170	0.170	0.172	0.168	0.167	0.163	0.286	0.109	0.028	0.028
IC255787	0.050	0.040	0.027	0.020	0.020	0.038	0.027	0.018	0.013	0.091	0.006	0.022	0.017
IC350429	0.070	0.066	0.06	0.050	0.030	0.066	0.055	0.043	0.034	0.200	0.017	0.059	0.052
SEd	0.0008	0.014	0.0015	0.0007	0.0006	0.0009	0.0011	0.0009	0.0019	0.0059	0.029	0.0007	0.0009
CD at (5 %)	0.0017	0.029	0.0032	0.0014	0.0013	0.0020	0.0023	0.0019	0.0041	0.0127	0.061	0.0014	0.0018
Interaction	NS	NS	NS	NS	NS	NS	NS	S	NS	S	S	NS	NS

S – Significant   NS – Non significant

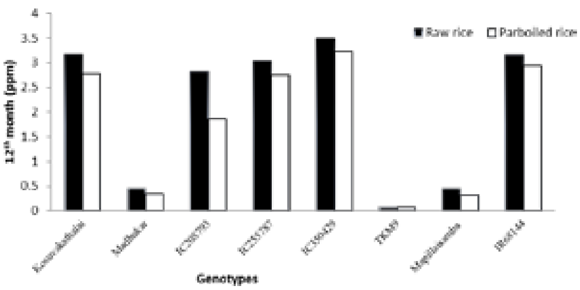

Fig 1 Effect of iron content in Raw and parboiled rice of selected genotypes at twelth month (ppm) of storage period

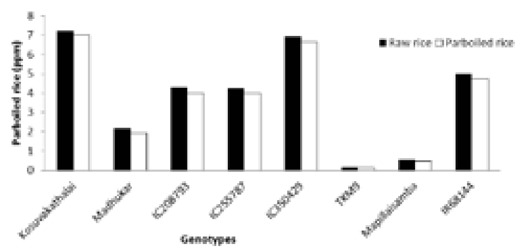

Fig 2 Effect of Iron content of raw and parboiled rice of selected genotypes in pressure cooking (ppm) method

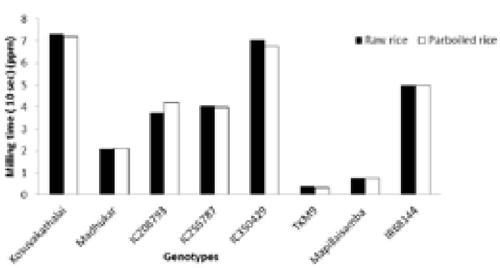

Fig 3 Effect of Iron content of raw and parboiled rice of selected genotypes at different milling times

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