Grain quality and iron density of Philippine rice cultivars

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Abstract

For breeding efforts on increasing the iron concentration of rice to succeed, stability of iron-dense traits of cultivars across environments and their acceptability to consumers must be considered. Ten Philippine rice cultivars were grown in various environments to measure effects on grain iron concentration. Cultivars were grown in Batac, Ilocos Norte and Mu?oz, Nueva Ecija during the wet and dry seasons of 2002. During the dry season, higher grain iron concentrations were observed at Batac compared to Munoz, although a significant correlation coefficient between Batac and Munoz analysis suggests that the level of iron concentrations across the genotypes tested remained stable and, while a significant environment effect was witnessed, there was no apparent G x E effect. Meanwhile, most of the cultivars exhibited lower grain iron during the wet season for both locations.

Grain quality data of the samples for 2001 wet and 2002 dry seasons were consolidated. All milled samples had excellent physical attributes and were found to be acceptable in the consumer sensory evaluation. Crude protein values ranged from 6.3% to 9.1%. Most of the samples had intermediate to low apparent amylose content and low to intermediate alkali spreading values. All cooked samples received acceptable ratings from the consumer panelists.

Keywords

biofortification, germplasm, chalky grains, ions, grain length and shape, volume expansion

Seasonal Effects on Iron Content of Rices Grown in Two Locations

A total of 438 lines/varieties were subjected to inductively coupled plasma-atomic emission spectroscopy (ICP-AES) for grain mineral concentration analysis in the Waite Analytical Services Laboratory of Adelaide University in Australia (as this facility is not yet locally available). From this germplasm, two sets of the 10 aromatic entries were planted in Munoz, Nueva Ecija and Batac, Ilocos Norte, and were reanalyzed to determine any GxE interaction, particularly in terms of iron content. These included IR68144, the iron-dense rice developed by the International Rice Research Institute (IRRI). Table 1 presents the iron contents of the ten cultivars in brown rice form.

Table 1. Iron (Fe) contents of mineral-dense cultivars harvested from two different fields in the 2002 WS.

Designation	Fe Content (mg/kg)		Mean Fe (mg/kg)
	Batac	Munoz	
IR841-85	7.5	8.0	7.7
PR27423 - MS6	7.4	6.9	7.1

PR27425 - MS8	8.7	7.9	8.3
PR31595 - PSC101	-	8.8	
PR27089-4-33-35-1	7.6	7.9	7.8
PR26243-69-1-6-1-1-1-1	11.2	8.4	9.8
IR69745-251-2-2-1-1	10.2	9.8	10.0
IR72860-80-3-3-3	10.5	9.2	9.9
IR72870-120-1-2-2-2	9.0	8.6	8.8
IR68144-2B-2-2-3-2	11.9	10.3	11.1

Note: (-) no data obtained; samples were infected

All samples, except IR841-85 and PR27089-4-33-35-1, had higher grain iron in Batoc than in Munoz. This may be due to differences in soil properties (Gregorio *et al.* 1999) and irrigation water (Juliano 1993). IR68144-2B-2-2-3-2 exhibited the highest iron concentration in both locations; PR27423-MS6 had the lowest. The correlation coefficients, r_1=0.836** and r_2=0.825** (Fig. 1) indicate that the iron-dense traits among the samples are expressed in both locations.

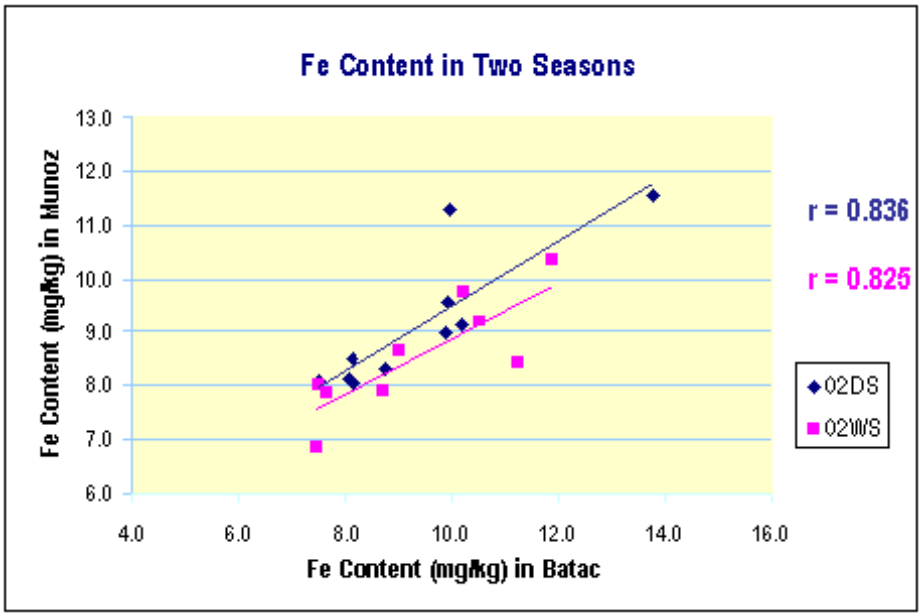

Figure 1. Correlation of Fe content across environments.

Table 2 summarizes the iron concentration data of the ten samples during the 2002 dry (DS) and wet seasons (WS).

Table 2. Iron concentrations of rice cultivars harvested in two seasons (2002) and locations.

Designation	Grain Iron (mg/kg)			
	Batac		Munoz	
	DS	WS	***DS***	**WS**
IR841-85	8.8	7.5	8.3	8.0
PR27423 - MS6	7.5	7.4	8.1	6.9
PR27425 - MS8	8.0	8.7	8.1	7.9
PR31595 - PSC101	8.2	-	8.1	8.8
PR27089-4-33-35-1	8.1	7.6	8.5	7.9
PR26243-69-1-6-1-1-1-1	9.9	11.2	9.6	8.4
IR69745-251-2-2-1-1	10.0	10.9	11.3	9.8
IR72860-80-3-3-3	9.9	10.5	9.0	9.2
IR72870-120-1-2-2-2	10.2	9.0	9.1	8.6
IR68144-2B-2-2-3-2	13.8	11.9	11.5	10.3

Note: (-) no data obtained; samples were infected

In Munoz, lower iron concentrations during the WS were observed, except PR31595-PSC101 and IR72860-80-3-3-3, which had 0.7 mg/kg and 0.2 mg/kg increases, respectively. The lower solar radiation at the reproductive stage, which slowed down the movement of ions in the transpirational stream, may have caused the drop (Cabuslay *et al.,* 2003). Five samples in Batac had lower grain iron during the WS than DS. These are IR841-85 (1.3 mg/kg difference), PR27423-MS6 (0.1 mg/kg), PR27089-4-33-35-1 (0.5 mg/kg), IR72870-120-1-2-2-2 (1.2 mg/kg), and IR68144-2B-2-2-3-2 (1.9 mg/kg).

Grain Quality Profiles of Iron-Dense Philippine Rice Cultivars

A rice variety must have excellent milling potential (MP) and physical attributes (PA) to command higher market value (Juliano 1993). These characteristics of the study samples are summarized in Table 3. Of the 10 samples, only IR841-85 and PR31595-PSC101 had poor mean MP – poor brown rice yield, and Grade 2 %total milled and Grade 2 %head rice. RTWG (1997) recommends $\geq$75.0% BR, $\geq$65.1% TMR,

and 48.0% HR. Another line, IR69745-251-2-2-1-1, had unacceptable mean %TMR and %HR (both Grade 2).

The PA consist of %chalky grains, grain length, and grain shape (RTWG 1997), whose standard values are <5.0% (Grade 1 to Premium), 6.6-7.4 mm (Long) and >3.0 (Slender). Of the 10 samples, only IR841-85, PR27425-MS8, and PR26243-69-1-6-1-1-1-1 passed for %chalky grains. Filipinos prefer long and slender grains, and PR27425-MS8, PR31595-PSC101, PR26243-69-1-6-1-1-1-1, IR69745-251-2-2-1-1, and IR72870-120-1-2-2-2 passed the standards for both.

The physicochemical properties of rice - apparent amylose, crude protein content, gelatinization temperature (GT), and gel consistency (Table 4) - affect its eating and cooking qualities. Low to intermediate-amylose varieties are preferred by most Filipinos (Juliano 1985) and all samples fall in these categories. Amylose content is the major eating quality factor in rice (Juliano 1993), is an indicator of volume expansion and water absorption during cooking, and correlates with hardness, whiteness, and dullness of cooked rice (Juliano 1985). Meanwhile, crude protein values ranged from 6.3% to 9.1%, with PR27423-MS6 containing the lowest and PR31595-PSC101 the highest. These values fall within the mean protein range (6.3-9.2%) of rice samples from different Asian countries (Juliano 1993). Generally, all samples had low to intermediate GT scores or alkali-spreading values. PR27089-4-33-35-1 alone had a high-intermediate GT score.

References

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Table 3. Milling potential, physical attributes and physicochemical properties of the ten test varieties. The values are the means of two seasons (2002 DS and WS)

Samples	Brown Rice (%)	Milled Rice (%)	Head Rice (%)	Grain Length (mm)	Grain Shape (mm)	Chalky Grains (%)	Apparent Amylose Content (%)	Crude Protein (%)	Gelatinization Temperature
IR841-85	74.5	64.7	45.2	6.7	3.3	1.8	19.1	8.7	6.4
PR27423-MS6	76.7	67.4	46.4	6.7	2.9	6.2	18.2	6.3	5.9
PR27425-MS8	76.5	67.4	45.0	6.6	3.3	4.4	15.5	8.5	6.0
PR31595-PSC101	74.7	63.6	44.1	6.7	3.6	5.3	12.9	9.1	5.9
PR27089-4-33-35-1	78.2	69.1	55.7	6.4	3.1	11.8	14.9	8.2	3.4
PR26243-69-1-6-1-	78.8	68.6	49.4	6.8	3.3	3.0	19.3	8.3	6.0

1-1-1	76.7	65.0	45.9	6.6	3.2	14.3	18.6	8.1	6.2
IR69745-251-2-2-1-1	77.1	66.5	53.4	6.4	3.2	15.0	22.1	9.0	6.5
IR72860-80-3-3-3	78.0	68.2	51.2	6.5	3.2	7.6	22.3	8.4	4.6
IR72870-120-1-2-2-2	76.9	66.2	51.2	5.7	2.8	9.1	19.8	9.0	4.9
IR68144-2B-2-2-3-2									

Table 4. Sensory evaluation scores of cooked rice samples. Mean values for two seasons (2002 DS and WS). Scores are described below the table.

Rice Samples	Aroma	Whiteness	Gloss	Cohesiveness	Tenderness	Smoothness	Acceptability (%)
IR841-85	1.63	3.19	2.38	2.38	2.54	2.51	97.2
PR27423-MS6	1.69	3.25	2.94	2.88	2.85	2.78	93.1
PR27425-MS8	1.57	3.07	2.88	2.91	2.85	2.78	88.8
PR31595-PSC101	1.51	2.94	3.00	2.85	2.88	2.82	78.8
PR27089-4-33-35-1	1.44	3.32	2.69	2.85	2.88	2.88	80.6
PR26243-69-1-6-1-1-1-1	1.38	3.44	2.57	2.57	2.41	2.41	83.4
IR69745-251-2-2-1-1	1.44	3.57	2.57	1.94	2.76	2.63	88.9
IR72860-80-3-3-3	1.57	3.25	1.94	1.94	2.19	1.94	79.2
IR72870-120-1-2-2-2	1.63	3.26	2.35	2.22	2.25	2.32	84.5
IR68144-2B-2-2-3-2	1.07	3.00	2.32	2.35	2.28	2.10	72.2

Aroma

2 slightly aromatic (SA)

1 none (N)

Whiteness

4 white (W)

3 creamish white (CW)

Gloss

3 glossy (G)

2 slightly glossy (SG)

Cohesiveness

3 cohesive '(C)

2 slightly cohesive (SC)

Tenderness

3 tender (T)

2 slightly tender (ST)

Smoothness

3 smooth (S)

2 slightly smooth (SS)