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EFFECT OF MILLING TECHNOLOGY ON IRON CONTENT IN RICE GRAINS OF SOME LEADING VARIETIES IN THE MEKONG DELTA

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ABSTRACTS

In this study, samples of paddy, brown rice, milled rice and cooked rice from 6 varieties (OM1490, IR64, Jasmine 85, OMCS2000, IR50404 and OM576) were collected from 10 rice mills to analyze iron content in these samples. The results showed that with the same variety, iron content in the rice samples (brown rice and milled rice) was similar among some rice mills, but not for all. This was partially due to different milling technology practiced in each mill. There was a common trend that samples with higher milling degrees (more whiteness percentage) had lower iron contents in milled rice. Almost two third of iron contents were lost upon milling the brown rice. The loss upon cooking was marginal. We have set a series of milling treatments in laboratory to obtain samples with similar whiteness of the samples from rice mills. In the most cases, iron contents in laboratory samples were similar as compared to rice mill's samples. Higher milling degrees in the laboratory also led to lower iron contents in the milled rice. Across the data of samples from rice mills or from laboratory, OM1490 and OMCS2000 showed higher iron content in rice grains than other varieties.

Key words: iron deficiency, malnutrition, micronutrient deficiency, milling

INTRODUCTION

Iron is one of the most important micronutrients in the human diets. The deficiency of iron caused anemia affecting a healthy life development. In Asia including Vietnam, iron and vitamin A deficiencies are the most common nutrition disorders (Gillespie and Haddad 2001). According to a national survey on anemia prevalence in Vietnam (Khoi et al. 2003), 34.1% children below 5 and 32.3% of pregnant women are affected by anemia as compared to 24.3% of non-pregnant women and 9.4% of men. The regions mostly affected by anemia include Central Highlands (45.1% of children below five), South East (43.4% of children below five), Northern Central Coast (40.6% of children below five), and Southern Central Coast (38.3% of pregnant women).

People absorb iron from food sources of which rice is predominant in Asia. In Vietnam, people consume a high portion of rice in daily meals being more than 150 kg per capita per year as compared to less than 100 kg in Thailand, Malaysia and the Philippines. Rice is the cereal crop, which in general is not rich in iron (Welch and Graham, 2000). Efforts, therefore, have been made in several research institutes worldwide to improve the iron content in the rice endosperm (Bouis et al. 2003). Most rice is consumed in form of milled rice. The degree of milling affects the content of milled rice. This study aims at to investigate the effect of various milling degrees in different rice milling factories on the iron content of different varieties and to identify the milling time of samples in laboratory to correspond to practical milling degree in rice mills.

Materials and methods

Sampling

The samples were collected randomly with 3 replications. Sampling was done as follows. Ten rice mills in Cantho province were selected as F1 to F10. Samples from two varieties (V1, V2) were taken in each mill. The varieties OM1490, IR64 and Jasmine 85 were present in four rice mills. Then OMCS2000 and IR50404 were present in three ones. The variety OM576 was present in 2 ones. The sampling code is given in Table 1. Samples of paddy, brown and milled rice were taken.

Table 1: Code of samples of varieties collected from 10 rice mills

Sampling code	Rice variety	Commercial rice mill
F1V1	OM1490	1
F2V1	OM1490	2
F5V1	OM1490	5
F8V1	OM1490	8
F4V1	IR64	4
F6V1	IR64	6
F7V1	IR64	7
F10V1	IR64	10
F4V2	Jasmine 85	4
F9V1	Jasmine 85	9
F6V2	Jasmine 85	6
F10V2	Jasmine 85	10
F1V2	OMCS2000	1
F5V2	OMCS2000	5
F8V2	OMCS2000	8
F2V2	IR50404	2
F3V2	IR50404	3
F9V2	IR50404	9
F7V2	OM576	7
F3V1	OM576	3

Analysis of iron content

Commercial sample analysis: approximately three grams of each paddy, brown and milled rice sample were prepared and placed in paper bags. The samples were analyzed at Waite Analytical Service (WAS), University of Adelaide, Australia. We used Agilent 7500c Inductively Coupled Plasma Mass Spectrometer (ICPMS). This instrument is manufactured by Agilent Technologies, Japan. The 7500c model, which features the Octopole Reaction System (ORS) that can chemically eliminate most common polyatomic interferences in a range of heavy matrix type. The ORS can be run with H2 or He, which virtually eliminates matrix, and argon based interferences. It also features a 27.12 MHz ICP RF generator, combined with a low flow nebuliser, Peltier- cooled spray chamber, and wide bore torch injector that produces a highly efficient mechanism for the decomposition of heavy matrix samples. This is evidenced by the low metal oxide specifications for this instrument. Applications by this technique (Sample-Detection Limits/Repotring Limits) were followed the procedures described by the Manufacture.

Laboratory dehulling and milling:

- Paddy rice samples were dehulled by hand. After dehulling, the brown rices, 3 grams of each sample were placed in paper bags and sent to WAS for analysis.
- To measure the milling degree, the instructions for the use of Satake meter were followed. Firstly, the commercial milled samples were read for the milling degree with Satake whitening meter (Table 2). The remaining rice samples from commercial factories were dehulled in Satake dehuller for laboratory milling. For designing the milling treatment to the laboratory mill sample, one hundred grams of each brown rice sample were milled in Grainman laboratory mill for a duration that results in the similar milling degree recorded in the commercial mill samples. A set of three time durations of milling was set for each sample (Table 2). After each milling, the milling compartment was cleaned with a brush and paper towels damp with 70% ethanol.

Cooking of milled rice samples

Ten grams of milled rice sample obtained from commercial milling factories or laboratory were placed in test tubes nestled in tube racks. Hot water bath was preheated. Approximately 20 ml of double distilled water were added to each tube. Test tubes were placed in hot water bath and the samples were left to cook for 30 minutes.

After cooking, the rice was left to cool for 10 minutes. Samples were dried in oven at 60°C for 12 hours. Three grams of each cooked rice sample was packed and sent to WAS for Fe analysis.

Table 2: Whiteness and milling degree of milled rice from rice mills and laboratory

Rice mill			Laboratory		
Sample of white rice	Whiteness (%)	Milling Degree	Milling duratio (min.)	Whiteness (%)	Milling Degree
F1 V1	40.2	97	40	36.7	77
			50	38.0	86
			60	40.7	100
F1 V2	38.2	90	30	35.8	74
			40	37.8	86
			50	40.4	96
F2 V1	38.9	93	10	34.6	70
			20	36.6	79
			30	39.4	97
F2 V2	40.7	102	30	34.6	73
			40	40.0	98
			50	40.5	103
F3 V1	40.5	103	80	39.2	96
			90	40.1	97
			100	40.3	100
F3 V2	43.6	113	50	36.9	82
			60	31.5	98
			70	43.0	118
F4 V1	42.7	115	40	39.2	97
			50	40.6	102
			60	40.7	115
F4 V2	42.0	114	60	43.2	101
			70	40.5	103
			80	39.3	117
F5 V1	40.6	103	60	42.6	95
			70	39.4	98
			80	39.7	104
F5 V2	39.1	95	20	36.7	78
			30	38.5	85
			40	39.4	98
F6 V1	43.0	118	80	42.8	108
			90	43.3	113
			100	44.5	115

Table 2: continue …

Rice mill			Laboratory		
Sample of white rice	Whiteness (%)	Milling Degree	Milling duratio (min.)	Whiteness (%)	Milling Degree
F6 V2	40.1	107	40	36.9	84
			50	39.5	98
			60	41.7	109
F7 V1	42.4	113	60	38.5	92
			70	41.4	107
			80	43.0	114
F7 V2	42.7	118	80	41.5	100
			90	40.8	97
			100	42.0	117
F8 V1	40.7	109	40	38.7	90
			50	41.0	100
			60	42.0	109
F8 V2	39.9	93	20	38.3	88
			30	39.5	96
			40	39.7	99
F9 V1	38.2	97	60	36.3	83
			70	37.0	88
			80	38.1	99
F9 V2	42.3	117	100	41.1	104
			110	41.2	105
			120	42.0	117
F10 V1	43.2	113	60	40.7	102
			70	41.8	110
			80	40.9	114
F10 V2	43.3	112	100	37.9	99
			110	39.5	101
			120	42.0	114

RESULTS AND DISCUSSION

Iron contents of paddy, brown rice, white rice and cooked rice of samples from different varieties and different milling factories are given in Table 3.

Samples of OM1490 were collected from four rice mills (1, 2, 5 and 8). Rice mills 1, 2 and 8 offered similar iron levels in brown rice, but rice mill 2 gave the highest iron levels in milled rice and cooked rice. Rice mill 5 obtained the lowest iron levels in paddy and brown rice and exhibited a similar level in milled rice as the remaining rice mills. Rice mill 2 obtained lower whiteness percentage; this might result a higher iron level of milled rice from this rice mill.

Samples of IR64 were collected from four rice mills (4, 6, 7 and 10). These mills offered similar whiteness percentage. Samples from the rice mill 10 showed the highest iron levels in milled rice and cooked rice, although they exhibited similar iron levels in brown rice as other rice mills.

Samples of Jasmine 85 collected from four rice mills (4, 6, 9 and 10). The whiteness percentage varied among surveyed rice mills; with the lowest value in mill 9 and the highest in mill 10. Rice mill 9 offered the highest iron level in milled rice and cooked rice; on the contrary, rice mill 10 obtained the lowest iron level in milled rice and cooked rice. Iron levels of brown rice from rice mills 4, 6 and 9 were almost the same.

Samples of OMCS2000 were collected from three rice mills (1, 5 and 8). The whiteness percentage from these mills was almost the same. However, rice mill 8 exhibited the highest iron level in milled rice and cooked rice, this also obtained the highest iron level in brown rice.

Samples of IR50404 were collected from three rice mills (1, 3 and 9). The highest iron level in brown rice was found in rice mill 9, but not in milled rice and cooked rice. Rice mill 3 obtained the highest iron level of milled rice and cooked rice, although it exhibited lower iron level in brown rice.

Samples of OM576 were collected from two rice mills (3 and 7). These obtained similar iron level in the brown rice, but rice mill 7 offered lower iron level in milled and cooked rice as compared to rice mill 3.

Among these varieties, OM1490 and OMCS2000 were noticed as higher iron genotypes (in brown, milled and cooked rice). Then IR64, Jasmine 85 and IR50404 were considered as lower iron genotypes. OM576 was identified in the lowest iron genotype. 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.

Difference of iron levels between brown rice and milled rice was highly significant (more than three times) but difference between milled rice and cooked rice is marginal.

Table 3. Iron content in paddy, brown rice, milled rice and cooked rice of different varieties sampled from different rice mills.

Sampling code	Rice variety	Rice mill	Whiteness (%)	Iron content (mg/kg)			
				Paddy	Brown rice	Milled rice	Cooked rice
F1V1	OM1490	1	40.20	24.86	14.71	4.18	4.14
F2V1	OM1490	2	38.93	19.03	13.06	5.21	4.60
F5V1	OM1490	5	40.60	15.40	11.38	4.73	3.27
F8V1	OM1490	8	40.67	21.85	14.45	4.75	4.22
F4V1	IR64	4	42.70	16.18	11.57	3.08	2.62
F6V1	IR64	6	43.03	16.98	12.84	2.76	2.07
F7V1	IR64	7	42.37	19.58	12.88	2.31	2.10
F10V1	IR64	10	43.20	16.17	12.58	3.55	2.91
F4V2	Jasmine 85	4	42.03	18.41	12.70	3.86	2.52
F6V2	Jasmine 85	6	40.07	18.50	11.89	3.32	2.17
F9V1	Jasmine 85	9	38.23	17.93	12.07	3.97	3.51
F10V2	Jasmine 85	10	43.33	12.84	10.29	2.30	1.94
F1V2	OMCS2000	1	38.20	29.88	12.93	4.14	4.20
F5V2	OMCS2000	5	39.13	15.08	11.77	3.73	3.25
F8V2	OMCS2000	8	39.93	18.26	14.78	5.98	5.58
F2V2	IR50404	2	40.70	15.88	12.28	3.09	2.72
F3V2	IR50404	3	43.63	17.88	11.33	3.65	3.70
F9V2	IR50404	9	42.30	19.00	12.66	2.56	2.79
F3V1	OM576	3	40.50	17.51	10.88	2.76	3.58
F7V2	OM576	7	42.73	27.55	10.98	1.09	1.14
SE (N=20)				1.32	0.30	0.27	0.25
5%LSD 57DF				3.75	0.85	0.77	0.72

The comparison of iron levels of milled rice samples from rice mill and laboratory with different milling duration is presented in Table 4 and is summarized as follows.

In case of OM1490, iron levels of milled rice from rice mills (except in rice mill 2), and laboratory T1 were not different. When milling duration increased (T3), there was a trend of decreasing iron levels in the milled rice.

In case of IR64, milling treatments in laboratory exhibited higher iron levels than in rice mills 6 and 7. The difference of iron contents was not obvious among milling durations.

In case of Jasmine 85, laboratory milling with T1 duration gave similar iron levels as rice mills 6, 9 and 10. Laboratory milling gave lower iron levels than rice mill 4. The more extended duration of milling (T3), the lower iron levels in the milled rice were obtained.

In case of OMCS2000, similar iron levels were found in laboratory treatments (T1 and T2) and rice mills 1 and 5. Rice mill 8 exhibited higher iron level than laboratory treatments. Extended milling duration (T3) obtained lower iron levels in milled rice.

In case of IR50404, iron levels in milled rice of laboratory milling treatments had higher than rice mills 2 and 9. Similarly, more milling duration (T3) obtained lower iron levels in milled rice.

In case of OM576, iron levels in laboratory milling were similar as well as rice mill 3, but higher than rice mill 7.

From these observations derived from Table 4, we may conclude that in most of the cases, laboratory milling treatments adjusted by the ways done in this study would obtain similar iron levels of milled rice as the milling practiced in commercial rice mills. It was also seen that treatments with more extended milling duration often obtained lower levels of iron in the milled rice.

Table 4. Iron content (mg/kg) of milled rice samples collected from rice mills and from laboratory with three milling duration treatments

Sampling code	Rice variety	Rice mill	Iron content	Laboratory milling		
				Duration T1	Duration T2	Duration T3
F1V1	OM1490	1	4.18	3.84	4.49	3.36
F2V1	OM1490	2	5.21	4.05	4.40	3.90
F5V1	OM1490	5	4.73	4.42	2.82	2.28
F8V1	OM1490	8	4.75	3.82	4.72	3.06
F4V1	IR64	4	3.08	2.66	2.83	2.87
F6V1	IR64	6	2.76	3.43	5.66	4.48
F7V1	IR64	7	2.31	4.52	4.36	3.78
F10V1	IR64	10	3.55	3.04	2.56	2.85
F4V2	Jasmine 85	4	3.86	2.87	2.56	2.84
F6V2	Jasmine 85	6	3.32	3.03	3.51	2.20
F9V1	Jasmine 85	9	3.97	3.91	4.15	2.68
F10V2	Jasmine 85	10	2.30	2.88	3.44	2.65
F1V2	OMCS2000	1	4.14	4.25	4.68	3.27
F5V2	OMCS2000	5	3.73	4.70	4.46	2.99
F8V2	OMCS2000	8	5.98	3.94	3.98	3.16
F2V2	IR50404	2	3.09	3.84	3.61	2.27
F3V2	IR50404	3	3.65	2.91	3.19	2.47
F9V2	IR50404	9	2.56	3.98	3.29	2.61
F3V1	OM576	3	2.76	2.83	3.52	2.21
F7V2	OM576	7	1.09	2.45	3.18	4.39
	SE(N= 3)		0.27			
	5%LSD 160DF		0.75			

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REFERENCES

Bouis HE, BM Chassy, JO Ochanda. 2003. Genetically modified food crops and their contribution to human nutrition and food quality. Trends in Food Sci.& Tech. 14: 191-209.

Gillespie S, L Haddad. 2001. Attacking the double burden of malnutrition in Asia and the Pacific. Asian Development Bank. pp. 179.

Gregorio GB, D Senadhira, RD Hunt Graham. 2000. Breeding for trace mineral density in rice. Food & Nutr. Bull. 21:382-386.

Khoi HH, NC Khan, LB Mai. 2003. General nutrition survey- 2000. Medical Publishing house, Hanoi. pp. 168.

Welch MR, RD Graham RD. 2000. A new paradigm for world agriculture: productive, sustainable, nutritious, healthful food systems. Food & Nutr. Bull. 21: 361-365.

SUMMARY IN VIETNAMESE

Ảnh hưởng của kỹ thuật xay chà đối với hàm lượng sắt trong hạt lúa, gạo của các giống lúa trồng phổ biến ở đồng bằng sông Cửu Long

Nghiên cứu về ảnh hưởng của kỹ thuật xay chà trên hàm lượng sắt trong hạt lúa gạo của các giống lúa trồng phổ biến ở đồng bằng sông Cửu long lần đầu được thực hiện ở Việt Nam. Trong nghiên cứu này, mẫu hạt lúa, gạo lứt, gạo trắng, và cơm của 6 giống lúa IR64, OM1490, Jasmine 85, OMCS2000, IR50404, OM576 thu thập từ 10 nhà máy xay chà được phân tích xác định hàm lượng sắt chứa trong các mẫu này. Kết quả cho thấy, đối với cùng một giống lúa, hàm lượng sắt trong hạt (gạo lứt và gạo trắng) tương tự ở một số nhà máy, nhưng không tương tự cho tất cả các nhà máy. Điều này có nghĩa, kỹ thuật xay chà của mỗi nhà máy phần nào có ảnh hưởng đến hàm lượng sắt trong hạt gạo. Có một xu hướng chung là khi độ xay chà tăng (tăng độ trắng hạt gạo) thường làm giảm hàm lượng sắt ở gạo trắng. Khoảng 2/3 hàm lượng sắt mất đi qua xay chà từ gạo lức đến gạo trắng. Sự mất hàm lượng sắt qua gạo nấu có xảy ra nhưng không đáng kể. Chúng tôi đã tiến hành xác định các nghiệm thức xay chà trong phòng thí nghiệm để đạt các mẫu có độ trắng tương tự như ở các nhà máy. Trong nhiều trường hợp hàm lượng sắt trong các mẫu xay ở phòng thí nghiệm tương tự nhự như mẫu ở nhà máy. Tăng mức độ xay chà trong phòng thí nghiệm cũng làm giảm hàm lượng gạo trắng. Qua kết quả phân tích hàm lượng sắt từ mẫu nhà máy hoặc ở phòng thí nghiệm, hai giống lúa OM1490 và OMCS2000 cho hàm lượng sắt cao hơn các giống lúa khác.