NOTE

Nutrient Content and Retention During Milling of Brown Rices from the International Rice Research Institute

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ABSTRACT

The nutrient content and retention during milling of brown rice was determined by energy-dispersive X-ray fluorescence spectrometry of elements on seven International Rice Research Institute (IR) rices differing in starch properties. With 10% bran-polish removal, milled rice retained 13% thiamine; 46% riboflavin; 33–50% crude ash, phosphorus, potassium, magnesium, silicon, and manganese; 54–66% calcium, iron, and zinc; and 82–90% Kjeldahl nitrogen, aluminum, sulfur, and chlorine. Mean silicon level in milled rice was 0.015%. Nutrient content and retention during milling of IR brown rices were similar to those of other brown rices.

The high-yielding semidwarf rice varieties, such as IR8, developed at the International Rice Research Institute (IRRI) in the Philippines, have higher levels of nitrogen (N), phosphorus (P), and potassium (K) in their panicles than do traditional varieties (Yoshida 1981). Improved methods of analysis allow accurate determination of analytes in foods such as rice. Energy-dispersive X-ray fluorescence spectrometry has been used in the elementary analysis of brown rice but not on milled rice (Juliano et al 1987). Mean silicon (Si) content of U.S. milled rices was reported as 0.046 ± 0.030% SD (Kennedy and Schelstraete 1975), whereas mean values for brown rices from Indonesia and the Philippines were 0.079–0.118% (Juliano et al 1987). Colorimetric assay of Si by phosphomolybdate at the IRRI showed 0.010% in a 7% protein milled IR32 rice and 0.007% for a high-protein (11%) milled IR480-5-9 rice (Juliano and Bechtel 1985).

The mineral distribution in IR brown rices has not been studied in detail, although the elementary composition of brown rice in normal and sulfur-deficient soils has been studied (Juliano et al 1987). The distribution of phytin P, K, magnesium (Mg), iron (Fe), and zinc (Zn) in milling fractions of 7% protein IR32 and 11% protein IR480-5-9 have been determined either colorimetrically or by atomic absorption spectroscopy (Resurreccion et al 1979). Chen et al (1989) reported that in Tokyo in 1985–88, indica varieties had higher contents of N, P, K, and Mg than did japonica varieties.

Thiamine and riboflavin levels in IR brown rices have been analyzed (Villareal and Juliano 1989), but corresponding values for milled rice have not been determined.

We analyzed the amount of selected elements in brown and milled rices of seven semidwarf IR varieties differing in starch

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properties (amylose content) by energy dispersive X-ray fluorescence spectrometry, with emphasis on loss during milling and on Si content of milled rice. We also determined thiamine and riboflavin levels in brown and milled rices to verify typical values expected from IR rices.

MATERIALS AND METHODS

Samples of rough rice were obtained from the demonstration plot of the Plant Breeding, Genetics and Biochemistry Division, IRRI. They were IR65 (waxy), IR24 (15–20% amylose), IR64 (20–25% amylose) and IR8, IR30, IR36, and IR72 (25–33% amylose). All except IR72 were from the 1989 dry-season crop. The rices were aged at least four months after harvest and dehulled in a Satake THU-37A-type dehuller; 100-g brown rice lots were milled in a McGill-type mill (no. 2) to remove 10% of bran-polish. Samples of brown and milled rice were ground in a Udy cyclone mill through a 60-mesh sieve and were analyzed for crude protein (N × 5.95) using micro-Kjeldahl digestion followed by colorimetric ammonia assay (Resurreccion et al 1979). Brown and milled rices were also analyzed for thiamine by the standard thiochrome assay and for riboflavin by the fluorometric method (AACC 1983).

Brown and milled rice flour samples were sent to the Department of Agronomy, University of Nebraska, to determine the content of sulfur (S), P, K, Mg, Si, chlorine (Cl), aluminum (Al), calcium (Ca), manganese (Mn), Fe, copper (Cu), Zn, and selenium (Se) using energy-dispersive X-ray fluorescence spectrometry according to Juliano et al (1987). Variation (including both instrument and sampling variation) was about 5% for the determination. Pooled standard deviation of the overall means was calculated. Thiamine and riboflavin data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Hull recovery from the seven rough IR rices was 22.6 ± 1.9%, which is characteristic of long-grain varieties. On milling to 10.1–10.2% bran-polish removal, the total milled rice yield was 69.5 ± 1.7% of rough rice and 62.2 ± 1.8% of head (whole-grain) rice.

TABLE I
Composition of Seven Brown and Milled Rices from the International Rice Research Institute (Wet Basis, Mean ± SD)[a]

Property	Brown Rice	Milled Rice	Percent of Brown Rice in Milled Rice[b]
Weight (% of brown rice)	100	89.9 ± 0.05	90
Crude ash (%)	1.56 ± 0.05	0.66 ± 0.09	38
Kjeldahl N (%)	1.62 ± 0.25	1.48 ± 0.20	82
Crude protein (% N × 5.95)	9.64 ± 1.48	8.81 ± 1.19	82
P (%)	0.38 ± 0.04	0.21 ± 0.01	50
K (%)	0.26 ± 0.02	0.14 ± 0.03	48
Mg (%)	0.13 ± 0.01	0.058 ± 0.06	40
Al (%)	0.006 ± 0.004	0.006 ± 0.004	90
Ca (%)	0.010 ± 0.001	0.006 ± 0.001	54
S (%)	0.15 ± 0.013	0.14 ± 0.009	84
Si (%)	0.041 ± 0.016	0.015 ± 0.009	33
Cl (%)	0.034 ± 0.007	0.031 ± 0.007	82
Mn (μg/g)	16.6 ± 1.4	8.4 ± 1.5	45
Fe (μg/g)	12.4 ± 1.4	9.0 ± 2.9	65
Cu (μg/g)	4.7 ± 1.0	5.2 ± 1.2	99
Zn (μg/g)	22.4 ± 3.9	16.4 ± 4.6	66
Se (μg/g)	trace	trace	90
Thiamine (μg/g)	3.2 ± 0.4	0.46 ± 0.09	13
Riboflavin (μg/g)	0.98 ± 0.07	0.50 ± 0.07	46

[a] IR65, IR24, IR64, IR8, IR30, and IR36 (1989 dry season); IR72 (1989 wet season).
[b] (89.9 × content in milled rice) ÷ (content in brown rice).

With the milling of brown rice to 10.1–10.2% bran-polish removal, crude ash decreased, corresponding to a retention of 38% of that for brown rice crude ash in milled rice (Table I). Losses were noted in minerals except Cu. Retentions of 33–50% were noted for P, K, Mg, Si, and Mn; 54–66% for Ca, Fe, and Zn; and 82–90% for Kjeldahl N (crude protein), S, Cl, and Al. The grain had only trace levels of Se. Similar distributions of Ca, P, Zn, Cu, and Fe in an Italian rice on milling were reported by Pedersen and Eggum (1983).

The Si level in the seven milled IR rices of 0.015 ± 0.009% was only about one third of the 0.046% mean reported by Kennedy and Schelstraete (1975). This difference may be attributed to the methods used, since HCl treatment of ash to render silica insoluble may not result in pure Si, whereas energy-dispersive X-ray fluorescence spectrometry is very specific for Si.

The Mg-K ratio was used by Horino et al (1983) as an indicator of Japanese brown rice grain quality. Chen et al (1989) found a higher Mg-K ratio of 0.42 for Koshihikari (a good quality brown rice) compared with 0.29–0.37 for others. Mg-K ratios for the seven IR brown rices were 0.39–0.62 (mean, 0.50) (Table I) and were above 0.4 for all brown rices except IR24. The Mg-K ratio for the indica rices, which differ widely in amylose content, may not be directly related to rice acceptability, unlike in Japanese rices (Horino et al 1983).

Thiamine and Riboflavin

Mean thiamine content decreased from 2.6–3.9 μg/g for brown rice to 0.37–0.62 μg/g for milled rice on removal of 10.1% bran-polish (Table I), equivalent to 11–17% retention. In contrast, riboflavin retention was higher: 39–54% (mean, 46%). Riboflavin contents were 0.90–1.12 μg/g in brown rice and 0.43–0.62 μg/g in milled rice. This substantiates data indicating that the thiamine gradient is steeper than that of riboflavin in rice grain (Juliano and Bechtel 1985). Varietal differences were highly significant for thiamine contents of brown and milled rices and for riboflavin content of milled rice and were significant for riboflavin content of brown rice (data not shown). The thiamine level in milled IR rices was lower than the 1.0 μg/g reported for Phillippine samples, but riboflavin levels were higher (0.5 μg/g), probably because regular milled rice has only about 7% bran-polish (FNRI 1980). Villareal and Juliano (1989) reported that 30 IR brown rices had thiamine levels of 2.6–5.2 μg/g and riboflavin levels of 0.52–0.98 μg/g. Milled IR8 rice reportedly had 0.20 μg of thiamine and 0.19 μg of riboflavin per gram (Resurreccion et al 1979).

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