NOTE

Quality Characteristics of Medium-Grain Rice Milled in a Three-Break Commercial Milling System[1]

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Within rice varieties, individual kernels vary in size. The effect of kernel size on milling performance and quality has been studied (Matthews and Spadaro 1976, Wadsworth et al 1982, Sun and Siebenmorgen 1993, Chen and Siebenmorgen 1997). These studies focused on long-grain rice milled in single-break, laboratory or commercial-scale friction mills. As rice was milled from a low to high degree of milling (DOM) level, more surface bran was removed from thin kernels than from thick kernels, and thin kernels were broken at a greater rate than thick kernels.

There is an increasing trend in use of multibreak milling systems by the rice industry. Chen et al (1998) conducted research on the milling performance of long-grain rice in both single- and triple-break commercial milling systems. For both milling systems, the surface lipids content (SLC) and protein content of milled rice varied significantly across kernel thickness fractions. SLC was influenced by DOM level more than by kernel thickness, whereas protein content was influenced by thickness more than by DOM level. As milling progressed from a low to high DOM level, thin kernels were milled at a greater bran removal rate than thick kernels, as indicated by SLC. However, protein content decreased much more uniformly across thickness fractions than did SLC during milling.

The studies mentioned above were limited to long-grain rice. The objective of the current work was to investigate the bran removal characteristics of medium-grain rice milled in a multibreak commercial milling system.

MATERIALS AND METHODS

The three-break commercial milling system used in this study comprised a Satake VTA vertical rice whitener (first break), a Satake VBF vertical rice whitener (second break), and a Satake KB-40 rice-polishing machine (third break) located at Jonesboro, AR. Brown rice was fed into the top of the VTA machine, which applied an abrasive milling action as rice flowed down through the mill. Rice from the VTA machine was fed into the top of the VBF machine, which applied a friction milling action. Water mist was injected into the VBF milling chamber. Rice from the VBF machine flowed horizontally through the KB-40 machine, which applied a friction milling action to polish the rice.

To produce milled rice for cereal manufacturers, the system was adjusted to remove only part of the bran from kernels, which corresponded to a low DOM level. For this application, brown rice was passed sequentially through only the first two breaks (VTA and VBF). To produce well-milled rice (medium or high DOM levels), brown rice was passed sequentially through all three breaks. The three-break commercial milling system was slightly different from the commercial milling system used previously to investigate long-grain rice milling performance (Chen et al 1998), in that the second break in the system was a VBF machine, whereas a KB-40 machine was used by Chen et al (1998). Both milling machines are friction-type mills.

Medium-grain rice variety Bengal (≈14% moisture content) was milled in the three-break commercial milling system in May 1997. The system was adjusted by professional milling personnel to yield three DOM levels (low, medium, and high). A single set of milled rice samples was collected from the first two breaks at the low DOM level and from all three breaks at medium and high DOM levels. All milled rice samples were separated into head rice and broken rice in a Satake test rice grader. Head rice was separated into four thickness fractions (<1.79, 1.79–1.84, 1.84–1.89, and >1.89 mm) with a Carter-Day laboratory precision sizer. Each thickness fraction was measured for SLC and protein content.

Surface lipids of milled head-rice samples from each thickness fraction were extracted in a Soxtec System HT extractor, consisting of an extraction (model 1043) and service unit (model 1044), as used previously (Chen and Siebenmorgen 1997, Chen et al 1998). Prior to extraction, 5 g of head rice was placed in a cellulose-extraction thimble (26 mm diameter, 60 mm long) and dried in a convection oven at 100°C for 1 hr. The thimble and dried samples were placed in the extractor for surface lipids extraction. SLC was calculated as the amount of extracted surface lipids, expressed as a percentage of original head-rice mass (5 g). For each sample, duplicate measurements were performed.

The protein content of milled-rice samples was measured with a Fisons NA-2000 nitrogen/protein analyzer, using the Dumas technique (Schmitter and Rihs 1989). Prior to measurement, head-rice samples from each thickness fraction were ground in a Udy cyclone sample mill with a 0.5-mm diameter screen. A ground 50-mg sample was placed in a tin capsule and loaded into the analyzer. The sample was melted and converted to combustion gases at 900°C in a combustion reactor. Nitrogen was separated from the combustion gases and detected with a thermal conductivity detector. The protein content (dry basis) of each sample was calculated as detected nitrogen content multiplied by a calibration constant of 5.95. Duplicate measurements were performed.

Experimental data were analyzed statistically. Using Duncan's multiple range test (SAS/STAT User's Guide, Release 6.03, SAS Institute, Cary, NC), thickness fractions at each DOM level for all three breaks were grouped according to SLC and protein content (Table I).

RESULTS AND DISCUSSION

Compared with several long-grain rice varieties (Alan, Katy, Newbonnet, and Kaybonnet) investigated previously (Chen and Siebenmorgen 1997, Chen et al 1998), Bengal had greater overall kernel thickness and was more uniform in thickness, as indicated by a narrower thickness range (Table I). For milled rice at each of the three DOM levels, Bengal had similar SLC and lower protein content compared with long-grain rice varieties.

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TABLE I
Surface Lipids (SLC) and Protein Contents Across Thickness Fractions for Three Degree of Milling (DOM) Levels at the Exit Stream of Each of the Three Breaks of a Commercial Milling System[a,b]

Thickness (mm)	SLC (%)								Protein Content (%)							
	Low DOM		Medium DOM			High DOM			Low DOM		Medium DOM			High DOM		
	VTA	VBF	VTA	VBF	KB40	VTA	VBF	KB40	VTA	VBF	VTA	VBF	KB40	VTA	VBF	KB40
<1.79	1.04a	0.72a	0.85a	0.53a	0.46a	0.77a	0.46a	0.38a	7.80a	7.78a	7.68a	7.50a	7.38a	7.80a	7.43a	7.38a
1.79–1.84	0.90b	0.63b	0.77ab	0.48b	0.42a	0.69b	0.42a	0.33a	7.63a	7.20b	7.30b	7.25b	7.08b	7.33b	7.13ab	7.08ab
1.84–1.89	0.83c	0.60b	0.74b	0.49b	0.42a	0.68b	0.42a	0.35a	7.35b	7.20b	7.23b	7.10bc	6.80c	7.20b	6.83bc	6.75b
>1.89	0.85c	0.63b	0.73b	0.50b	0.44a	0.69b	0.43a	0.35a	7.18b	6.90c	7.05b	6.98c	6.63d	6.98c	6.63c	6.70b

[a] Values are means of duplicate measurements.
[b] Values in each column followed by the same letter are not significantly different at $P = 0.05$ based on Duncan's multiple range test. Satake VTA, VBF, and KB40 milling machines were used for first, second, and third breaks, respectively.

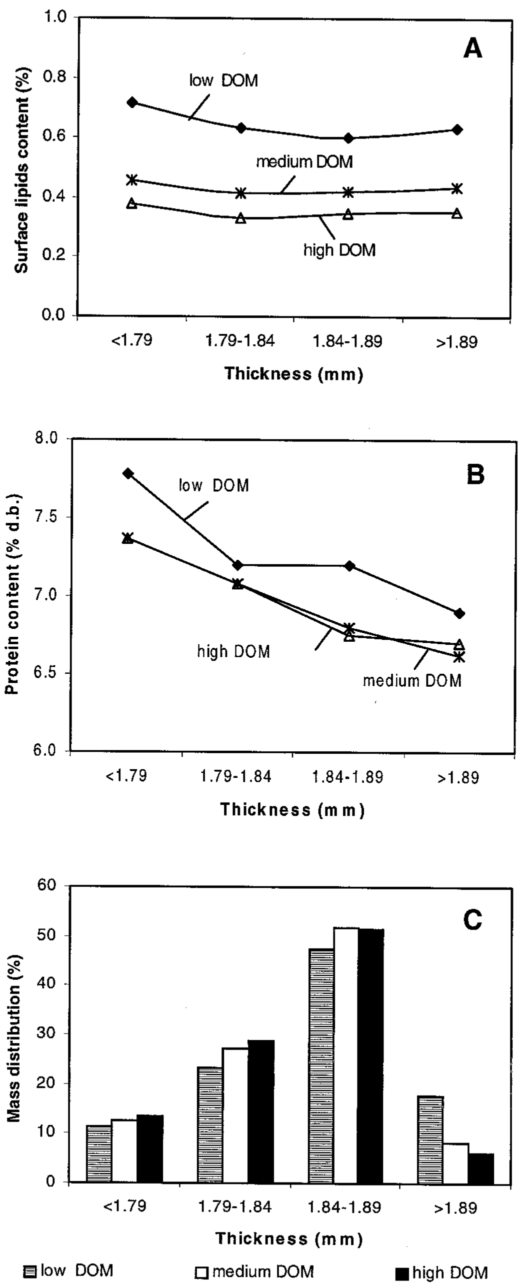

Fig. 1. A, Surface lipids content, **B,** protein content, and **C,** mass distribution of head-rice thickness fractions at the indicated degree of milling (DOM) levels for Bengal medium-grain rice milled in a multibreak commercial milling system. Data for the medium and high DOM levels represents rice milled by sequentially passing through Satake VTA, VBF, and KB40 milling machines, whereas rice milled at the low DOM level passed through only the VTA and VBF machines.

For rice leaving the first break (VTA), the thinnest kernel fraction had higher SLC than other thickness fractions at all three DOM levels (Table I). The ranges of SLC across thickness fractions were 0.21, 0.12, and 0.09 percentage points (pp) at low, medium, and high DOM levels, respectively. For rice leaving the second break (VBF), the thinnest kernel fraction had higher SLC than the other thickness fractions only at low and medium DOM levels. Corresponding ranges were reduced to 0.12 and 0.05 pp. For rice leaving the second break (VBF) at the high DOM level and the third break (KB40) at medium and high DOM levels, SLC was not significantly different across thickness fractions. As milling progressed from a low to high DOM level or from one break to another, SLC was reduced at a greater rate from thin kernels than from thick kernels. At all milling settings, thin kernels had higher protein content than thick kernels (Fig. 1, Table I). Increasing the DOM level from low to high did not significantly influence the distribution of protein content across thickness fractions.

For rice milled at the low DOM level (Fig. 1), the thinnest kernel fraction (<1.79) had higher SLC than the thicker kernel fractions, and thin kernels had higher protein content than thick kernels across the entire thickness range. For well-milled rice (medium and high DOM levels in Fig. 1), SLC was not significantly different across thickness fractions, whereas protein content decreased almost linearly with increasing kernel thickness. The trends in SLC distribution were similar to those for long-grain rice. However, the nearly linear trends in protein content distribution were different from those for long-grain rice, which approximated the general trends found in SLC distributions.

Head-rice milled to a high DOM level had fewer thick kernels (>1.89 mm) and more thin kernels (<1.79 mm) than rice milled to low and medium DOM levels (Fig. 1). One possible cause of the shift in mass distribution toward thinner kernel fractions was that the thickest kernels (>1.89 mm) were broken at a higher rate than thinner kernels in the three-break commercial milling system. A second possibility was that bran removal during milling caused an effective reduction in kernel thickness. As a result of increased milling and reduced kernel thickness, kernels would be moved into the adjacent, thinner thickness fractions. At this stage, no conclusion can be made as to which possibility is the predominant factor causing mass distribution changes.

CONCLUSIONS

As milling of medium-grain rice variety Bengal progressed from a low to high DOM level, thin kernels were milled at a greater bran removal rate than thick kernels, as indicated by SLC. This trend was similar to those observed in earlier studies with long-grain rice.

For rice milled at a low DOM level (milled only by the first two breaks), the thinnest kernel fractions had significantly higher SLC than the other thickness fractions. Thin kernels also had a higher protein content than thick kernels over the entire thickness range.

For well-milled rice (milled by three breaks at medium and high DOM levels), SLC was uniform across kernel thickness fractions, whereas protein content varied across thickness fractions, similar to variations observed at low DOM. Well-milled rice (high DOM) had fewer thick kernels (>1.89 mm) and more thin kernels (<1.79 mm) than rice milled at lower DOM levels.

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