A NOTE ON SURFACE LIPID CONTENT AND SCANNING ELECTRON MICROSCOPY OF MILLED RICE AS RELATED TO DEGREE OF MILLING[1]

C. A. WATSON, E. DIKEMAN, and R. A. STERMER[2]

ABSTRACT

Long-grain rice was milled by nine different treatments to obtain samples with a wide range in degree of milling. Surface lipid, ash, and protein were determined for each treatment and milled rice was examined by scanning electron microscopy. The milling treatment, surface lipid, and ash contents, and the amounts of pericarp and aleurone removed were related. Within a treatment, however, the amounts of pericarp and aleurone removed varied among kernels and on the same kernel.

Degree of milling of rice is an important processing and grading factor. Degree of milling usually is determined by visual examination. Analytical methods include photometric measurements (1,2) and determination of surface lipid content (3). We used the latter, which is the most widely used chemical assay, as the standard method of comparison.

Degree of milling of rice is related to the amount of bran layers (pericarp and aleurone) and germ removed during the milling process. The more severe the degree of milling, the lower the surface lipids and ash because more aleurone and outer endosperm have been removed. Lipid and ash contents are higher in the outer than in the inner endosperm (4). A more definitive understanding of what part of the kernel is removed in relation to various degrees of milling is important. Rice kernels were examined by scanning electron microscopy (SEM), and relations to the visual degree of milling and surface lipid, ash, and protein contents were studied.

MATERIALS AND METHODS

Long-grain rice, variety "Labelle," was used. Scanning electron photomicrographs were taken of the transverse cross-sectional area of a rice kernel with an ETEC scanning electron microscope at an accelerating voltage of 20 kV. A razor blade was used to cut the kernels, although the kernels fractured under the blade. Unsuccessful attempts were made to cut or fracture the kernel in the longitudinal direction, but the kernels shattered. The kernel sections were then mounted on aluminum stubs with Duco® cement and coated with a ~150 Å-thick gold-palladium alloy before observing with the SEM. Surface lipids were determined by the method of Hogan and Deobald (3). The rice was shelled with a McGill Laboratory Sheller, Model MS-1, and milled with a McGill Laboratory

[1]Cooperative investigations between the U.S. Department of Agriculture, Agricultural Research Service, North Central Region, and the Department of Grain Science and Industry, College of Agriculture, Kansas State University, Manhattan.

[2]Respectively: Research Chemist, Research Assistant, and Research Agricultural Engineer, Grain Marketing Research Center, 1515 College Ave., Manhattan, KS 66502.

Reference to a company or product does not imply approval or recommendation of the product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

Mill, No. 2, as reported in Table I. To determine weight loss (per cent of the kernel removed during milling), the kernels in about 15 g were counted before and after milling, and per cent loss was calculated. Protein and ash contents were determined by AACC Approved Methods (5).

Degree of milling was evaluated visually by the Board of Appeals and Review—Rice, Grain Division, Agricultural Marketing Service, U.S. Department of Agriculture, New Orleans, Louisiana.

RESULTS AND DISCUSSION

Results of the visual examination of the milled rice, per cent material removed, and surface lipid, ash, and protein contents are reported in Table II.

Visual examination shows that all samples graded "well-milled" after 30 sec of milling with weight (1000 g) at the full-length (24.5 cm) of the bar. There was a

TABLE I
Treatment, Setting of Weight on Mill Arm, and Milling Time

Treatment	Weight and Setting on Mill Arm	Milling Time sec
1	125 g at 24.5 cm	30
2	1000 g at 24.5 cm	10
3	125 g at 24.5 cm	60
4	1000 g at 12.2 cm	30
5	1000 g at 24.5 cm	30
6	1000 g at 12.2 cm	60
7	1000 g at 24.5 cm	45
8	1000 g at 24.5 cm	60
9	1000 g at 24.5 cm	120

TABLE II
Treatment, Visual Degree of Milling, Weight Loss, Surface Lipid, Ash, and Protein Contents of Milled Rice

Treatment	Degree of Milling	Weight Loss %	Surface Lipids %	Ash %	Protein (N × 5.95) %
0	Brown (unmilled)		0.39	1.33	8.0
1	Undermilled	3.0	0.99	0.84	8.1
2	Undermilled	6.0	0.78	0.61	7.7
3	Lightly milled	6.9	0.63	0.54	7.8
4	Reasonably well milled	7.7	0.55	0.47	7.6
5	Well milled	8.0	0.36	0.35	7.6
6	Well milled	8.1	0.33	0.34	7.6
7	Well milled	8.9	0.26	0.24	7.6
8	Well milled	8.7	0.22	0.20	7.6
9	Well milled	9.7	0.17	0.17	7.5

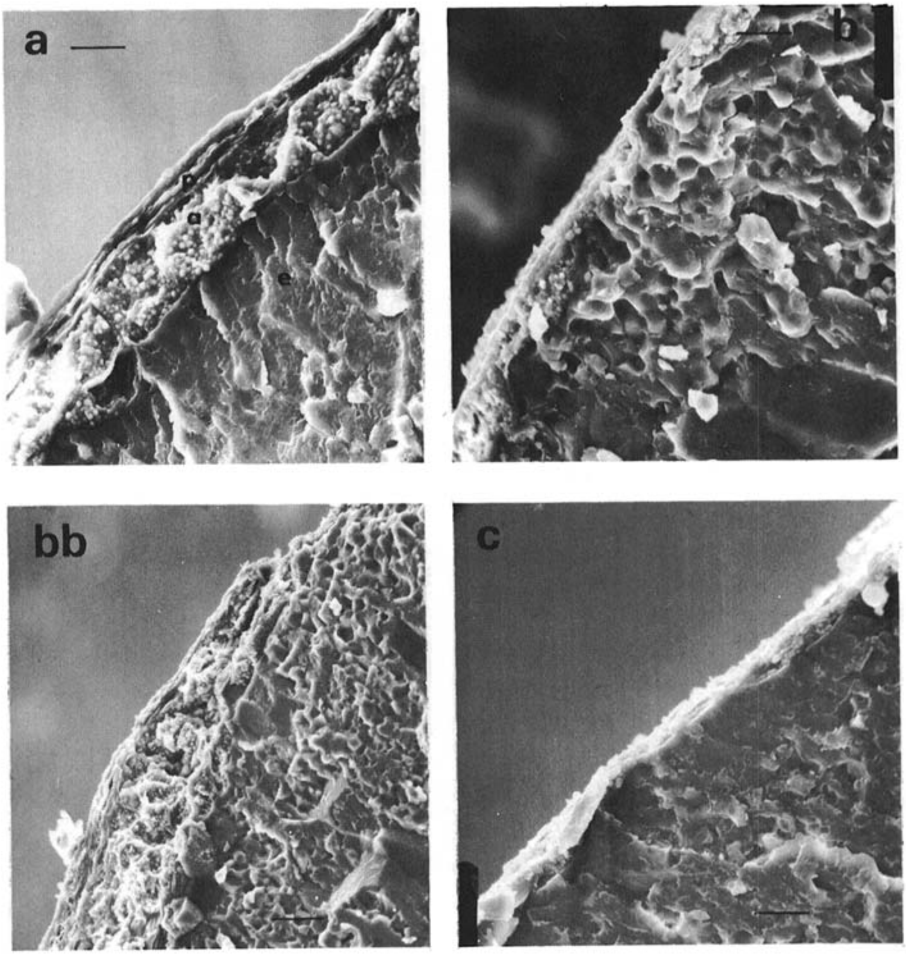

Fig. 1. SEM of brown and milled rice. Bar equals 14.3μ, except where noted. **a**) Brown rice, unmilled; **p**=pericarp; **a**=aleurone; **e**=endosperm; **b**) treatment No. 1, undermilled; **bb**) treatment No. 1, undermilled (bar = 20μ); **c**) treatment No. 2, undermilled.

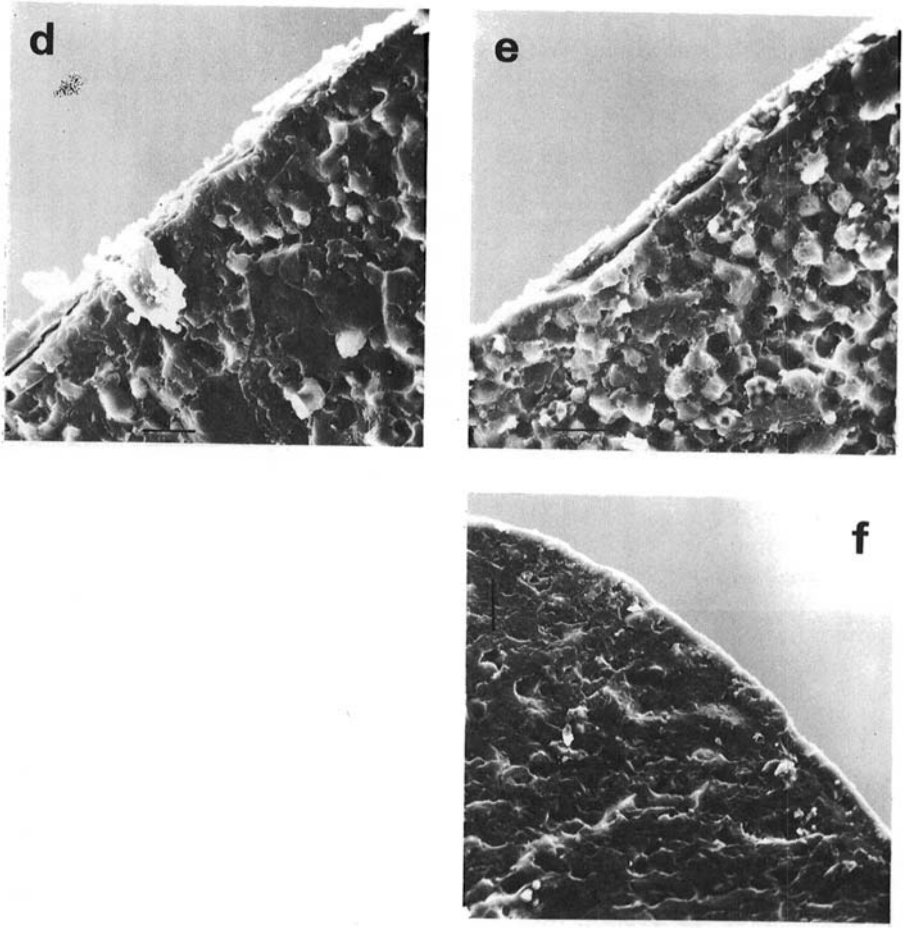

Fig. 1. SEM of brown and milled rice. Bar equals 14.3μ, except where noted. **d)** treatment No. 3, lightly milled; **e)** treatment No. 4, reasonably well milled; **f)** treatment No. 5, well milled.

definite decrease in surface lipid and ash contents with increase in severity of milling treatment. Surface lipid content decreased from 0.99% for treatment No. 1 to 0.17% for treatment No. 9. The surface lipid content of brown rice was 0.39%, indicating that the pericarp acts as a protective layer for the aleurone layer which has a high lipid content. Ash content decreased from 1.33% in brown rice to 0.17% in treatment No. 9. Surface lipid and ash contents at the various degrees of milling were significantly related (r = 0.99); per cent weight loss was not as highly correlated to either surface lipid (r = 0.96) or ash contents (r = 0.97). Protein content of the residual samples changed little.

SEM of the transverse cross section of rice kernels representing milling treatments No. 1-5 are shown in Fig. 1. In the brown rice kernels examined, the pericarp contained two to three layers of apparently fibrous material and the aleurone layer was one to two cells thick (Fig. 1a). However, additional SEM (not shown here) indicated that the aleurone layer may be from one to three cells thick in the same kernel—the three layers occurring on the dorsal surface.

Degree of milling, per cent weight loss, surface lipid, and ash contents are associated, as predicted, with the amount of pericarp and aleurone layers removed. Treatments No. 1-5 (Fig. 1b, 1c, 1d, 1e, and 1f) show decreasing amounts of pericarp and aleurone. In fact, all of the pericarp was removed with treatment No. 1 and essentially all of the aleurone was removed with treatment No. 5. Within a treatment, however, the amounts of pericarp and aleurone removed varied among kernels and on the same kernel. The kernels used for the SEM's were selected as being representative of the average degree of milling for each treatment. The variation in the amount of pericarp and aleurone removed on the same kernel is shown in Fig. 1bb. The upper portion of the photograph shows that the major portion of the pericarp and aleurone layers have been removed, whereas the lower portion shows some pericarp still attached. The SEM's for treatments 6-9 were all similar to the SEM for treatment No. 5.

SEM of treatments No. 7-9 show that only the endosperm was left. Though the aleurone was essentially removed by treatments No. 7 and 8, surface lipid and ash contents were reduced further by treatment No. 9, presumably because some of the subaleurone layer that is relatively rich in lipid was removed.

Table II shows the range in surface lipid and ash contents within a specified degree of milling. For example, all samples with 0.36% surface lipid content and 0.35% ash content and below graded "well-milled." This finding suggests that a specified degree of milling might be more closely associated with a range in contents of surface lipid and ash than with a specific amount. The method for surface lipid requires a flammable solvent and the methods for surface lipid and ash are lengthy and, therefore, unsuitable for grading rice. Consequently, we believe that an instrumental method for measuring degree of milling objectively, rather than the present subjective visual method, would be desirable. Our research is being directed toward this objective.

Acknowledgment

The authors gratefully acknowledge the assistance of Pam Tuillez for taking SEM's and the Board of Appeals and Review—Rice, Grain Division, Agricultural Marketing Service, U.S. Department of Agriculture, New Orleans, Louisiana, for visual examination and determination of degree of milling of the rice samples.

Literature Cited

1. STERMER, R. A. An instrument for objective measurement of degree of milling and color of milled rice. Cereal Chem. 45: 358 (1968).
2. STERMER, R. A., SCHROEDER, H. W., HARTSTACK, A. W., Jr., and KINGSOLVER, C. H. A photometer for measuring the degree of milling of rice. Rice J. 65: 22 (1962).
3. HOGAN, J. T., and DEOBALD, H. J. A method for determining the degree of milling of whole milled rice. Cereal Chem. 38: 291 (1961).
4. BARBER, S. Milled rice and changes during aging. In: Rice: Chemistry and technology, ed. by D. F. Houston; chap. 9, p. 223. Amer. Ass. Cereal Chem.: St. Paul, Minn. (1972).
5. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Approved methods of the AACC. The Association: St. Paul, Minn. (1962).

[Received October 15, 1974. Accepted December 22, 1974.]