

LIGHT-REFLECTANCE METER MEASURES DEGREE OF MILLING AND PARBOILING OF PARBOILED RICE¹

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ABSTRACT

A rapid objective method for determining the degree of milling and parboiling of parboiled rice which may be used in routine inspection of rice under the Official Rice Standards of the United States is described. A light reflectance meter is used to measure differences at 546 m μ . Approximately 400 samples of rice can be tested for degree of milling per day by one operator.

Color is used by rice inspectors as a principal criterion for determining the numerical grade of rice. Both degree of milling and degree

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of parboiling influence the color of rice kernels.

The color of milled rice varies from white to gray, usually depending upon the degree of milling. Varying amounts of bran may be left on the kernels after milling, and this residual bran imparts a grayish color to the rice. Therefore, degree of milling is an important factor contributing to the color of the milled rice. Using color as the determinant of degree of milling, rice inspectors visually grade milled rice into one of six numerical grades as follows (1):

U.S. No. 1 shall be white or creamy, and shall be well milled. U.S. No. 2 may be slightly gray, and shall be well milled. U.S. No. 3 may be light gray, and shall be reasonably well milled. U.S. No. 4 may be gray or slightly rosy, and shall be reasonably well milled. U.S. No. 5 and U.S. No. 6 may be dark gray or rosy, and shall be reasonably well milled.

In parboiling, the color of rice changes from white to amber. During this process the nutrients from the bran are driven into the kernel. The following conditions of processing affect the degree of color change: 1) temperature of the water; 2) length of soaking period; 3) duration of steaming time; and 4) temperature maintained during drying.

The degree of color in parboiled rice is classified into three categories which are used in marketing parboiled rice. According to the U.S. Grain Standards (1), the words "Parboiled Light" shall be added to the grade "if the milled rice is not colored or is slightly colored by the parboiling treatment, the word 'Parboiled' if the milled rice is distinctly but not materially colored by the parboiling treatment, and the words 'Parboiled Dark' if the milled rice is materially colored by the parboiling treatment."

The present official method for determining both degree of milling and degree of parboiling in rice is based purely on a visual comparison. To aid the inspector, sample standards of each of the categories are used as guides. The rice inspector compares the test sample with preselected sample standards and establishes the degree of milling or degree of parboiling, or both. His accuracy depends upon his skill in matching colors. Therefore, an objective, simple, rapid, and more precise method of differentiating both degree of milling and degree of parboiling in rice is needed.

The present research, however, was limited to developing a simple, objective method for determining degree of milling and degree of parboiling in parboiled long-grain rice which could be used in routine inspection of rice under the Official Rice Standards of the United States. Obviously, the method should be practical, rapid, and precise.

Because degree of milling and degree of parboiling in parboiled rice can be differentiated visually, a Bausch & Lomb No. 505 recording

spectrophotometer was used initially to determine the optimum wave length in the visual spectrum to measure these color differences. Later, the possibility of using a simpler device that would measure reflected light was investigated. Accordingly, an Agtron Model F2-61 was used in this study to measure differences at 546 $m\mu$.

Material and Methods

A Bausch & Lomb 505 recording spectrophotometer was used to obtain the spectral reflectance curves of white, slightly gray, light gray, gray, and dark gray parboiled light rice in the 400- to 700- $m\mu$ range. Fifty grams each of the five types of milled parboiled light rice was placed in a plastic cup with a clear bottom. Reflectance of only the surface layer at the bottom of the cup was measured.

The spectral reflectance curves of well-milled parboiled light, parboiled, and parboiled dark rice were obtained in a similar manner with representative samples of the three types of parboiled rice. However, before the curves were recorded, the three samples were remilled for 10 sec. in a McGill miller to remove any excess bran which might influence the color. Even in well-milled samples, it was possible to remove trace amounts of bran by remilling.

Agtron meter readings were taken on 190 samples of long-grain milled parboiled rice obtained from field offices of the Grain Division, AMS. These samples had been graded visually for degree of milling and also for degree of parboiling in the Grain Division by comparison with sample standards; these official grades were compared with meter readings.

The Agtron was calibrated as described by Gillis (2) as follows:

1. Turn on power switch and allow instrument to warm up for about 2 hr. Turn on meter switch 5-10 min. before taking readings.
2. Turn the "Standardize" dial to the extreme counterclockwise position.
3. Place calibration standard No. 24 in the sample compartment and set the meter to read 0 by adjusting the "Zero" dial. In like manner, set the meter to read 100 with calibration standard No. 41 in place by adjusting the "Standardize" dial. Repeat this step about every 30 min. until the meter becomes stable. NOTE: To ensure uniform results, the calibration standard should be placed in the sample compartment with the serial number forward and touching the front.

To determine degree of milling in parboiled light and parboiled rice, the following procedure was used:

1. Place 60 ± 1 g. of milled parboiled rice in the Agtron sample container.

2. Insert container in the sample compartment.
3. Rotate sample container by hand and obtain an average meter reading to the nearest 0.5 Agtron unit.
4. Make duplicate tests and compute average of two readings.

To determine degree of parboiling, the milled parboiled rice samples were first remilled for 10 sec. in a McGill miller to remove any excess bran, and broken kernels were removed by sizer plates and then tested in the Agtron by the same standards and procedures as for the degree of milling.

Results

Recording Spectrometer. Tests with the Bausch & Lomb 505 recording spectrophotometer showed that the reflectance curves for the five types of milled parboiled light rice differed, depending on the amount of bran or gray color present (Fig. 1).

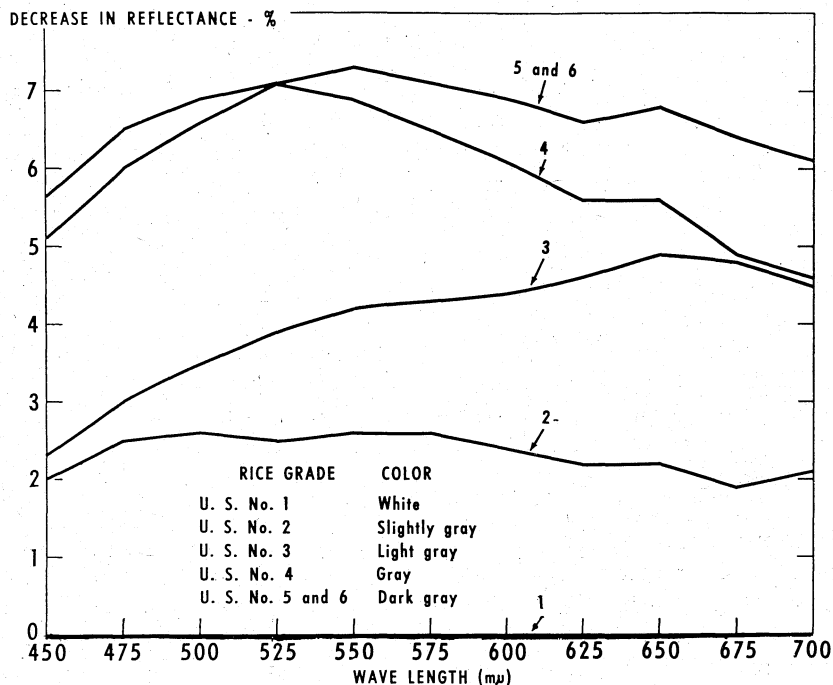


Fig. 1. Reflectance curves for five types of milled rice.

Similarly, reflectance curves for well-milled parboiled light, parboiled, and parboiled dark rice were recorded and compared (Fig. 2).

A wave length of 546 $m\mu$ was selected for measurement for both de-

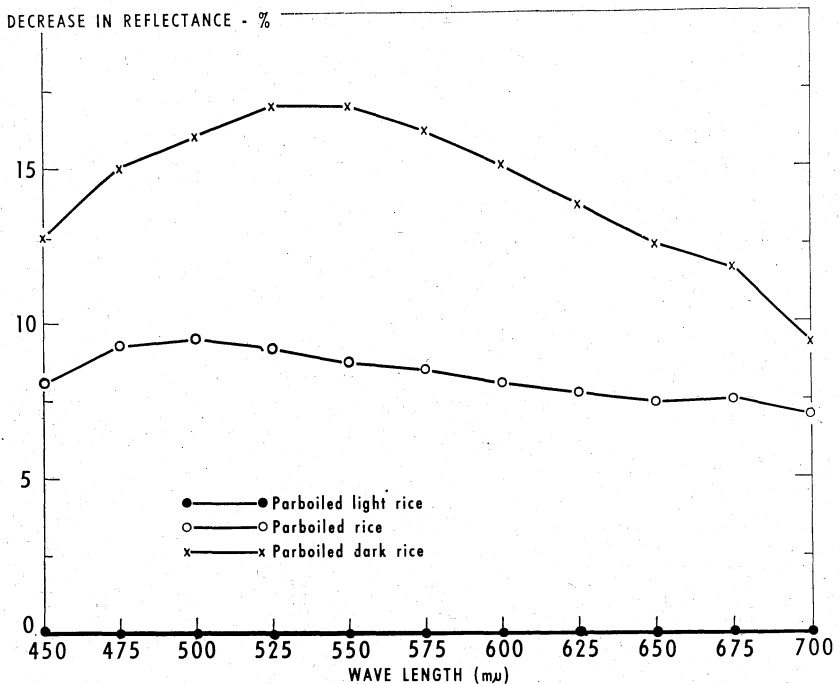


Fig. 2. Reflectance curves for three types of parboiled rice.

gree of milling and degree of parboiling in the parboiled rice samples, since greater differences between samples are apparent in this area of the spectrum.

Reflectance Meter. One hundred twenty samples of officially graded long-grain milled parboiled light rice, tested in duplicate, were read on the Agtron meter, which measures in the green spectral region at 546 mμ. Duplicate tests agreed within about three meter readings. The visual grades obtained by the official method for determining degree of milling in parboiled light rice were compared with the meter readings (Fig. 3). Meter readings were established for corresponding degree of milling in parboiled light rice as follows:

Rice Grades	U.S. No.	Color	Meter Reading
Well milled	1	White	> 64
Well milled	2	Slightly gray	50-64
Reasonably well milled	3	Light gray	35-49
Reasonably well milled	4	Gray	25-34
Reasonably well milled	5	Dark gray	< 25
Reasonably well milled	6	Dark gray	< 25

Seventy samples of officially graded milled parboiled rice were also

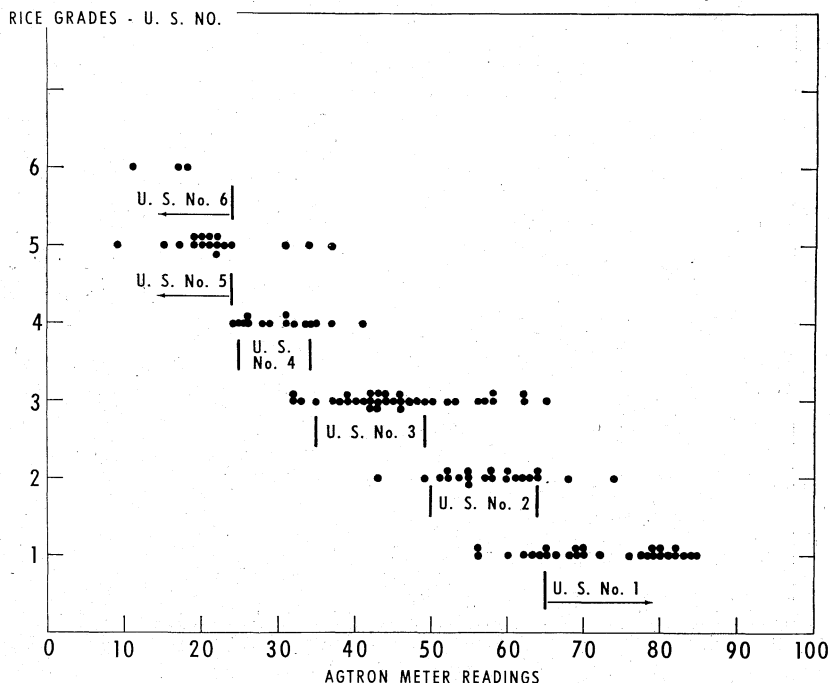


Fig. 3. Relation between U.S. grades and meter readings, showing effect of degree of milling in parboiled light rice.

tested in duplicate on the Agtron reflectance meter at 546 $m\mu$. The visual grades were compared with meter readings as before (Fig. 4). Meter readings were established for corresponding degree of milling in parboiled rice as follows:

<i>Rice Grades</i>	<i>U.S. No.</i>	<i>Color</i>	<i>Meter Reading</i>
Well milled	1	White	>40
Well milled	2	Slightly gray	30-39
Reasonably well milled	3	Light gray	20-29
Reasonably well milled	4	Gray	10-19
Reasonably well milled	5	Dark gray	<10
Reasonably well milled	6	Dark gray	<10

A chart was not prepared for milled parboiled dark rice for degree of milling because the number of samples was insufficient.

After the 190 samples of parboiled light and parboiled rice were remilled to remove any excess bran and broken kernels were removed by sizing, duplicate samples were tested in the Agtron for degree of parboiling. When compared with the visual grades obtained by the official method for determining the degree of parboiling, 91% of

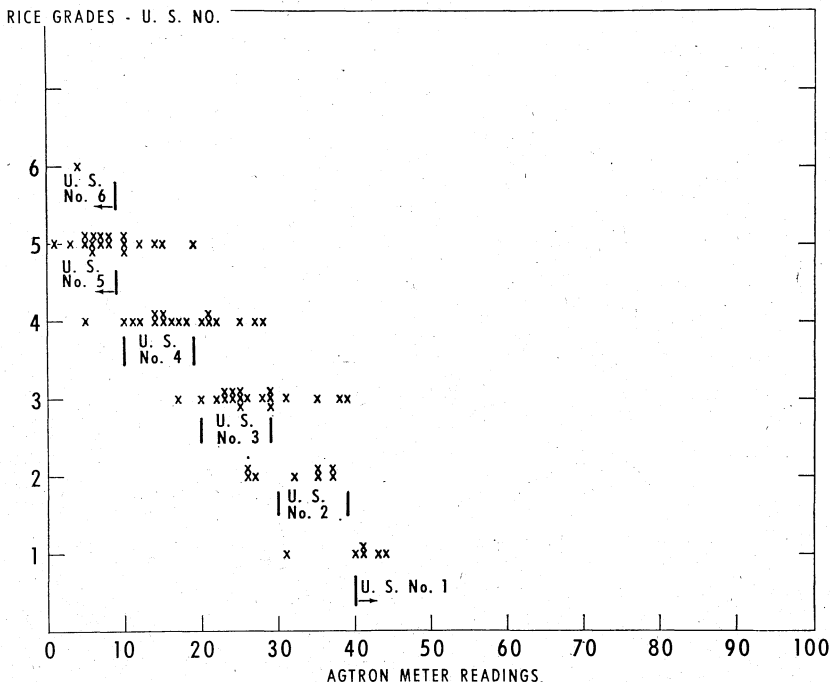


Fig. 4. Relation between U.S. grades and meter readings, showing effect of degree of milling in parboiled rice.

the samples fell in line with the proposed grades (Fig. 5). The bran was not completely removed from some of the reasonably well milled samples and some kernel breakage resulted during remilling. Therefore, meter readings for parboiled and parboiled light samples were established for corresponding degree of milling as follows:

Rice Grades	U.S. No.	Meter Readings	
		Parboiled	Parboiled Light
Well milled	1	<50	50-100
Well milled	2	<45	45-100
Reasonably well milled	3	<40	40-100
Reasonably well milled	4	<35	35-100
Reasonably well milled	5	<30	30-100
Reasonably well milled	6	<25	25-100

Conclusions

In view of some overlapping of values as determined by visual inspection, it was necessary to draw arbitrary limits of meter readings for each numerical grade. These limits were chosen in such manner as to include as many points as possible in each numerical grade. This

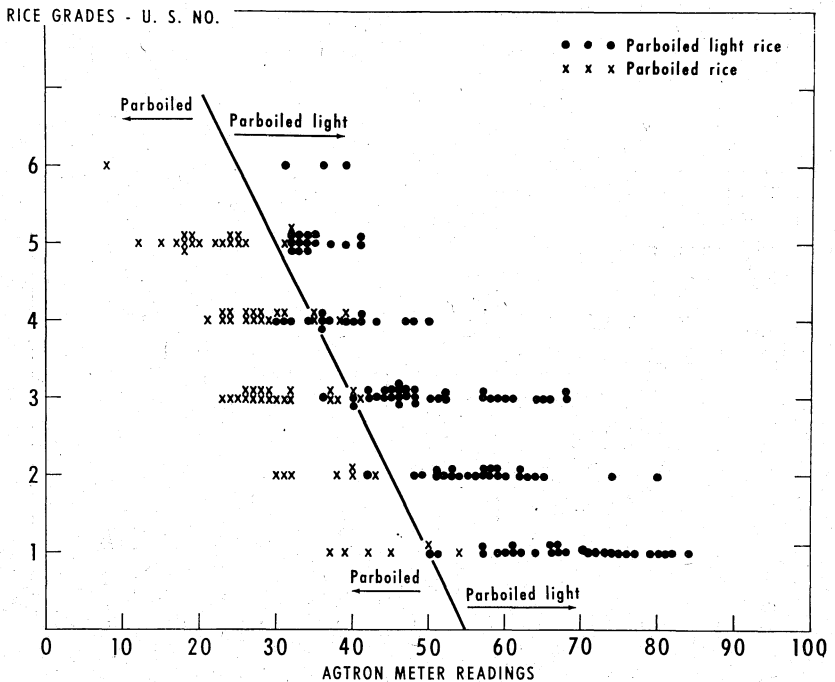


Fig. 5. Relation between visual grades and meter readings, showing effect of degree of parboiling in parboiled rice.

method has the advantage of objectivity; it is not dependent upon the visual perception of an inspector.

The Agtron test for differentiating the degree of milling and degree of parboiling in long-grain parboiled rice is rapid and precise. Approximately 400 samples of rice can be tested for degree of milling per day by one operator.

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Literature Cited

1. UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL MARKETING SERVICE. U.S. Standards for rough rice, brown rice, and milled rice. Washington, D.C. (1961).
2. GILLIS, J. A. Photoelectric method of determining flour color with the Agtron. *Cereal Sci. Today* 8: 40-42, 44, 46, 55 (1963).