FLOUR DISK REFLECTANCE AS A MEASURE OF BREADMAKING QUALITY[1]

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ABSTRACT

A preliminary study indicates that wheat quality can be determined indirectly by light-reflectance measurements of pressed disks of a flour-lactic acid mixture. In laboratory tests of 67 hard wheat samples, the reflectance readings of the flour disks were inversely and significantly correlated, at the 1% level, with breadmaking quality as measured by protein content, sedimentation value, and loaf volume.

A rapid, inexpensive method for determining the quality of wheat has long been sought. Many determinations, such as protein content, sedimentation value, and numerous physical dough tests, as well as experimental baking procedures, are used to measure the quality of wheat or flour for bread-baking. However, it is generally agreed that, except for the bread-baking test, none of these quality tests by themselves accurately predict bread-baking quality (1). The sedimentation test is claimed (2,3) to come closest to the baking test in measuring bread-baking quality. On the other hand, the Kjeldahl protein test is generally considered a good measure of protein content but not of protein quality.

Fifield *et al.* (4) described a disk method for determining quality of durum wheat. The test measured visual color differences by transmitted light from pressed disks made from semolina and water.

The purpose of this paper is to provide an objective basis for subclass designation instead of the present subjective method for determining percentages of dark, hard, and vitreous kernels. The light-reflectance measurement of a flour disk prepared from ground whole wheat or flour could be valuable as a practical quality indicator to plant breeders, grain inspectors, and millers.

At first, fluorescence meter readings at 630 mμ of the whole-wheat flour disks were found to vary inversely with protein content of the wheat samples; results, however, were not reproducible, probably because of the instability of the Xenon light source. Another approach involving the relation between light transmittance of whole-wheat flour disks and protein content was investigated. However, the thickness of the whole-wheat flour disk (light path) was extremely critical,

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and reproducibility of meter readings was poor. Therefore, these two approaches were abandoned in favor of a less complex reflectance measurement in which only the surface of the whole-wheat flour disk would be involved.

Materials

Forty-two samples of hard red winter (HRW) and 25 of hard red spring (HRS) wheats drawn from nine Midwestern states and representing three crop years were used in these studies. These samples represented commercial lots of wheat collected at terminal markets.

A laboratory pulverizing mill (Udy Analyzer cyclone mill) was used to grind the wheat samples into whole-wheat flour.

The Buhler Pneumatic experimental flour mill (Model MLU-202) was used for milling. The wheat samples were tempered in two stages to moisture content between 14.0 and 17.0% depending upon the hardness of the wheat. Ten percent of the low-grade flour was discarded, leaving a 90% patent flour which was used for the bread-baking.

Bread-baking tests were made by a straight-dough procedure using 100 g. flour, 2 g. compressed yeast, 2 g. salt, 5 g. sugar, 0.25 g. malt flour, 3 g. hydrogenated shortening, 4 g. nonfat dry milk, and varying amounts (1–4 mg.) of potassium bromate. The doughs were mixed to optimum consistency in a Swanson-type mixer. They were then fermented for 3 hr. at 86°F. and proofed for 55 min. At the end of the fermentation period, the doughs were moulded, panned, and baked for 25 min. at 440°F.

A Moulinex coffee mill was used to blend the mixture of flour and lactic acid.

A Carver laboratory press with a cylinder 2¼ in. in internal diameter was used to prepare flour disks. Plastic disks of the same diameter were placed below and above the dough before it was pressed.

A reflectance meter (Agtron Model M-400) and torsion balance (± 0.01 g.) were used.

The reagent was lactic acid solution (0.5*N*).

Methods

Selection of Wave Length. A Bausch & Lomb 505 recording spectrophotometer was used to determine the optimum wave-length for measuring the reflectance of the whole-wheat flour disks. Reflectance values of eight whole-wheat flour disks representing wheats ranging in protein content from 8.2 to 16.4% were recorded. As is evident in Fig. 1, almost any wave-length between 400 and 780 mμ could be used to measure differences in the reflectance of the whole-wheat flour disks.

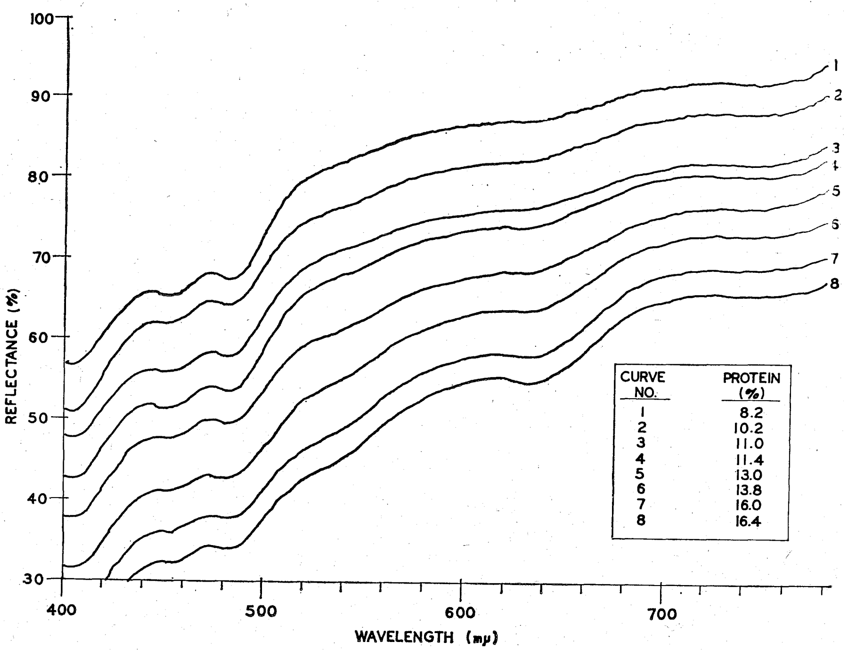

Fig. 1. Reflectance curves of whole-wheat flour disks.

A wave-length of 546 mμ was selected because an Agtron meter at this wave-length was available.

Whole-Wheat Flour Disk Method. 1. Pass the wheat sample through a Boerner divider to obtain a representative sample.

2. Grind duplicate wheat portions in a cyclone mill.

3. Weigh 15 $\pm$ 0.01 g. of the flour and place into a 250-ml. beaker. Add exactly 5 ml. of 0.5*N* lactic acid solution. Stir with spatula until well blended.

4. Transfer contents to Moulinex mill and blend for 15 sec.

5. Transfer to cylinder of hydraulic press, using plastic disk below and above the dough, and press for 1 min. at about 2,000 lb. per sq. in.

6. Remove from the press and separate the flour disk carefully from the plastic supports.

7. Calibrate the Agtron reflectance meter with standards Nos. 24 and 44. Turn instrument on for about 16 hr. before using.

8. Record meter readings of the flour disks exactly 15 min. after preparation.

Buhler-Milled Flour Disk Method. For testing milled flour start with step 3 above and use standards 44 and 75 in the reflectance meter.

Figure 2 shows the equipment used in preparing the flour disks and making reflectance measurements.

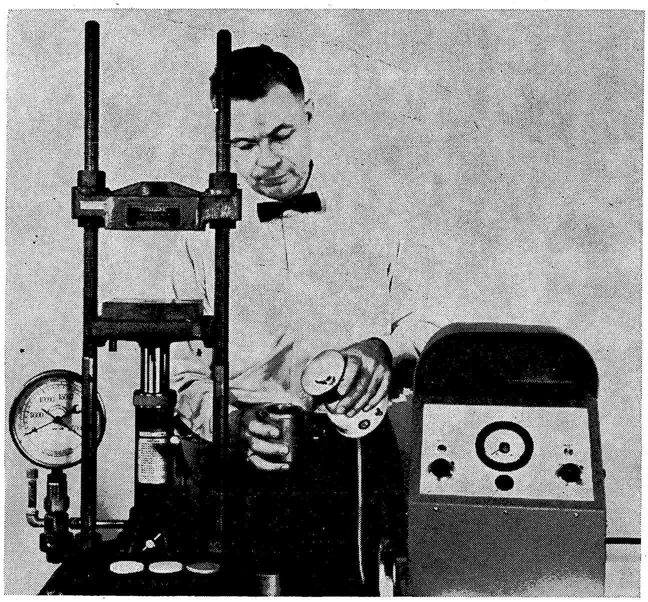

Fig. 2. Equipment for preparing flour disks and for reflectance measurements.

Results

Composite Test Sample Disks. Eleven composite test sample disks were prepared from wheat to represent a range in the percentage of dark, hard, and vitreous (DHV) kernels from 0 to 100% in increments of 10%. Reflectance meter readings, Kjeldahl protein content, and sedimentation values of these composite test sample disks were determined. Table I shows the inverse relation of meter readings of prepared composite test sample disks to percent DHV kernels, protein content, and sedimentation values.

Flour Disks. Reflectance meter readings of whole-wheat flour disks were plotted against protein content and sedimentation values (Figs. 3 and 4). Likewise, with these same samples, meter readings of the Buhler-milled-flour disks were plotted against protein content, sedimentation value, and loaf volume of the bread made from the flour samples (Figs. 5, 6, and 7).

Correlation coefficients for reflectance meter readings of whole-wheat flour disks and protein content (−0.928) and sedimentation value (−0.836) were significant at the 1% level. The correlation coeffi-

TABLE I
RELATION OF REFLECTANCE METER READINGS OF PREPARED TEST SAMPLE DISKS TO PERCENT DARK, HARD, AND VITREOUS KERNELS, PROTEIN CONTENT, AND SEDIMENTATION VALUES

Reflectance Meter Readings	Dark, Hard, and Vitreous Kernels	Protein Content[a]	Sedimentation Values
	%	%	
100	0.0	8.1	10.0
100	10	8.5	10.0
100	20	8.6	11.0
88	30	9.7	19.5
82	40	9.9	26.0
72	50	11.1	29.5
58	60	12.5	40.5
53	70	13.1	43.5
45	80	13.5	50.0
33	90	15.0	58.5
23	100	15.2	64.0

[a] N × 5.7.

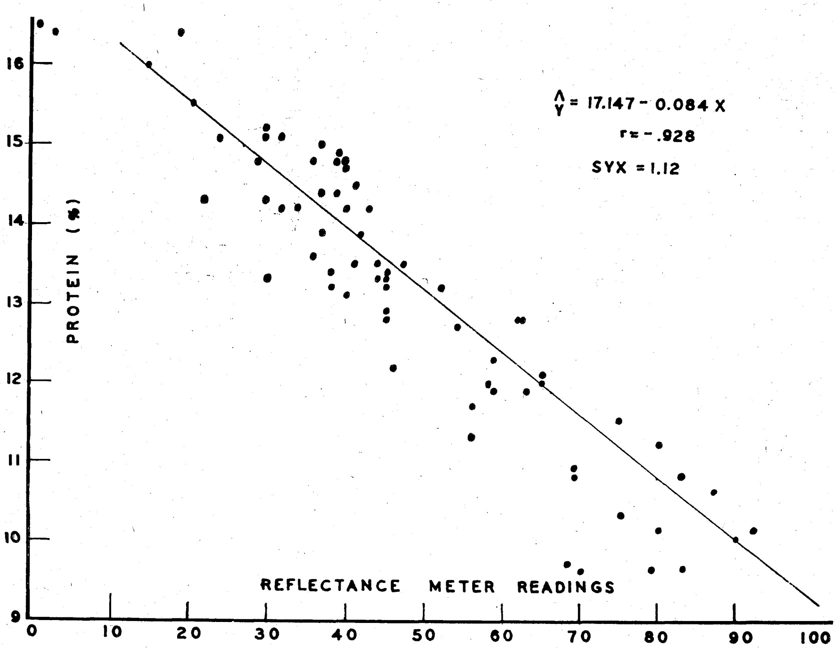

Fig. 3. Meter readings *vs.* protein content; whole-wheat flour disks.

cients for reflectance meter readings of Buhler-milled flour disks and protein content (−0.975), sedimentation value (−0.927), and loaf volume (−0.908) were also significant at the 1% level.

Moisture Correction. Moisture content of the wheat or flour used for preparing disks had an effect on the Agtron meter readings. To cor-

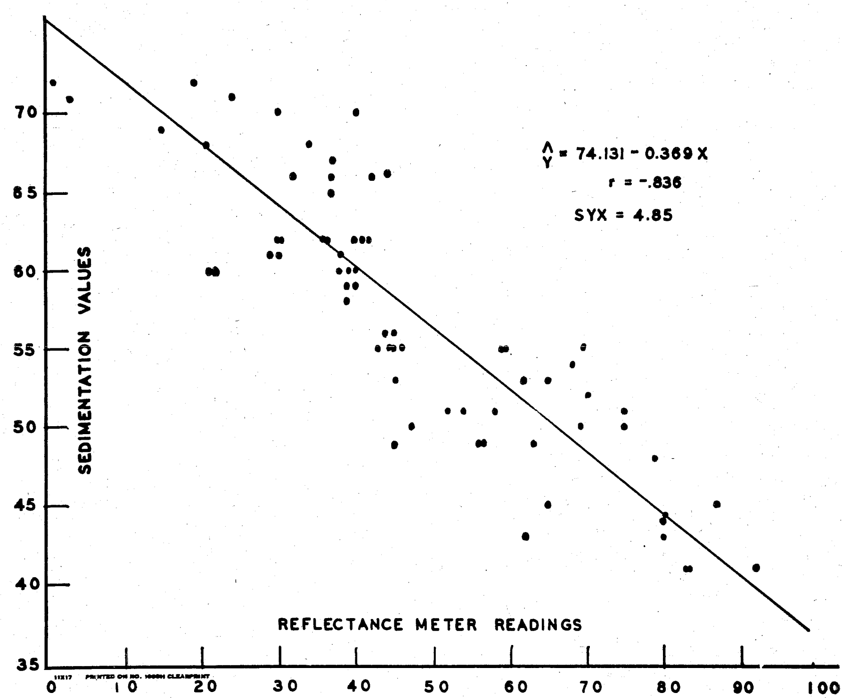

Fig. 4. Meter readings *vs.* sedimentation values; whole-wheat flour disks.

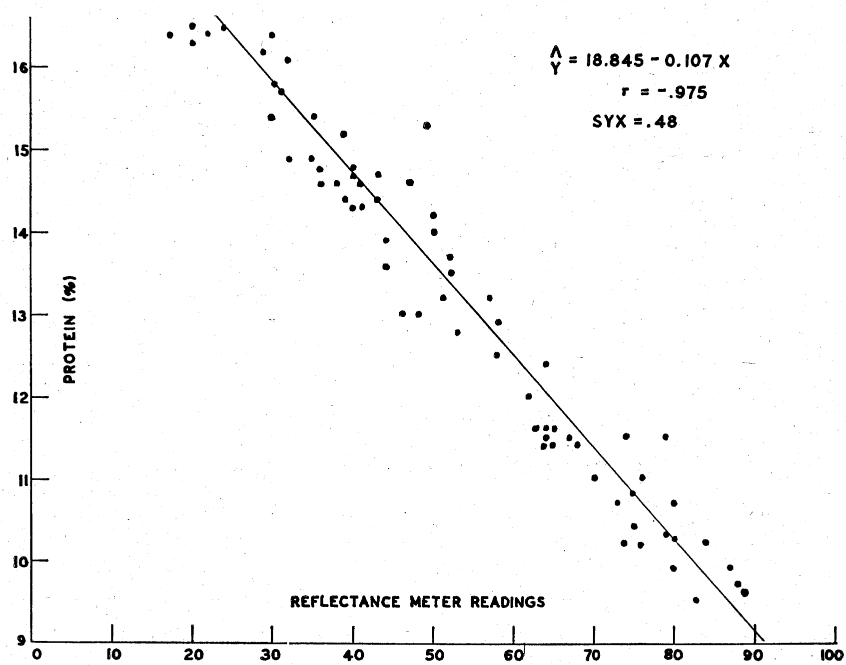

Fig. 5. Meter readings *vs.* protein content; Buhler-milled flour disks.

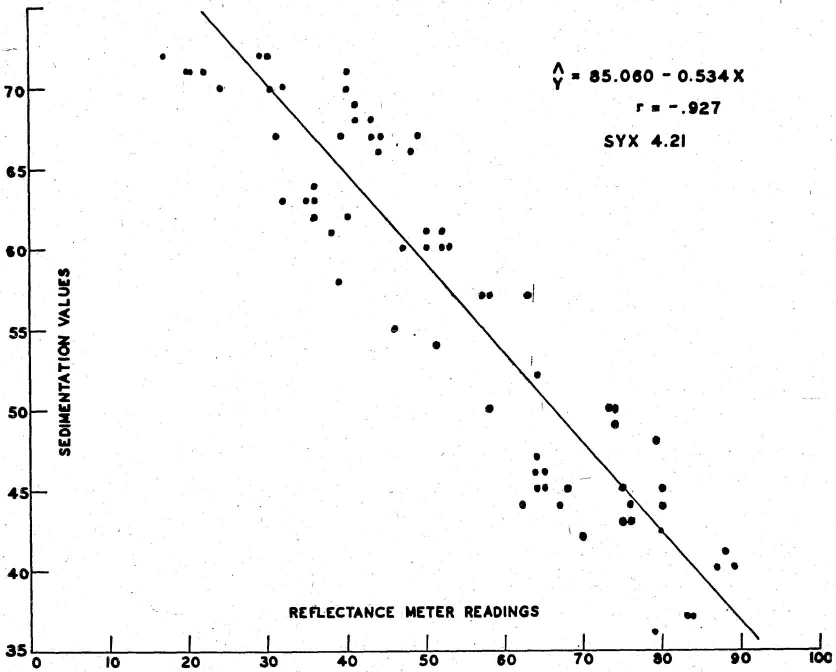

Fig. 6. Meter readings *vs.* sedimentation values; Buhler-milled flour disks.

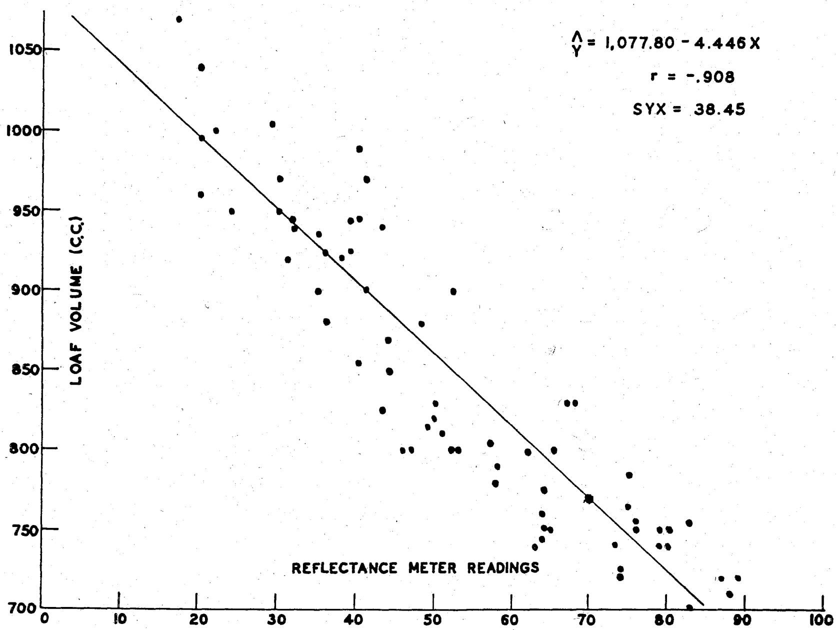

Fig. 7. Meter readings *vs.* loaf volume; Buhler-milled flour disks.

rect meter readings to a common base (12%), the following corrections should be applied:

Wheat Moisture Content	*Meter Reading Correction*	*Wheat Moisture Content*	*Meter Reading Correction*
%		%	
8	+8	13	−2
9	+6	14	−4
10	+4	15	−6
11	+2	16	−8
12	0		

Discussion

The Official Grain Standards of the United States are designed to reflect differences in quality of commercial lots of wheat. One of the measures to differentiate quality is the use of the count of DHV kernels. It has been shown that the correlation between this measurement and protein content is highly significant (5).

Subclasses of wheat (HRS and HRW) are determined by the percentages of DHV kernels – the greater the percentage of these kernels the higher the economic value of the wheat. Since the presence of protein (dark, hard, and vitreous areas) obscures light reflected from the starchy areas of the kernel, the higher-quality samples show the lowest light-reflectance values. Lactic acid solution was used rather than water in preparing the disks because a greater range in reflectance readings was thereby obtained.

For both classes of wheat (HRS and HRW), all factors studied such as protein, sedimentation, and loaf volume covered rather wide ranges. Therefore, the disks made from both classes of wheat showed considerable range in reflectance meter reading. There was no distinct class pattern distribution when these readings were plotted against the factors mentioned.

At approximately 12% protein and 50 sedimentation value, the disks made from both whole-wheat flour and Buhler-milled flour (made from the same sample) showed almost identical light-reflectance meter readings. Above and below this point both protein and sedimentation values varied inversely with light-reflectance meter readings.

Under the conditions of these tests, reflectance meter readings of flour disks can accurately predict protein content, sedimentation value, and loaf volume of hard wheats. A single test can be performed in 15 min. or in an average time of about 5 min. when a number of tests are made simultaneously.

With the use of established flour disk standards, colors can be compared by eye without an instrument. Because disks reflect more light when dry than when wet, the flour disk standards and the sample flour disks were dried at room temperature. After about 1 hr. of drying, little change in color is evident. Therefore, this visual comparison procedure might become an inexpensive rapid test as a measure of wheat quality. The dried flour disks are durable and can be used to represent the quality of a lot of wheat in the general course of grain trading.

Acknowledgments

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