Determination of Wheat Milling Potential and Its Influence on Flour Quality Deterioration Rate[1]

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ABSTRACT

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The milling quality of a newly bred hard white winter (HWW) wheat was evaluated by comparing its flour quality (ash and color) deterioration rate, correlated to the increase of flour extraction, with that of a control hard red winter (HRW) wheat. Milling performance of the HWW wheat as indicated by sizing production and milling hardness also was compared with the control wheat. In respect to production of low ash and whiteness of flour at the same extraction level, the HWW wheat was superior to the HRW wheat.

Wheat breeding programs can be greatly improved by incorporating information on the evaluation of wheat milling performance. Flour extraction potential, milling performance, and flour quality of wheat are becoming important in determining the feasibility of new wheat breeding programs.

Currently, cost evaluation of wheat milling quality is based on the results of the so-called "single run milling" experiment, in which wheats are milled to a single flour extraction level. The milling is accomplished by a setting-fixed system, in which grinding actions (milling gaps and roll surface features) are fixed for all wheats, or by a setting-changed system, in which grinding actions are adjusted according to the specific characteristics of the wheat. The superiority of a wheat is determined by comparing flour yield and quality of the resultant flour with those of control wheats. Although simple and labor saving, this method does not provide any information on the maximum potential yield of a wheat with flour quality criteria equivalent to those of the reference wheat.

Recently, a method was suggested for the evaluation of potential flour yield (Li and Posner 1989). This method is based on the measurement of flour quality deterioration rate, or the rate of increase or decrease of flour quality criteria (ash content and color grade) correlated to an increase of flour extraction level. A slower milling deterioration rate indicates a potential of the wheat for producing better quality flour at a given extraction level or possibly a higher flour yield at the given flour quality criteria. This experimental technique enables the wheat to be milled to different extraction levels with the flour quality criteria (ash level and color grade) being linearly related to the extraction level.

A hard white winter (HWW) wheat was recently developed at Kansas State University. The light bran color of HWW was expected to have less deteriorative effect on the flour produced. The objective of this study was to compare the milling quality of the HWW wheat with that of a hard red winter (HRW) wheat by employing the method mentioned above.

MATERIALS AND METHODS

An HWW wheat newly developed at Kansas State University and Hawk cultivar HRW, as reference control, were used in this study. The wheats were free of rodent damage and diseased kernels. Before physical tests and milling, wheats were cleaned on a dockage tester to remove light impurities and nonwheat grains. Descriptions of wheats are given in Table I.

Tempering prior to milling was accomplished in an experimental scale tempering machine with 5-kg maximum capacity. Two 3-kg wheat samples were tempered. Wheat samples were tempered for 24 hr to 16% moisture.

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The experimental milling technique presented by Li and Posner (1988) was used. In the conventional laboratory milling method for obtaining various extraction levels, stock from regrinding wheat bran fraction was included in the flours. The technique used in this study employed different break releases and flow sheets with additional equipment to obtain extraction levels ranging from 74 to 82%.

A milling flow sheet consisting of four breaks, two sizings, two tailings, and five reductions was used for the 74 and 76% extraction levels. Based on this basic flow sheet, an extension of the break system was made for the higher extraction levels, with the addition of coarse and fine fifth break for 78% extraction and the inclusion of bran dusters for 80 and 82% extraction. Flours produced were believed to be representive of those obtained commercially. This increased the reliability of the milling results for the prediction of milling performance on a commercial scale.

The environmental temperature and humidity for milling were kept constant throughout the experiment at 70°F and 62% rh. Milling loss was kept within 2.0 ± 0.5%. For each flour extraction level, duplicate millings were run, and the milling sequence was arranged randomly.

Protein and ash content of wheat and flour were determined according to AACC methods 46-13 and 08-01 (AACC 1983), respectively. Moisture content of flour was determined according to AACC method 44-15A (AACC 1983). Flour color was measured according to AACC method 14-30 (AACC 1983) using the Agtron color meter. The Kent-Jones color grade meter was also used to compare the colors of flours of different extraction levels. The slurry for the Kent-Jones color meter determination was prepared with 30 g of flour and 50 ml of distilled water mixed for 120 sec.

RESULTS AND DISCUSSION

Size analysis of wheat kernels (Table I) showed that the HWW wheat contained a higher percentage of large kernels (76.1%) than the HRW wheat (29.43%) over the 7W sieve. The size distribution of the HWW wheat explains its higher test weight and 1,000-kernel weight. The higher values in this physical test rank the HWW wheat as better than the HRW wheat.

TABLE I
Physical and Chemical Characteristics of Hard White Winter and Hard Red Winter Wheat

Characteristic	Hard White Winter	Hard Red Winter
Test weight, lb/bu	62.25	60.25
1,000-Kernel weight, g	34.45	24.10
Pearling value, %	57.93	60.78
Ash content,[a] %	1.50	1.39
Protein content,[a] %	12.80	13.00
Wheat size, %		
Over 7W	76.10	29.43
Over 9W	23.90	68.00
Over 12W	0.00	2.57

[a]Values are on 14% moisture base.

TABLE II
The Break Releases of the First Break Systems for Different Extraction Levels[a]

Extraction Level (%)	First Break (%)	Second Break (%)	Third Break (%)
Hard white winter wheat			
74	47.9	61.8	47.6
76	45.8	60.9	55.8
78	50.7	63.5	53.0
80	54.1	57.0	51.5
82	55.4	56.9	52.8
Hard red winter wheat			
74	46.2	58.6	48.7
76	48.9	59.6	50.5
78	51.4	57.4	51.0
80	52.2	56.8	52.1
82	54.9	56.4	40.3

[a]Figures are the averages of duplicate milling experiments, on "as is" moisture basis.

Performance on the first three breaks in the milling flow was considered critical to the overall balance of the milling system and the final results. Therefore, the break releases, defined as the quantity of the stock passing through the first coarse sieve (20W) were carefully controlled during milling.

The break release data for each extraction are presented in Table II. It can be seen that an increasing value of first break release was employed for a higher extraction level. This decreased the amount of endosperm going to the third, fourth, and fifth breaks (in the case of 80 and 82% extraction), where much narrower milling clearances were used. To extract this part of the endosperm, a strong grinding action would have to be applied, which could greatly impair flour quality. The method used should help minimize the powderization of bran and the inclusion of bran particles in the flour.

It is believed that a higher sizing yield is favorable for a high yield of low ash flour, no matter whether the high quantity of sizings is obtained by proper adaptation of milling technology to the specific wheat characteristics or results from the inherent property of the wheat milled.

Data on the yields of different sizing stocks in the break system (Table III) show that about 8% higher coarse sizing (overs on 50 GG) was obtained from HWW wheat. No significant differences were observed in production levels of coarse sizing production at different extraction levels. Coarse sizings were devised from first-, second-, and third-break systems. The cumulative break release values were quite close at the third break (data not presented). Therefore, it seems that the higher sizing yield is a characteristic of the HWW wheat. This gives a relative advantage to the HWW wheat.

Although a lower pearling value can be seen in the HWW wheat (Table I), the higher sizing yield, lower medium size stock yield (overs on 70 GG), and the lower break flour (Table III) indicate the greater hardness of the HWW wheat during milling. This result also showed that the pearling value of wheat is not sufficient to predict the hardness of wheats during milling and is associated more with wheat kernel dimensions.

The increase of ash content in flour as the level of extraction was raised was expected. This increase in ash content comes from the incorporation of the endosperm close to the bran and aleurone layer, which inherently contains a higher level of minerals. As the extraction level goes higher, the proportion of bran included in flour also can be increased, resulting in increased ash content.

The ash content of the whole wheat kernel varies from one variety to another. In evaluating wheat quality, the comparison of ash levels of flours from different wheats, even at the same extraction level, could be meaningless without considering the corresponding wheat ash levels. The ratio of the flour ash value to the wheat ash value (FA/WA) and the changing pattern of

TABLE III
Flour Extractions and Yields of Different Sizing Stocks in Break System[a]

Sizing Stocks[b]	74%	76%	78%	80%	82%
Hard white winter wheat					
Coarse	67.5	67.5	67.3	66.7	67.6
Medium	7.9	8.5	7.1	8.5	8.0
Fine	7.0	7.6	8.7	7.3	7.0
Break flour	7.9	7.9	8.4	8.1	8.4
Hard red winter wheat					
Coarse	59.3	59.3	60.0	59.9	60.4
Medium	12.9	12.4	12.1	12.4	11.0
Fine	5.8	5.1	5.9	5.8	5.7
Break flour	10.3	11.0	11.2	10.7	10.7

[a]Values are expressed on "as is" moisture basis and are the averages of duplicate milling experiments.
[b]Coarse = overs on 50 GG, medium = overs on 70 GG, fine = overs on 10 XX.

this ratio as flour extraction increases reflect the superiority of one wheat over another in respect to production of low ash flour. A lower value for the ratio indicates a better separability of endosperm from wheat outer layers and/or a desirable ash distribution with a rich concentration in outer layers. At the same flour extraction level, wheats can be ranked by comparing this ratio.

Figure 1 presents the relationship between the ash content of the straight grade flour and extraction levels. The regression lines of the straight grade flour ash for HWW and HRW wheats are parallel, indicating an equal deteriorative rate of flour ash content as extraction increases. The lower position of the regression line for the HWW wheat, however, implies the possibility of obtaining a higher flour yield with equal ash content.

The lower FA/WA values for HWW flour at each extraction level, as shown in Figure 2, indicate that the higher wheat ash content of the HWW wheat (Table I) is not associated with the flour. Therefore, it is reasonable to believe that in the HWW wheat, ash is more richly distributed in the outer layers, which are excluded as mill feed. This property of the HWW wheat makes it superior to the HRW wheat, from which higher FA/WA values were obtained.

Color is an important optical attribute of flour and its food products. The light bran color of HWW is believed to be favorable for producing a higher extraction rate of flour than red wheat, with equal color appearance.

Figure 3 shows the reflectance of flours of different extraction levels with the Agtron color meter. A fairly linear relationship can be seen between the reflectance readings and the flour yield levels extracted from both white and red wheat. The flours from HWW had higher reflectance values than the corresponding flours from HRW wheat at the same extraction level. This indicates that the flour from HWW wheat is whiter than the flour from the HRW wheat at the same extraction level.

From Figure 3 it can be seen that the reflectance of HWW flour at 82% extraction is equal to that of the HRW flour at 74% extraction. Therefore, an 8% higher potential extraction from the HWW would be possible while maintaining flour color. This is also shown in Figure 4 for flour color grades measured by

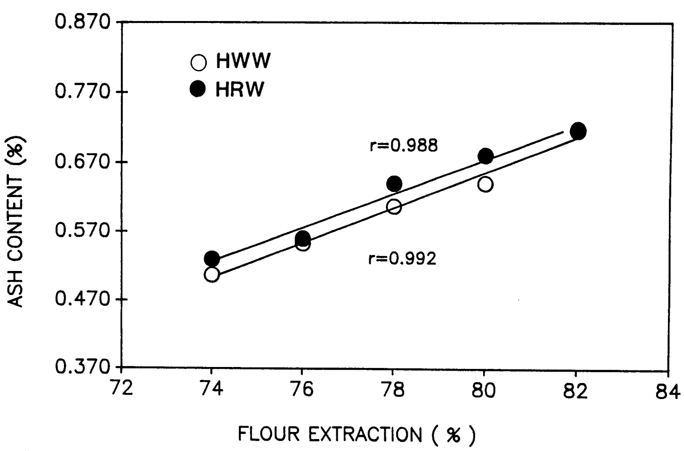

Fig. 1. Relationship between straight grade flour ash content and the flour extraction level of hard white winter and hard red winter wheats (duplicate results fall within the circles).

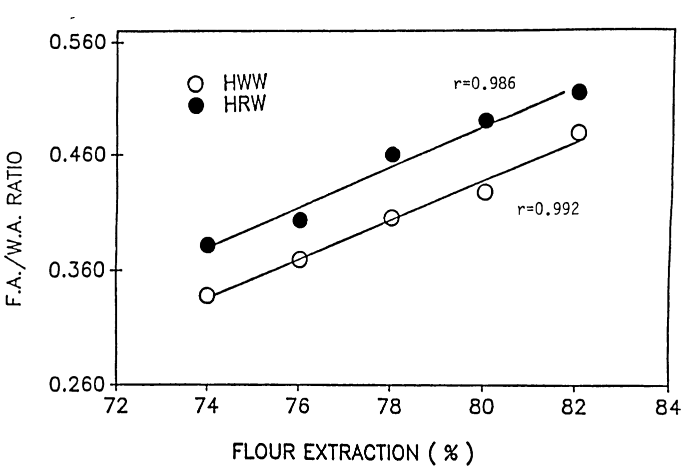

Fig. 2. Relationship between flour ash/wheat ash ratio and flour extraction level.

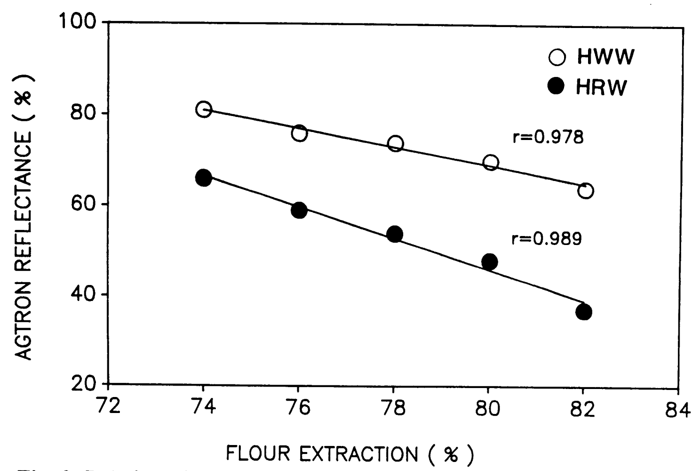

Fig. 3. Relationship between Agtron color reflectance reading and flour extraction level of the hard white winter and hard red winter wheats (duplicate results fall within the circles).

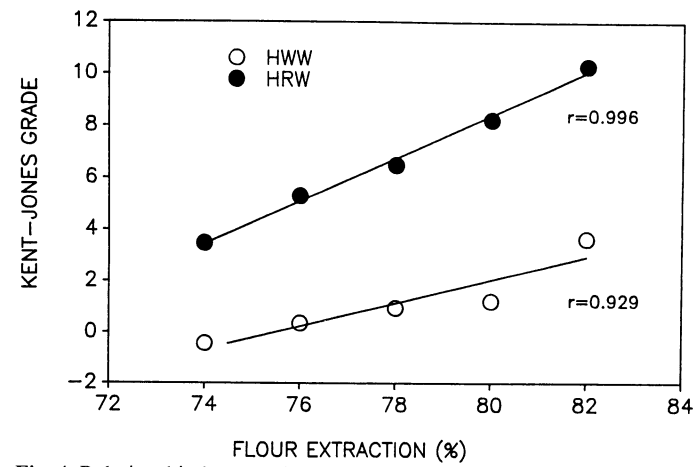

Fig. 4. Relationship between Kent-Jones color grade and flour extraction level of the hard white winter and hard red winter wheats (duplicate results fall within the circles).

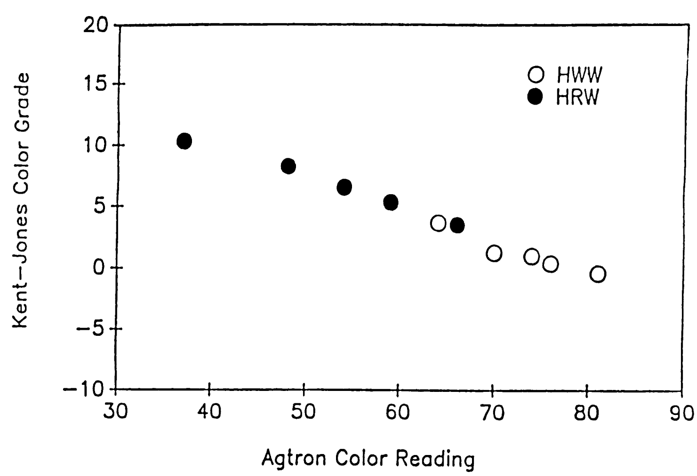

Fig. 5. Correlation curve between the Kent-Jones color grader and Agtron color meter reflectance readings of flours at different extraction levels.

Kent-Jones color grader, where a lower grade reading indicates a higher light reflectance by the flour. The milling deterioration of the wheat can be expressed as the slope of the regression line shown in Figure 4, 0.832 and 0.452 for HRW and HWW, respectively.

The Kent-Jones flour color grader is extensively used in Europe and other areas for measuring flour color appearance. The Agtron color meter, however, is mostly used in the United States. The relationship shown in Figure 5 indicates a strong correlation ($r = -0.965$ for HWW, $r = -0.996$ for HRW) between these two instruments in measuring the color of flours from different wheat classes.

Wheat bran and tissues other than endosperm are the primary components contributing to the color of milled flour. A recent study recognized the influence of wheat endosperm on flour color grade (Barnes 1986); however, its contribution is much less significant than that of the bran and germ particles unavoidably included during milling. The light color of the HWW wheat bran makes the inclusion of it into flour less noticeable visually and instrumentally.

CONCLUSIONS

A higher sizing yield can be obtained from milling HWW wheat, which is desirable for the production of low ash flour, especially in a commercial mill where a continuous purification process is available. The milling performance of the HWW wheat showed that it possesses a greater milling hardness than the HRW wheat, as indicated by smaller amounts of medium-size particle stock and lower break flour yield in the break system. High correlation was determined in color reflectance values between the Agtron color meter and the Kent-Jones color grader at different extraction levels. As the flour extraction increased, there was an equal rate of increase in flour ash with the HWW and the HRW wheats. The flours from the HWW wheat, however, were much whiter than those from the HRW wheat. A potential of about 8% higher flour extraction might be achievable from the HWW wheat while maintaining flour color.

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