EFFECT OF STORAGE TIME ON AGTRON REFLECTANCE VALUES OF FLOUR[1]

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ABSTRACT

Samples of hard red spring (HRS) wheat patent and selected mill stream flours were stored at ambient conditions for 6 months. In addition, six samples each of HRS straight-grade and extended extraction flours of about 80% extraction were stored at ambient conditions for 2 months and at 38°C for 1 month. No pronounced changes occurred in the green or blue Agtron values of the flours during the storage periods, indicating that flour color as measured by the Agtron is essentially stable.

Millers and bakers associate low-ash flour with white flour because of the general relation of ash content and flour extraction rate. In the U.S., flour color is emphasized because of consumer demand for a white bread and not because of its relation to product quality. In today's world of food shortages and malnutrition, the highest possible flour yield from wheat should be obtained without reducing the quality of the finished product or consumer acceptance, regardless of flour color or ash.

The percentage ash content of flour has long been used as a measure of wheat milling quality. It is regarded as one of the most important measures of flour milling quality of wheat and of the efficiency of a milling operation (1). Ziegler and Greer (2) and Shuey (3) summarized the relation between ash content of wheat and flour with flour extraction rate. Many formulas to evaluate milling efficiency have been proposed, and nearly all have included ash content (4–6). Pratt (7) states that the ash content of flour has been used for years as a measure of flour quality, even though ash content per se is not related to the final performance of the flour.

Although ash content of the flour gives some indication of the miller's skill and the degree of refinement in the milling process, we believe there is little reason for its use as an exact measure of quality. Because ash content does not indicate absolute quality of the flour or end product, its continued use may be due to tradition and resistance to change.

Ziegler and Greer (2) described the inverse relation between flour color and flour extraction rate. However, Ziegler and Greer (2) and Gillis (8) pointed out that flour color depends not only on flour extraction rate but on other factors as well, including inherent pigments in the wheat, stains or discolorations, and microbial infestations. The carotenoid pigments can be whitened by bleaching agents or by natural oxidation and are not usually considered a factor.

Gillis (8) and Patton and Dishaw (9) described a method of determining flour

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color with the Agtron color meter. Shuey and Skarsaune (10) noted a high relation between different color modes and flour ash content using a new model Agtron. Skarsaune and Shuey (11) reported that particle size affected Agtron color readings. More recently, Shuey (12) showed that wheat variety and environmental growing conditions affected flour color, as determined by the Agtron. All of these authors suggested the Agtron as a control tool in flour mills.

Considerable interest has been shown recently in Agtron color readings rather than ash content for quality control of wheat milling and flour specification. Should Agtron readings be accepted as quality control measurements, the effect of flour storage on flour color should be known. Thus, we report a study of the effect of storage on flour color as determined by the Agtron.

MATERIALS AND METHODS

Waldron hard red spring (HRS) wheat was grown on about 1-acre replicated plots at four locations (Crookston, Minn., Casselton and Minot, N. Dak., and Plentywood, Mont.). The replicate plots were on opposite sides of the field. Wheat samples from each of the plots were milled on a Buhler experimental mill (3); and the patent flours were stored at ambient conditions for 6 months and checked periodically for changes in Agtron color readings. Also, samples from the 1st and 5th breaks and the 1st and 6th midds from the same Waldron blend from our pilot mill (3) were stored at ambient conditions for 5 months and checked periodically for changes in Agtron color readings.

In addition, five varieties of spring wheat, one of which was grown at two locations, were milled on the pilot mill. Straight-grade flours and flours of about 80% extraction were obtained according to Shuey *et al.* (13). A portion of these flour samples was stored at ambient conditions for 2 months; another was stored at 38°C for 1 month so that any changes might be accelerated.

One commercial lot of Kansas-grown hard red winter (HRW) wheat and Anza, a HRS semidwarf wheat grown in California, were milled on the Buhler experimental mill (3). The straight-grade flour was stored at ambient conditions for 1 month and tested.

Waldron and several advanced experimental lines were grown on 1-acre plots at Crookston, Minn., Casselton and Minot, N. Dak., and Plentywood, Mont., in 1975. The samples were milled on our pilot mill (3) and Agtron color readings (green mode) of the straight-grade flour were made initially after milling and after 3 months' storage at ambient conditions.

Color values were determined on a Model M-500 Agtron according to the slurry method of Patton and Dishaw (9). The blue mode readings were taken so that any change in the yellow pigmentation during storage would be observed. Discs used to calibrate were standards 63 and 85 for the green mode and 52 and 78 for the blue mode.

RESULTS AND DISCUSSION

Data for the Buhler-milled flour samples are reported in Table I. Because there were virtually no changes in Agtron color readings for the storage period of 24 weeks, only the range, mean, and standard deviation are reported for each replicate. There was close agreement between Agtron color readings of flours from replicate samples of wheat grown at Crookston, Minn., and Plentywood, Mont. We attributed the wide spread in color readings for the replicates grown at Casselton, N. Dak., to Rep. II, which had inseparable dirt clods. The flour color values which were inversely related to ash values were lower for Rep. II than for Rep. I from Minot because of the field location of the replicated plots. Rep. I was located next to a shelter belt that minimized the effect of the sun and depleted the soil nutrients. The standard deviations were small, considering that the readings were taken over a 24-week period, and show the precision and consistency of the method.

If the Rep. II sample from Casselton, N. Dak., were not included, the ranges in Agtron readings for the blue and green modes would be 9.2 and 6.0 units, respectively, for the four locations. These ranges reflect the differences in growth conditions of the wheat. Corresponding ranges (*i.e.*, Rep. II data excluded) of flour yield and ash content were 1.8 and 0.067%, respectively.

The correlation coefficients calculated on the blue mode Agtron were not significant. However, for the green mode Agtron, highly significant correlation coefficients were obtained for flour yield *vs.* flour color (0.878) and flour ash *vs.* flour color (−0.837). Also, a highly significant correlation of −0.867 was obtained between flour yield and flour ash.

There were wide ranges in ash content and Agtron color readings for the four streams from the pilot mill (Table II). There was virtually no change in color readings during the 8 weeks of storage, and the standard deviations were small. The small standard deviations, like those for the Buhler-milled flour samples, show the precision and consistency of the Agtron color readings.

TABLE I
Yield, Ash Content, and Agtron Color Readings of Waldron Flours after 24 Weeks' Storage at Ambient Conditions

Station and Wheat Sample	Flour		Agtron Color Readings					
			Green mode			Blue mode		
	Yield %	Ash %	Range	Mean	SD[a]	Range	Mean	SD[a]
Crookston, Minn.								
Rep. I	67.6	0.453	49.0–51.5	50.7	0.88	24.5–25.5	24.9	0.35
Rep. II	67.9	0.450	49.0–52.0	50.4	1.12	25.0–26.0	25.5	0.38
Casselton, N. Dak.								
Rep. I	67.1	0.467	51.5–54.0	52.7	0.79	22.0–24.0	23.2	0.80
Rep. II[b]	66.8	0.493	46.0–48.5	47.1	0.79	17.0–19.0	18.0	0.71
Minot, N. Dak.								
Rep. I	68.4	0.400	58.0–59.0	58.6	0.41	28.5–29.5	29.2	0.38
Rep. II	68.3	0.420	53.0–56.0	54.9	0.96	27.0–28.0	27.6	0.32
Plentywood, Mont.								
Rep. I	68.9	0.430	58.5–60.5	59.6	0.62	26.0–28.0	27.4	0.73
Rep. II	68.4	0.433	57.0–59.0	58.0	0.76	26.0–27.5	26.5	0.46

[a]Standard deviation.
[b]Wheat sample had inseparable dirt clods.

The data for the flour samples stored at ambient conditions for 2 months and at 38°C for 1 month show essentially no change in the Agtron color readings of any given flour sample (Table III). The data thus indicate that wheat variety and

TABLE II
Ash Content and Agtron Color Readings of Waldron Flours after 8 Weeks' Storage at Ambient Conditions for Selected Mill Streams from Pilot Mill

		Agtron Color Readings					
		Green mode			Blue mode		
Mill Stream	Ash %	Range	Mean	SD[a]	Range	Mean	SD[a]
1st Break	0.620	27.0–28.5	27.6	0.55	4.5– 5.5	5.0	0.35
5th Break	1.013	6.5– 7.0	6.8	0.27	NR[b]	...	...
1st Midds	0.297	77.0–79.0	77.6	1.14	45.5–46.5	45.7	0.57
6th Midds	0.577	43.0–46.0	44.8	1.26	12.5–13.5	12.8	0.45

[a]Standard deviation.
[b]Sample too gray to obtain a reading.

TABLE III
Flour Yield, Ash Content, and Agtron Color Readings of Flour Stored at Ambient and Elevated Temperatures

	Flour		Agtron Color Readings					
			Green mode			Blue mode		
Extraction, Wheat Variety, and Location of Growth	Yield %	Ash %	A[a]	B[b]	C[c]	A[a]	B[b]	C[c]
Straight-grade								
Prodax; Casselton, N. Dak.	70.5	0.50	50.5	49.3	50.0	20.0	19.0	20.0
Chris; Crookston, Minn.	73.9	0.42	58.0	56.8	57.0	28.8	28.8	28.0
Era; Minot, N. Dak.	77.3	0.42	70.5	69.3	70.5	37.5	35.8	36.0
Era; Crookston, Minn.	77.2	0.44	63.3	61.8	63.0	32.5	31.5	32.0
Kitt; Plentywood, Mont.	73.9	0.42	69.8	69.3	69.5	33.8	34.0	33.5
Waldron; Casselton, N. Dak.	72.4	0.47	53.5	50.8	52.0	22.3	22.5	22.5
80% Extraction								
Prodax; Casselton, N. Dak.	77.4	0.72	24.5	24.8	24.0	NR[d]	...	...
Chris; Crookston, Minn.	80.1	0.63	34.0	34.8	34.0	9.5	8.3	9.0
Era; Minot, N. Dak.	81.5	0.54	52.8	52.0	52.5	22.0	20.8	21.5
Era; Crookston, Minn.	81.6	0.59	41.3	39.8	41.5	15.3	13.5	15.0
Kitt; Plentywood, Mont.	79.7	0.54	53.3	52.5	53.5	18.8	18.5	18.5
Waldron; Casselton, N. Dak.	78.7	0.70	28.8	29.3	28.5	1.5	1.3	1.5
Straight-grade								
Hard red winter (commercial lot)	65.2	0.47	60.3	...	60.0	19.5	...	19.0
Anza; Calif.	67.2	0.44	70.5	...	70.5	34.0	...	34.0

[a]Initial reading after milling.
[b]Reading after 1 month's storage at 38°C.
[c]Reading after 2 months' (1 month in case of HRW and Anza samples) storage at ambient conditions.
[d]Sample too gray to obtain a reading.

extraction rate do not affect the readings during storage. If any changes were to occur, they would be expected in the 80% extraction flours stored at 38° C. As compared to straight-grade flours, 80% extraction flours have higher lipid and vitamin contents and are therefore more subject to changes during storage, especially at elevated temperatures.

We included the HRW wheat and the semidwarf HRS wheat, Anza, in the study to determine the effect of storage on flours of these types of wheat. Table III indicates that the colors of these flours as determined by the Agtron were stable during 1 month of storage.

Green Agtron color readings for the straight-grade flours obtained from our pilot mill are shown in Table IV. There were no noticeable or consistent changes in the color values during 3 months' storage. These flour samples (Table IV) represent a wide range in growing conditions, color readings for straight-grade flours, and a relatively long storage time. Therefore, if changes in green Agtron color values were to occur during storage of straight-grade flours, certainly they would be noticed in these samples.

The data presented show quite conclusively that no noticeable changes occur in the green and blue Agtron color values of flours stored up to 3 months at ambient conditions. The samples and storage conditions used in this research include extremes seldom encountered in industry. A wide extraction range was used which provided samples with low and high lipid and vitamin content. The samples were stored for 3 months at ambient conditions and at elevated temperature (38° C) for 1 month to accelerate changes that might occur during storage. Since a large percentage of commercial flour is held less than 30 days, the Agtron color values would not be expected to change during normal storage time and could be used as a quality test.

Previously published data (9–12) show the reliability, precision, and consistency of the Agtron method of measuring flour color. The Agtron thus appears to be useful for quality control measurements. Flour color as determined by the Agtron could be used in place of ash content as a criterion for flour specification, as there is little, if any, relation between flour ash content and flour

TABLE IV
Green Agtron Values of Flour Samples Stored 3 Months at Ambient Conditions[a]

	Location and Reading							
	Crookston, Minn.		Casselton, N. Dak.		Minot, N. Dak.		Plentywood, Mont.	
Variety	I	II	I	II	I	II	I	II
Waldron	57.3	57.5	60.0	59.5	60.5	60.0	73.0	73.3
Experimental A	66.5	66.3	68.3	69.0	69.5	68.3	76.5	75.0
Experimental B	69.3	69.8	71.0	71.8	69.8	69.3	77.8	79.3
Experimental C	67.8	68.8	68.5	68.8	68.3	68.3	81.5	81.8
Experimental D	65.0	64.3	64.0	64.3	67.3	66.3	...	...
Experimental E	71.0	70.3	70.0	70.3	...	...	77.3	78.3
Experimental F	66.0	65.8	...	...	69.5	68.8	...	...
Experimental G	63.3	61.8	...	...	...	...	...	...
Average	65.8	65.6	67.0	67.3	67.5	66.8	77.2	77.5

[a]I = Initial reading; II = reading after 3 months' storage.

quality per se. Such a criterion would appear logical because the consumer is more concerned with bread color than flour ash content. However, before flour color is used as a control tool, the minimum level of flour color acceptable to the consumer should be determined. The advantages of substituting flour color value for flour ash content may be offset by the introduction of variables, such as wheat variety and growth conditions, that affect color value (12).

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