Agtron in Evaluation of Cereal Flours

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ABSTRACT

Wheat flour samples were made into slurries with water, and the color read in an Agtron Reflectance Spectrophotometer. Various grades of wheat flours were graded on color basis. When blends of flours were read in the Agtron, linear relationships between the percent of one ingredient and the Agtron color reading were found. A simple and rapid method for determining the percentage composition of a two-component blend is described. It is necessary to establish only one standard curve if the same batches of ingredients are used throughout the operation. The degree of bleaching of flours with benzoyl peroxide was followed by this color technique.

The color of wheat flour has been of major interest to millers and bakers since white flour is generally preferred by consumers. The main sources of color in flour are carotenoid pigments, outer layers of the wheat kernel, darker mill streams, and extraneous matter. The carotenoid pigments can be bleached with the commercial bleaching agents and do not represent a major problem. However, contamination of flour with the outer layers of the wheat kernel and low-grade flours gives rise to darker flours since the pigments from these sources cannot be bleached. Thus, flour color is one of the several criteria used in determining flour quality.

A common method used by millers to evaluate flour color is visual examination by the slick method. However, various color-measuring instruments like the Kent-Jones and Martin color grader (1,2) and Agtron Reflectance Spectrophotometer[1] (3,4) are also used for objectively measuring the color of flour. Gillis (3) used Model F2-61 Green Agtron and Model F Blue Agtron to measure the color of flour. He showed that bleaching flour with benzoyl peroxide would change the Blue Agtron readings with little or no change in the Green Agtron readings. Patton and Dishaw (4) used Model F2-61 Green Agtron for objectively grading flour on a color basis. They used flour-water slurries (20 g. flour + 25 ml. water) instead of dry flours to eliminate the reflectance errors caused by particle-size differences and nonuniform packing of dry flours in the Agtron sample cup. They calibrated the Model F2-61 Green Agtron with standard discs No. 63 set at 0 and No. 85 set at 100 on the meter scale and read the flour-water slurries on this scale. They reported a linear decrease in Agtron readings when bran or clear flour was added to a short patent flour.

The purpose of this investigation was to evaluate the use of the Agtron, to 1) grade flours on a color basis by objective measurement of color; 2) determine the degree of whiteness produced when flour is bleached with benzoyl peroxide; and 3) determine the percentage composition of a blend of two flours based on color measurement.

MATERIALS AND METHODS

The Agtron Reflectance Spectrophotometer, M-400-A, was used in this study. In this instrument, the product is illuminated by light from mercury and neon gas-discharge tubes, and the product's monochromatic reflectance is measured at one or more of three selected spectral lines: blue (436 nm.), green (546 nm.), and red (640 nm.). A number of standard calibration discs are supplied with the instrument. The discs have varying shades of gray, the whiteness increasing with the number on the disc. The Agtron meter scale is calibrated with any two discs to give 0 to 100 percent reflectance for a given spectral line (mode), and the sample's relative reflectance in that mode is read on the scale.

The flour samples were made into slurries with water according to the method of Patton and Dishaw (4) and read in the Agtron. The flour sample (20 g.) was weighed into the Agtron sample cup, and 25 ml. distilled or deionized water was added from a buret. The slurry was mixed for 2 min. by hand using a glass stirring rod fitted with a rubber policeman to give a smooth slurry without lumps. The slurry was set aside for 5 min. before reading in the Agtron.

The Agtron was allowed to warm up for 1 hr. before use. However, it was found necessary to check and recalibrate the Agtron every 15 min. as the instrument

[1] Magnuson Engineers, Inc., San Jose, Calif.

TABLE I. GRADES OF FLOUR, PERCENT ASH, AND AGTRON READINGS

Flour Grade	% Ash	Agtron Green, No. 52 = 0, No. 68 = 50
Patents and straight grades	0.38–0.47	83–95
First clear	0.64–0.78	55–70
Second clear	0.90–1.50	25–50
Regrounds of bran and shorts		10–50

continued to warm up. This problem was particularly noticeable when the Agtron was calibrated with closely numbered discs.

The variation in Agtron readings between two operators was found to be ± 0.5 unit, which indicated a good reproducibility of the method. There was no change in the Agtron readings when the flour-water slurries were allowed to stand for up to 7 min. after mixing.

A variable-speed, air-driven mechanical stirrer (Arrow Engineering Company, Inc.,Hillside, N. J.) was found to be satisfactory for mixing the flour-water slurries. The water was added to the flour sample from a self-filling 25-ml. pipet, and the slurry mixed for 20 sec. at a low speed to give a smooth, uniform slurry free of air bubbles. The slurry was allowed to stand for 5 min. before reading in the Agtron. No differences in Agtron readings were found when slurries were mixed either by hand or with the mechanical stirrer. By preweighing flour into the sample cups and using the mechanical stirrer, approximately 20 samples can be run per hour by coordinating the mixing, standing, and reading times. By reading the samples at 30-sec. intervals, one can reduce the frequent recalibration steps of the Agtron.

Four blends–1) clear flour-rye flour, 2) HRW straight-grade flour-soy flour, 3) durum flour-whole-egg solids, and 4) semolina-soy flour–were studied in this experiment to evaluate the use of Agtron in determining the percentage composition of the blends. In the case of clear flour-rye flour blends, preblends were used. For the other three blends, the ingredients were weighed in calculated quantities into the sample cup to give a 20-g. blend and made into slurries with water without premixing. For blends containing soy flour, 20 g. blend and 30 ml. water were used to give a smooth slurry.

The flour samples were bleached with benzoyl peroxide by dry-blending and allowed to stand for 48 hr. before reading in the Agtron.

RESULTS AND DISCUSSION

Color Grading of Flour

Color Measurement in Green Mode. Color measurement in the green mode is unaffected by the creamy-yellow or yellow color of flour arising from the bleachable carotenoid pigments (3), but measures the color resulting from the presence of bran and low-grade colored materials. Based on a study of 400 flour samples obtained from experimental mill and flour mills, it was found that patent flours, straight-grade flours, clear flours, and regrinds from bran and shorts can be graded for color by reading the reflectance values in the green mode of the Agtron. By calibrating the Agtron in the green mode with discs No. 52 and No. 68 set at 0 and 50, respectively, on the meter scale, the four common grades of flour can be read on one scale. Typical Agtron readings for the four common grades of flour and the percent ash range covered are shown in Table I. The color readings ranged from 10 to 95, increasing with the quality grade of the flour. While a general inverse relationship existed between the percent ash and the Agtron readings, no attempt was made to correlate the two values since the purpose of this study was objective measurement of color as one of the criteria of flour quality.

Color Measurement in Blue Mode. Agtron readings in the blue mode measure the yellow color of flour caused by the presence of carotenoid and other pigments. The carotenoid pigments can be bleached by commercial bleaching agents, while other pigments such as flavones and anthocyanins which arise mainly from contamination of flour with bran and germ particles are not bleached. The blue mode readings primarily measure the extent of color removal by bleaching compounds, and as the carotenoid pigments are bleached, the blue mode readings increase with little or no change in the green mode readings.

Three flour samples, hard red winter (HRW) straight-grade flour, hard red spring (HRS) straight-grade flour, and a blend of 80% HRS patent and 20% first-clear flour, were treated with benzoyl peroxide, and the extent of bleaching was measured in the Agtron. The quantities of benzoyl peroxide used, 1.25×10^{-4}, 1.43×10^{-4}, 1.67×10^{-4}, and 2.0×10^{-4} lb. per lb. flour corresponded to 1 lb. per 80, 70, 60, and 50 cwt. flour, respectively. This was in the commercial operating range used by millers. The increase in blue mode readings with increasing amounts of benzoyl peroxide is shown in Table II and Fig. 1. For the HRW flour studied in this experiment, it took 0.18×10^{-2}, 0.24×10^{-2}, and 0.33×10^{-2} lb. benzoyl peroxide per cwt. flour to increase the Agtron readings by three units from 75 to 78, 78 to 81, and 81 to 84, respectively. Increasing amounts of benzoyl peroxide were required to obtain successive increases of three Agtron units, and the bleaching action appeared to decrease beyond a certain extent of bleaching. For the same increments of benzoyl peroxide, HRS flour gave an increase of four Agtron units. The blend of HRS patent and first-clear flour showed a bleaching rate similar to that of HRS straight-grade flour, although the blend was darker in color.

There was no significant change in the green mode readings after bleaching the flour with benzoyl peroxide (Table II). This observation is in agreement with the findings of Gillis (3). The slight increase in the green mode readings could have resulted from the whiteness of added benzoyl peroxide.

Agtron readings in the blue mode may be used to determine the amount of benzoyl peroxide required to bleach a flour to a desired color reading. One needs to bleach small batches of flour with known amounts of benzoyl peroxide and plot the Agtron readings against the amounts of the bleaching agent.

From the standard curve, the amount of benzoyl peroxide required to give a desired reading can be obtained. From an economic standpoint one can determine the cost of additional amounts of benzoyl peroxide required to obtain an increase of one Agtron unit beyond a certain extent of bleaching, as well as determine whether the color can be effectively removed by this agent.

TABLE II. EFFECT OF BENZOYL PEROXIDE TREATMENT OF FLOURS ON AGTRON READINGS[a]

Benzoyl Peroxide lb./lb. Flour, $\times 10^{-4}$	HRW		HRS		80% HRS patent 20% first clear	
	Blue	Green	Blue	Green	Blue	Green
None	42.0	87.5	42.5	83.5	22.5	76.5
1.25	75.0	87.5	65.0	83.5	44.0	76.5
1.43	78.0	87.5	69.0	83.5	46.5	77.0
1.67	81.0	88.0	73.0	84.0	50.0	78.0
2.00	84.0	88.0	77.0	84.0	55.0	78.0

[a]Agtron was calibrated in the blue mode with discs No. 56 set at 0 and No. 68 at 100, and in the green mode with No. 52 at 0 and No. 68 at 50 on the meter scale.

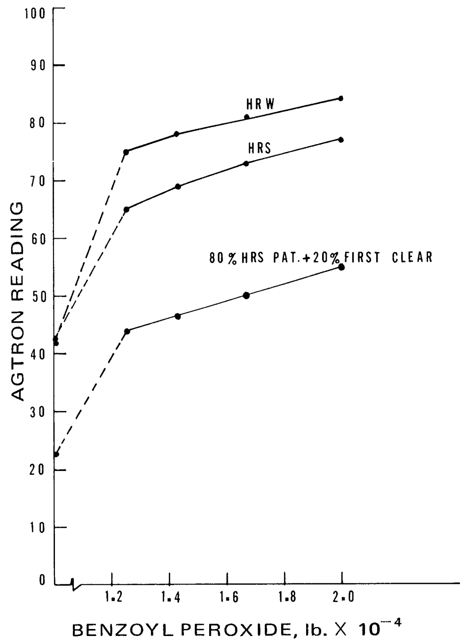

Fig. 1. Effect of increasing amounts of benzoyl peroxide on Agtron readings (blue mode, No. 56 = 0, No. 68 = 100) for HRW, HRS, and blend of HRS patent and clear flour.

Compositional Analysis of Blends

Most cereal flours exhibit differences in color when measured objectively with a color instrument such as the Agtron. When two such flours are blended together, the resultant color readings bear a direct relation to the proportions in which they are mixed. Thus, one can determine the percentage composition of a blend by measuring its color reading in the Agtron and comparing with the color readings of blends of known composition. Only three blends of known composition, usually in the range of the expected composition of the unknown, are needed to obtain a standard curve from which the percentage make-up of the unknown is determined. Since the analysis is based on color measurement only, the standard blends must be made with the same ingredients as those used in the unknown. The standards can be made by weighing the ingredients directly into the Agtron sample cups in the calculated proportions to give a total of 20 g.

The choice of the color mode (blue, green, red) depends upon the color of the ingredients used in the blend. For example, if one of the ingredients has much more yellow color than the other, the blue mode is chosen, e.g., HRW straight-grade flour and soy-flour blend. Although linear relationships can be obtained in more than one mode, one mode is generally more sensitive to color changes than the others. The selection of calibration discs for the Agtron depends upon the sensitivity desired, the color range of the samples, and the precision required.

First Clear-Rye Flour Blend. Blends of first-clear flour (0.80% ash, 16.0% protein) and medium rye flour (1.03% ash, 11.8% protein) containing 15 to 50% rye were made into slurries (20 g. + 25 ml. water) and read in the green mode of the

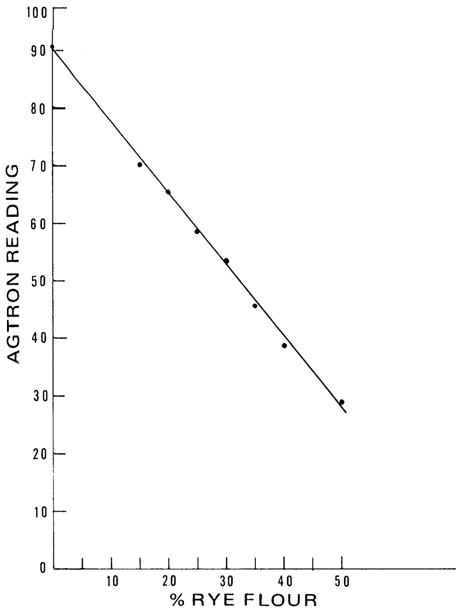

Fig. 2. Relation between Agtron readings (green mode, No. 41 = 0, No. 75 = 100) and rye flour percent in first clear-rye flour blend.

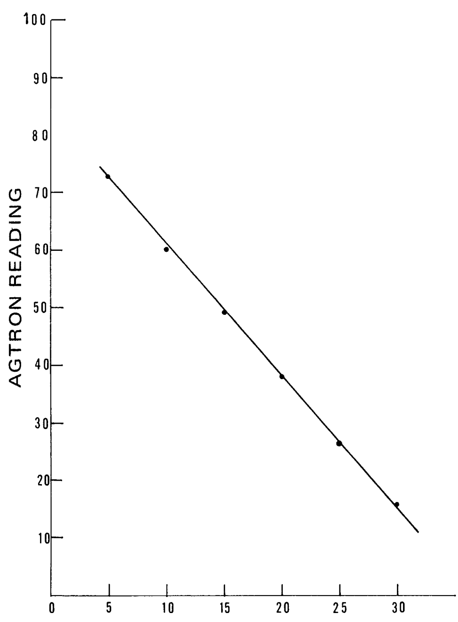

Fig. 3. Relation between Agtron readings (blue mode, No. 33 = 0, No. 68 = 100) and soy flour percent in HRW straight-grade flour-soy flour blend.

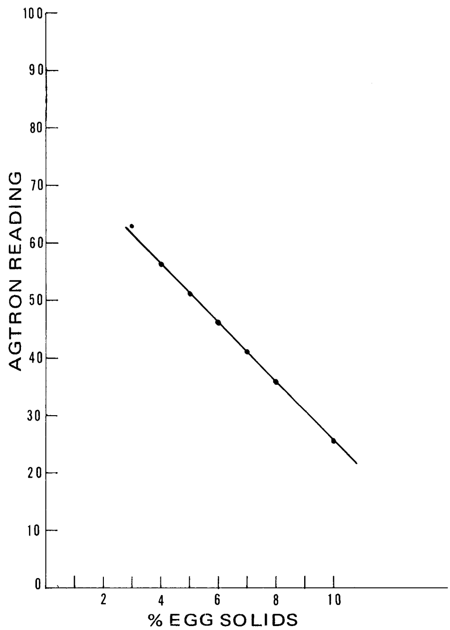

Fig. 4. Relation between Agtron readings (blue mode, No. 33 = 0, No. 52 = 100) and egg solids content in durum flour-egg solids blend.

Agtron. A plot of Agtron versus percent rye flour in the blend is shown in Fig. 2.

Straight-Grade Flour-Soy Flour Blend. Blends (20 g.) of HRW straight-grade flour and defatted soy flour containing 5 to 30% soy flour were made by weighing the ingredients into the sample cups in calculated quantities, made into slurries (20 g. + 30 ml. water), and read in the blue mode of the Agtron. The linear relationship between the Agtron readings and percent soy flour is shown in Fig. 3.

Durum Flour-Whole Egg Solids Blend. This blend illustrates the color change produced in a cereal flour by addition of a noncereal ingredient. Standard curves for blends containing known amounts of egg solids can be established, and the egg solids content in a blend of unknown composition can be determined. A plot of Agtron readings versus percent egg solids is shown in Fig. 4.

Semolina-Soy Flour Blend. Standard blends containing 5 to 20% soy flour were made into slurries (20 g. + 30 ml. water) and read in the blue mode of the Agtron. The Agtron readings were plotted against percent soy flour (Fig. 5). The four blends studied in this experiment illustrate a method by which the percentage composition of a blend can be determined rapidly and accurately by objective color measurement. Such a method has advantages in the control of blending operations at the plant in that several batches of the blend can be analyzed rapidly for composition and degree of mixing. It is necessary to establish only one standard curve if the same batches of ingredients were used throughout the operation. Such analyses can replace time-consuming methods such as the ash and protein determinations and the slick test commonly used at the plant and in quality control departments.

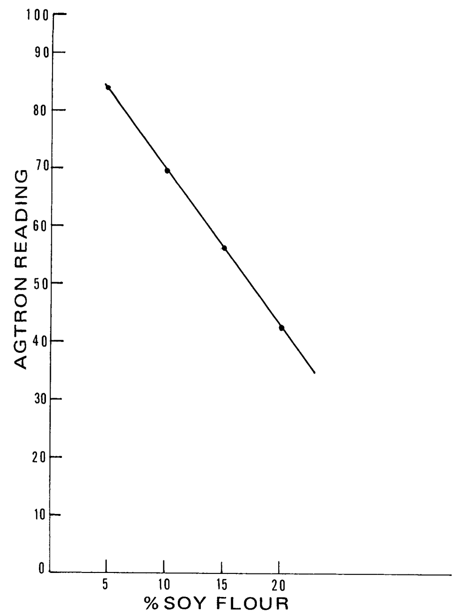

Fig. 5. Relation between Agtron readings (blue mode, No. 30 = 0, No. 52 = 100) and soy flour percent in semolina-soy flour blend.

SUMMARY

Four commercial mill flours—patent, straight-grade, clear flours, and regrinds of shorts and bran—were graded for color on a single scale by measuring their color in the green mode of Agtron with one pair of calibration discs. This system classified flours on a color basis into accepted commercial grades.

Treatment of flour with benzoyl peroxide did not affect the green mode reading which is an independent measure of the flour grade. The whiteness of flour produced by bleaching was measured objectively in the blue mode of the Agtron. The amounts of benzoyl peroxide required to produce a desired whiteness can thus be determined.

A rapid method, based on color measurement, for determining the percentage composition of a blend was illustrated.

Literature Cited

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