NOTE

An Automated System for the Continuous Measurement of Time-Dependent Changes in Noodle Color

HAROLD CORKE,[1,2] LUN AU-YEUNG,[3] and XIAOFANG CHEN[1]

Cereal Chem. 74(3):356–358

ABSTRACT

Fresh noodles may develop a gray discoloration over time during storage. This characteristic is related to polyphenoloxidase activity and is partly a varietal characteristic of the wheat flour; it is also influenced by processing conditions and is regarded as a major negative factor in noodle quality. Screening of wheat genotypes by measuring color at a fixed-time interval (commonly 24 hr) after manufacture is not informative about time-dependent color development. We developed a computer-controlled automated sample platform attached to a reflectance spectrophotometer to simultaneously monitor color changes (L^*, a^*, b^*) over time in up to 12 noodle samples. Application of the unit to monitor color changes in white-salted and yellow-alkaline noodles is described.

Color is one of the most important considerations in assessment of noodle quality. It is more important for raw noodles than for boiled or steamed noodles since time-dependent darkening (graying) due to polyphenol oxidases (PPO) may occur (Miskelly 1984, Hatcher and Kruger 1993). Many factors could affect the noodle color, such as genotypic and environmental effects on flour quality, processing conditions, storage time and conditions, and formulation. Fresh Cantonese-style yellow alkaline noodles have the added complication that an alkaline reagent (*kansui*) is used in the formulation (Kruger et al 1992, 1994), which contributes a desirable yellow color by interaction of flavonoids with the alkali. Such noodles may also commonly be stored for up to one day before use, and the yellow and gray color development may occur simultaneously.

In assessing noodle quality, it is common practice to make a test batch of product and measure color after a fixed-time interval, such as 24 hr, using a reflectance instrument such as the Minolta Chroma Meter model CR-300 (Minolta Corporation, Tokyo) (Sammy Huang, California Wheat Commission, Woodland, CA, *personal communication*). Little information is available on the time-course development of gray color in fresh white-salted noodles (WSN), and gray and yellow color in fresh yellow-alkaline noodles (YAN) because of the lack of an easy method to monitor color of multiple samples at defined intervals over time. We developed an automated color difference detection platform that can simultaneously monitor the color of up to 12 noodle sheet samples with up to one color reading per minute. The data is automatically collected and stored by a computer program for subsequent analysis.

In this note, we describe the development of the system and its application in the comparison of the time-dependent color changes of two types of noodles (WSN and YAN), each made with two different samples of flour.

[1]Cereal Science Laboratory, Department of Botany, The University of Hong Kong, Pokfulam Road, Hong Kong.
[2]Corresponding author. Fax: 852/2858-3477. E-mail: harold@hkuxa.hku.hk
[3]Electronic Services Unit, The University of Hong Kong.

Publication no. C-1997-0415-03R.

MATERIALS AND METHODS

Development of the Color Difference Measuring Platform

A color difference detection platform was built to perform data capture automation for the color measurement of target specimens with slow change in their colors. It is able to schedule successive color measurements of up to 12 specimens at user-defined intervals (1–12 min). The platform consists of three parts: the platform mechanism, the power supply unit, and the control unit (Fig. 1). The platform mechanism was fabricated by the University Industrial Center of the University of Hong Kong. It has a circular platform with 12 square compartments (each 5 × 5 cm) to hold the target specimens under investigation. Rotation of the platform is achieved to an accuracy of 0.018° by a stepping motor (model 103-8575-7041, Sanyo Denki Co., Ltd., Tokyo) installed in the chassis beneath it. Another stepping motor (model 103-8573-7041, Sanyo Denki Co., Ltd., Tokyo) controls the vertical displacement of the Minolta CR-300 measuring head to obtain a desired position within 0.01 mm resolution for color measurement. With this mechanism, the specimens can be aligned properly and placed in close contact with the measuring head so color measurement can be conducted with high precision. The power supply unit is designed to provide reliable DC voltages with 5V/1.5A and 24V/6A to the whole system under prolonged operation.

The heart of the control unit is an Intel 8031 (Intel Corporation, Santa Clara, CA) micro-controller, and the system software was developed using a high-level programming language, C-51 (Franklin Software, Inc., San Jose, CA). Besides the micro-controller, there are other supporting electronic modules and circuits to enable the control unit to provide a number of functions such as the man-machine interface, timing control, motor driving, measurement scheduling, and coordination of all these activities.

Users can easily select the operation settings such as the test mode, total number of specimens under test, test duration, and measurement mode using several push buttons and obtain the status display at the front panel through the man-machine interface design. A 0.25-msec time base is generated using one of the micro-controller built-in timer features so that all timing events can be scheduled exactly with appropriate multiples of that time-base unit. The micro-controller is capable of calculating the number of driving pulses needed for the two stepping motors, determining the appropriate motion profile, and processing the motor excitation using the associated electronic circuit. Optical sensors

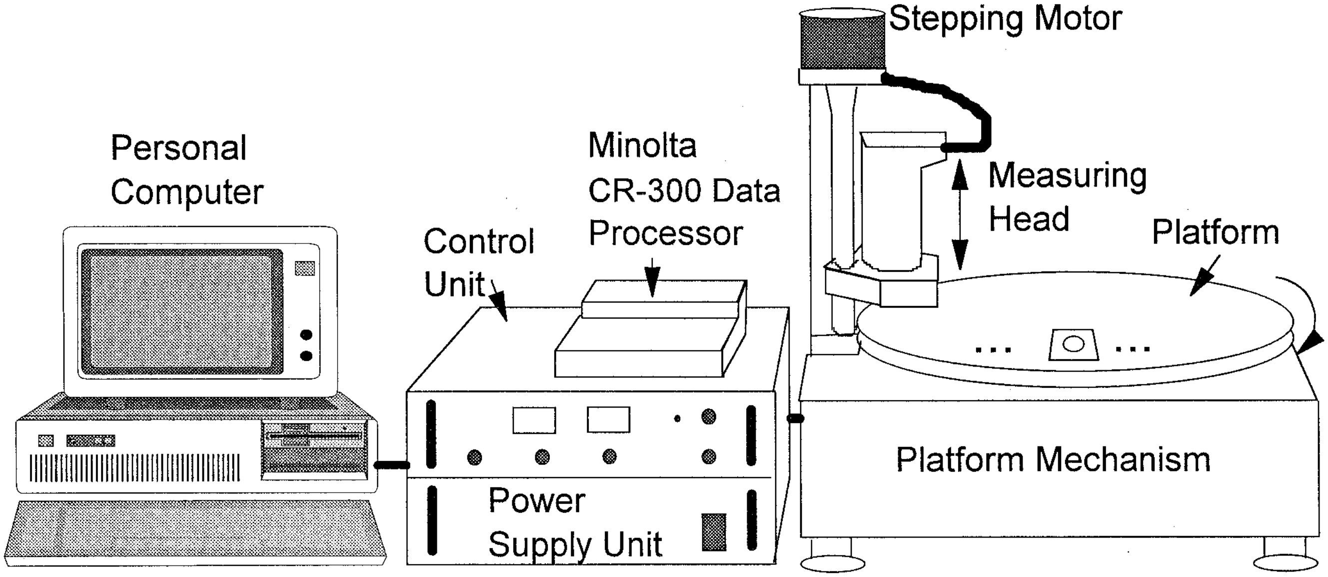

Fig. 1. Color difference detection platform diagram. A stepping motor is installed inside the platform mechanism for rotation.

and contact switches have been installed to ensure accurate rotary and vertical positioning and thus a closed loop control can be achieved. Furthermore, switches were employed to protect the motor from erroneous vertical movement beyond the upper and lower limits. The micro-controller uses its timing feature to generate an external triggering signal through a driving circuit to the data processor for accurately initiating color measurement.

A complete fully automatic color difference detection system should include the platform, the Minolta CR-300, and a personal computer. On the basis of the user's selected parameters, the platform acts as a master to schedule the stepping motor motion on time and monitor the position with high accuracy. Also, the platform triggers the Minolta CR-300 to conduct color measurement. Under the control of Minolta ChromaControl program, the personal computer is able to obtain all the color measurement data through an RS-232C communication link and provide data for subsequent analysis in a standard personal computer data file format.

Noodle Sheet Preparation

Two brand name types of flour, Red Bicycle (RB, a Hard Red Winter flour of U.S. origin widely sold for noodle production) and Darkie (DK, similar to Red Bicycle and used for noodles or baking) were obtained from Hong Kong Flour Mills, Kowloon, Hong Kong. Protein content of DK flour (11.7%) is higher than RB flour (11.0%). WSN and YAN were prepared from each type of flour. WSN consisted of 30:11:0.6 parts flour, distilled water, and NaCl on a weight basis. YAN consisted of 30:11:0.3 parts flour, distilled water, and alkaline salts or *kansui* on a weight basis. The *kansui* was made from 9:1 Na_2CO_3 and K_2CO_3.

The dough was hand-mixed, and the water absorption used in the formula was confirmed to be appropriate by the appearance and handling properties of the dough sheet. After resting covered for 30 min at room temperature, the dough was transferred to a domestic-type pasta machine (Atlas Electric model 150, Marcato Co., Italy) for sheeting. Four sheeting stages were used with a reduction percentage of 50% at each step. Every step was repeated six times, consistently in the same orientation in order to prepare a noodle sheet with good surface firmness.

Sample Color Measurement

Raw noodle-sheet color was measured by the color difference detection platform. Noodle sheets (5 × 5 cm) were placed in the

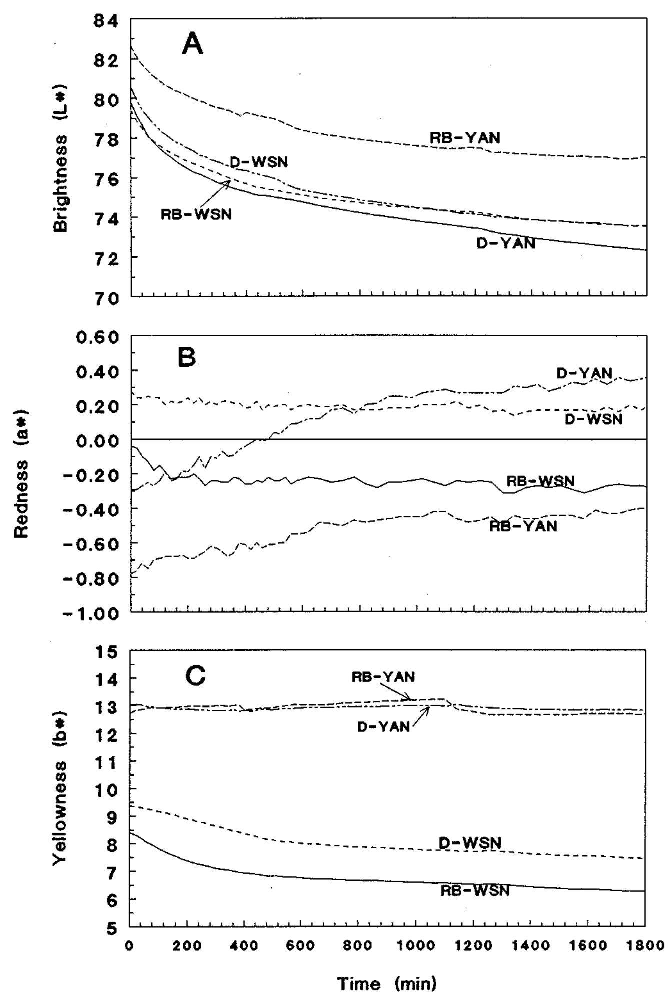

Fig. 2. Color changes with time of four noodle samples. **A,** brightness (L^*); **B,** redness (a^*); **C,** yellowness (b^*). RB-YAN and RB-WSN are Red Bicycle yellow-alkaline and white-salted noodles, respectively; D-YAN and D-WSN are Darkie yellow-alkaline and white-salted noodles, respectively.

perspex sample container developed for the platform. The sample container base was made of black perspex. The lid of opaque perspex had a circular hole 15 mm dia. cut in the center, surrounded on top by a half-recessed "O"-ring to assure close contact with the Minolta measuring head. The bottom of the hole was covered by a permanently affixed glass coverslip (~0.5 mm above the surface of the noodle sheet). The containers were sealed to prevent air movement and, hence, excessive drying, but contained ~10 mL of air to enable oxidation reactions to proceed. This method approximates the storage conditions for fresh noodles for domestic consumption. One of the containers always had a Minolta standard white tile as a control. Measurement of the surface color of the noodle sheets or of the standard white tile took place through the glass cover slip. The results were corrected against the values for the standard white tile taken by direct measurement against its surface. Despite the correction, the three chromaticity coordinates may be affected differently by the measuring system employed, although, in our experience, the differences for this type of material are slight. We emphasize that the intention is to provide relative measurements for comparison of genotypes or processing conditions, and the present system is suited for such purposes.

The multi-measure mode (three measurements were made and automatically averaged for each sample reading) of the Minolta CR-300 Chroma Meter was used to record the color parameters of the surface of the noodle sheets. One reading per sample was made at 10-min intervals for 28 hr. The L^*, a^*, b^* color system (CIE 1976) was used for the measurement of color difference. L^* is a measure of brightness, and a^* and b^* indicate the red-green and yellow-blue chromaticity, respectively (Pomeranz and Meloan 1987). Increased values of a^* and b^* indicate increased redness and yellowness.

RESULTS AND DISCUSSION

The dough pH of the Red Bicycle and Darkie WSN was 6.0 and 5.9, respectively, and for the Red Bicycle and Darkie YAN was 9.5 in both cases. The changes in L^*, a^*, and b^* with time for four wet noodle formulations are shown in Fig. 2A–C. Brightness of noodle sheet is affected by water absorption, but the wheat flours in this study were all processed at the same flour-water absorption. The noodles prepared by the different methods all showed continuous decrease in brightness (L^*) with time (Fig. 2A). The WSN made with Red Bicycle and Darkie flour were very similar in L^*, not differing by more than ~1 unit. The YAN noodles from Red Bicycle and Darkie flour were quite different from each other, with Darkie rapidly declining in L^*, increasing the difference in brightness from 2 to 4 units from 0 to 28 hr. These changes in color show that single time-point measurements made at different times would not give the same relative separation in color values between samples.

For YAN, a^* (redness) increased with time, with Darkie being more red than Red Bicycle. For the WSN, a^* was fairly constant or decreased slightly with time (Fig. 2B). Generally, the a^* values were very small and unlikely to pose significant problems in color development for these samples.

Yellowness (b^*) for the noodles was, of course, greatest in the two YAN samples, but there was virtually no differences between Red Bicycle and Darkie YAN for this parameter (Fig. 2C). There was also very little change over time in b^* for the YAN. There were slight differences in b^* between Red Bicycle and Darkie WSN. Both WSN samples declined slightly in b^* for ~7 hr before stabilizing.

In summary, there were significant differences in color change between the two wheat flours, between the two noodle formulation methods, and significant changes with time in the relative ranking of color of the samples. The color difference detection platform was effective in detecting these types of changes and appears to have excellent potential in screening larger numbers of samples both in breeding and cultivar selection, and in quality monitoring in noodle formulation and production. We also note that the system has applications in measuring color changes in many other systems, such as storage changes in salmon color (J. R. Stark, Heriot Watt University, *personal communication*).

ACKNOWLEDGMENTS

We thank P. W. Lo of the University Industrial Center at the University of Hong Kong for fabricating the platform mechanism; and G. B. Crosbie of the Western Australia Department of Agriculture for valuable discussions on noodle color. Grant support was provided by the Hong Kong Research Grants Council and the University of Hong Kong Committee on Research and Conference Grants. Salary support to X. Chen was provided by Pronova Biopolymer (Hong Kong) and the Hong Kong Department of Industry.

LITERATURE CITED

Hatcher, D. W., and Kruger, J. E. 1993. Distribution of polyphenol oxidase in flour millstreams of Canadian common wheat classes milled to three extraction rates. Cereal Chem. 70:51-55.

Kruger, J. E., Anderson, M. H., and Dexter, J. E. 1994. Effect of flour refinement on raw Cantonese noodle color and texture. Cereal Chem. 71:177-182.

Kruger, J. E., Matsuo, R. R., and Preston, K. 1992. A comparison of methods for prediction of Cantonese noodle color. Can. J. Plant Sci. 72:1021-1029.

Miskelly, D. M. 1984. Flour components affecting paste and noodle color. J. Sci. Food Agric. 35:463-471.

Pomeranz, Y., and Meloan, C. E. 1987. Food Analysis: Theory and Practice. 2nd ed. Van Nostrand Reinhold: New York.

[Received July 22, 1996. Accepted January 29, 1997.]