Noodle-making quality from Australian standard white wheat and Montana wheat and barleys
by Xianzhong Han

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agronomy
Montana State University

Abstract:
The influence of machining on the color of Chinese noodle dough was examined in this study. When sheets of noodle dough were prepared, it was noted that the L* (lightness/darkness) value and the b* (yellow/blue) chromaticity value were different for the top and bottom of the dough sheets. When the doughs were subsequently passed through the rolls of the noodle machine, the L* and b* values increased after each passage for at least 3 hr after the doughs were made. Interestingly, if identical dough sheets were compared, the dough sheets which passed through the reduction rolls at 1, 2 and 3 hr respectively after initial preparation maintained higher L* and b* color value over dough sheets which were passed through the reduction rolls after initial preparation and stored.

In the first part of study, we compared the color changes in response to machining using Australian Standard White wheat and Nuwest, a Montana hard white winter wheat.

In the second part of the study, Nuwest, a Montana hard white wheat was compared to Australian Standard White (ASW) wheat for Asian noodle and breadmaking quality parameters. Noodles made from these two wheats were stored under environmental conditions similar to the climatic conditions found in South East Asia. The color and texture of the noodles were monitored for a period of 96 h. Nuwest produced noodles which were equal to or superior to those produced from ASW. Nuwest and ASW also had similar breadmaking quality.

In the third part of the study, four Montana barleys, Merlin, Glacier, high amylose Glacier, and high amylose hull-less Glacier were added into two wheat flours, Nuwest and ASW. This study showed that incorporation of barley flours into noodles increased the insoluble fiber, soluble fiber, insoluble P-glucan and soluble β-glucan content of the product but resulted in an undesirable color change.

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ABSTRACT

The influence of machining on the color of Chinese noodle dough was examined in this study. When sheets of noodle dough were prepared, it was noted that the L* (lightness/darkness) value and the b* (yellow/blue) chromaticity value were different for the top and bottom of the dough sheets. When the doughs were subsequently passed through the rolls of the noodle machine, the L* and b* values increased after each passage for at least 3 hr after the doughs were made. Interestingly, if identical dough sheets were compared, the dough sheets which passed through the reduction rolls at 1, 2 and 3 hr respectively after initial preparation maintained higher L* and b* color value over dough sheets which were passed through the reduction rolls after initial preparation and stored. In the first part of study, we compared the color changes in response to machining using Australian Standard White wheat and Nuwest, a Montana hard white winter wheat.

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In the third part of the study, four Montana barleys, Merlin, Glacier, high amylose Glacier, and high amylose hull-less Glacier were added into two wheat flours, Nuwest and ASW. This study showed that incorporation of barley flours into noodles increased the insoluble fiber, soluble fiber, insoluble β-glucan and soluble β-glucan content of the product but resulted in an undesirable color change.

CHAPTER 1

LITERATURE REVIEW

Introduction

Noodles originated in China and are still a popular food throughout Asia. Fifty percent of wheat consumed in Asia is in the form of noodle products which may vary in their ingredients, degree of cooking before sale, and degree of drying (Hoseney, 1992). They may be white (Japanese type) or light yellow (Chinese type). Chinese noodles are commonly consumed in South-East Asia and Japan. The essential ingredients of Chinese noodles are flour, water and alkaline salts called Kansui. Kansui can be sodium or potassium carbonate or bicarbonate - or even sodium hydroxide (Moss et al., 1986). Kansui raises the pH of the raw noodles to between 9 and 11 and is responsible for the yellow color of Chinese noodles which develops under alkaline condition. Kansui confers a unique characteristic of Chinese noodles.

Noodle Color

Carotenoids and flavonoids are two types of pigments in wheat flour which are related to the yellow color of Chinese noodles. Carotenoid pigments are found in the endosperm and give flour its creamy-yellow color. These pigments can be bleached rather easily and are destroyed by bleaching agents added to flour. Flavonoid pigments, which come mostly from bran contamination of flour, are not bleached by the normal bleaching agents. The flavonoids are relatively stable and are colorless at acidic pH but give a yellow color at high pH. Alkaline solutions detach flavones from the polysaccharides, allow the yellow color to become manifest (Hoseney, 1992). Different formulations of Kansui affect noodle brightness and yellowness. Using sodium hydroxide instead of potassium carbonate or sodium carbonate produced substantially increases yellowness in noodle sheets (Kruger et al., 1992).

Darkening of the noodles during storage is mainly caused by polyphenoloxidase located largely in bran (Kruger et al., 1992). Tyrosinase is involved in the oxidation of phenols to quinones which are subsequently converted to dark colored melanins by polymerization and interaction with protein. Tyrosinase activity is found to be an inherited characteristic (Miskelly, 1984). Enzymatic browning in noodles increases with increasing extraction rate of flour, presumably since bran particles contain a high concentration of oxidative enzymes, phenolics, and pigments (Oh et al., 1985a).

Flour protein content is strongly associated with color. Moss (1971) found that brightness was inversely proportional to flour protein content. As protein content increases, the color become less attractive. Discoloration is associated with gluten washed from the samples (Miskelly and Moss, 1985).

Miskelly (1984) found the brightness and yellowness of the noodle sheet was highly correlated with milling yield. The yellowness of the noodle sheets increases while the brightness of the noodle sheets decreases with increased yield. An increased flour extraction rate results in a higher level of germ, and hence more flavone compounds are available for reaction with Kansui to produce more yellowness; the decrease in brightness of the product is due to discoloration from bran and other components high in minerals. The granularity may also influence the color of dry flour; a flour with finer particle size is brighter and whiter.

Hunter L*a*b* color values have been used to measure noodle color. In the L*a*b* color space, L* indicate brightness and a* and b* are the chromaticity coordinates. The a* value is a measure of red (+a)/green (-a) and b* value is a measure of yellow (+b)/blue (-b). In general, L* and b* values are inversely related (Miskelly, 1984). L* values should be as close to 100 as possible. The higher the value, the brighter the noodle. b* values must be approximately 30 or above and a* values should be as close to 0 as possible for acceptable noodle color.

Noodle Texture

Wide variations exist in the type of noodle preferred by different people. In China and Korea, noodles with a "chewing" texture are preferred. In Japan, a soft texture is desired. The eating quality of cooked noodles depends largely on their firmness, resilience, and surface characteristics besides flavor (Oh et al., 1985b).

Protein quantity and quality are important in noodle making. A high levels (10-14%) of strong protein produce noodles with a chewy, elastic texture. Flours with a low protein content give noodles with poor cooking tolerance and the noodles are mushy and sticky when overcooked (Hoseney, 1992). Strong flours (those with high resistance and extensibility in the extensograph) give firmer and more elastic noodles than do weaker flours, in fact, no flour with protein content below 9.5% gives noodles of satisfactory eating quality (Miskelly and Moss, 1985). Increases in flour protein levels and strengths from different classes of wheat are accompanied by increases in the values of textural properties of the cooked noodles. Flour protein might produce a tight noodle structure resulting from a strong adherence between starch and protein. Such a tight structure might cause uncooked noodles to appear translucent, resulting in less reflected light in high-protein noodles. The tight structure of a high protein noodle retards moisture penetration into its core during cooking, so the cooking time of hard wheat noodles increases linearly with protein content.

Starch is the predominant component in flour. It changes from the raw granular form to the gelatinized form during cooking (Hoseney, 1992). Oda et al. (1980) found that the amylose level in wheat starch from 13 commercial flours was negatively correlated with the eating quality of noodles. Miskelly and Moss (1985) prepared noodles from over 150 wheat flours from all over Australia, and the eating quality of the Chinese noodles was correlated with starch that showed a low pasting consistency . Crosbie (1991) isolated starch from 13 flours milled from Australian wheats that varied in quality for the production of Japanese salt noodles and found positive correlations between starch swelling power (at 92.5 ^{0}C), peak viscosity in the amylograph, and the overall texture score of the cooked noodles.

Enzymes also influence the quality of noodles. Excessive amounts of α-amylase in flour cause rapid breakdown of the noodle structure (Hoseney, 1992).

Alkaline salts toughen the dough and affect pasting properties (Terada et al., 1981). Enzyme activity such as enzymatic darkening is inhibited under alkaline conditions. Alkaline treatments also cause isomerization of amino acids, desulfuration of cysteine and a decline in the biological availability of lysine and dehydroalanine.

Resting dough before sheeting is known to improve dough sheeting properties by allowing uniform moisture distribution and mellowing of wheat gluten. Increasing resting time increases surface firmness (Oh et al., 1985b). The speed of the noodle machine rolls also affects the firmness of the dough. The surface firmness of noodles increases as the roll speed decreases or as reduction percentage increases at a constant roll speed (Oh et al., 1985c).

Water absorption also influences the characteristics of a noodle dough. Too much water results in a sticky dough that stretches excessively during handling, but too little water results in a stiff dough that resists sheeting (Oh et al., 1986).

Cooked noodle textural properties are not affected greatly by different flour refinements. The relative ranking of wheats in terms of raw noodle color or cooked noodle texture is mainly independent of flour refinement (Kruger et al., 1994).

Several instruments have been used to measure noodle texture, including the General Foods Texturometer (Chang and Lee 1974, Cheigh et al., 1976), Autograph S-100 (Lii and Chang 1981), Texturecorder (Nielson et al., 1980), Viscoelasticity Meter (Okada 1971), and Instron Universal Testing Instrument (Oh et al., 1983).

Objectives

The objectives of this study were to: (I) identify machining influences on the color changes in noodle dough sheets, (ii) determine the suitability of the Montana hard white winter wheat, Nuwest, for noodle-making, (iii) establish a Chinese noodle standard from Australian Standard White wheat which is well recognized in the Asian market, and (iv) incorporate Montana barley flours into noodle products and identify the potential value added nutritional benefits of these products.

CHAPTER 2

THE EFFECTS OF MACHINING ON COLOR CHANGES IN CHINESE NOODLE DOUGH

Introduction

Color is one of the most important considerations in the assessment of the quality of Chinese noodles. The final product may be raw, lightly boiled and coated with oil, dried, steamed and fried or steamed and dried. However, when various flours for noodlemaking quality are evaluated, the color of the uncooked noodle dough provides the critical predictive factors (Kruger et al., 1992). Most consumers prefer a clear, pale, yellow product free from specks and discoloration (Shelke et al., 1990). Hunter Lab color values have been used to evaluate noodle color characteristics, with high L* (brightness) and b* (yellowness) values being desirable (Kruger et al., 1992, Miskelly, 1984). Chinese noodles depend on the development of the natural yellowness of the flavones under alkaline conditions for their final color (Miskelly and Moss, 1985). Noodles prepared by a variety of different methods have been shown to decrease in brightness (L* values) over time and increase in yellowness (b* values) rapidly during the first half hour after processing. Subsequently the L* and b* values changed at a much slower rate (Kruger et al., 1992). Changes in noodle dough color are caused by a variety of factors. The large shift in the total reflectance spectrum during the first hour of dough resting is quite different from that in the later period and may be indicative of factors such as changes in water distribution that alter the surface characteristics of the dough (Kruger et al., 1992). Tyrosinase, located in the bran layer of the wheat, may affect noodle dough color as it may become involved in the oxidation of phenols to quinones which are subsequently converted to dark colored melanins by polymerization and interaction with protein (Miskelly, 1984). Polyphenol oxidase (PPO) has also been implicated in undesirable color changes in noodles (Kruger et al., 1992). As the PPO activity increases, the rate of change in brightness (L*) values and yellowness (b*) values increases. The brightness and yellowness values of dried Chinese noodles have been shown to be governed by protein content, cultivar and environmental conditions affecting the wheat from which the noodles were produced (Moss, 1971). The brightness (L*) values of noodles have been shown to decrease as the flour protein content increased (Miskelly, 1985). Brightness (L*) and yellowness (b*) values decrease with increasing flour refinement since PPO is located predominantly in the bran, and high-extraction milling exacerbates this time-dependent browning (Hatcher and Kruger, 1993, Kruger et al., 1994). Starch may also influence the color of noodle products. Color differences between noodle doughs produced from several wheat varieties are highly correlated with differences in starch characteristics (as measured by gelatinization, differential scanning calorimetry, or amylose-amylopectin parameters) (Baik et al., 1995).

The objective of this study was to investigate machining influences on the color of noodle dough. L* and b* values change greatly during the first hour after processing, but these changes may not be simply a result of enzymatic activity. In this study, the effects of re-machining the doughs after various periods of resting time were examined to determine the physical effects of machining the dough on color attributes.

Materials and Methods

Materials

'Nuwest', (reg. no. CV-812, PI 586806), a hard white winter wheat (Triticum aestivum L.) cultivar, was developed and released by the Montana Agricultural Experiment Station in 1994 (Bruckner et al., 1996). Nuwest was kindly provided by Dr. Biggerstaff, Western Plant Breeders Inc., Bozeman, MT. Australian Standard White (ASW) was kindly provided by M. Kruk, Wheat Marketing Center, Inc. Portland, OR.

Noodle Preparation

During all procedures, laboratory conditions were maintained at 25°C and 50% relative humidity. Flour (300g) was pre-mixed at a low speed in a Hobart mixer for 1 min, the mixing speed was then increased to medium and a solution containing 3 g sodium chloride, 3 g sodium carbonate and 114 ml distilled water was poured into the flour within a 20 to 30 second period of time. Mixing continued for a total mixing time of 5 min. The dough was rested in a plastic bag for 10 min. After resting, the dough was folded length wise and passed through a noodle machine (Otake Mfg. Co. Ltd., Tokyo, Japan) six times at a gap size of 8 mm (compression series). The temperature of the noodle machine rolls was maintained at 30°C. The dough was rested in a plastic bag for 10 min, and then passed through the gradual reduction series until a final dough thickness of 1.6 mm was achieved. Noodle dough sheets were stored in sealed bags at 85% relative humidity and 30°C throughout the color analyses.

Dough Color Analyses

The doughs were cut into circular pieces (6 cm in diameter) and color values were measured by the Minolta CR-310 Chroma Meter using the L*a*b* color system.

Statistical Analyses

All the doughs were repeated three times and each dough was measured twice at different point. Color measurements of noodle doughs are the averages of 6 individual determinations. Data were analyzed by analysis of variance using the General Linear Model Procedure (SAS, 1986). The error bars in the graphs show the standard deviation.

Results and Discussion

Machining Influences on Dough Surface Color Values

The differences in the color of the two surfaces of the dough sheets made from Australian Standard White (ASW) and Nuwest are reported in Figs. 1 and 2 with “top” and “bottom” referring to the orientation of the dough surfaces as the dough sheet emerges from the noodle machine. Initially, the top surfaces of the doughs had higher L* values than the bottom surfaces, while the bottom surfaces of the doughs had higher b* values than the top surfaces. The differences in the L* and b* values diminished during the first hr, and after the first hr of resting, the L* and b* values for the top and bottom surfaces were similar. It is likely that the initial differences were caused by uneven force angles exerted on the two surfaces of the dough from the rolls of the noodle machine. These differences allowed for uneven distribution of water on the two surfaces of the dough (Oh et al., 1986). It is also possible that differences in the temperatures of the atmosphere (25°C) and the noodle machine rolls (30°C) affected the distribution of water on the surfaces of the doughs.

Influence of the Number of Times Dough Passes through Machine Rolls on Color Values

The number of times a dough was passed through the noodle machine rolls had a great effect on the color of the doughs made from both ASW and Nuwest (Figs. 3 and 4.).

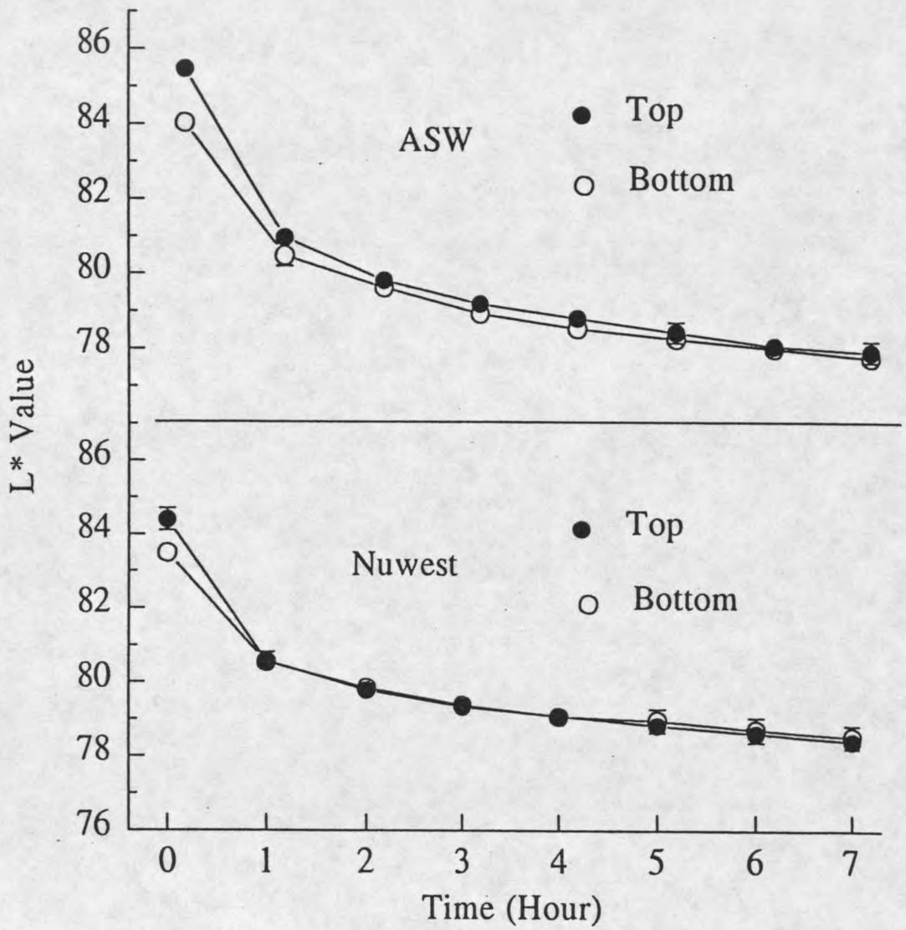

Fig. 1. Change in L* values on top and bottom surfaces of the dough during storage.

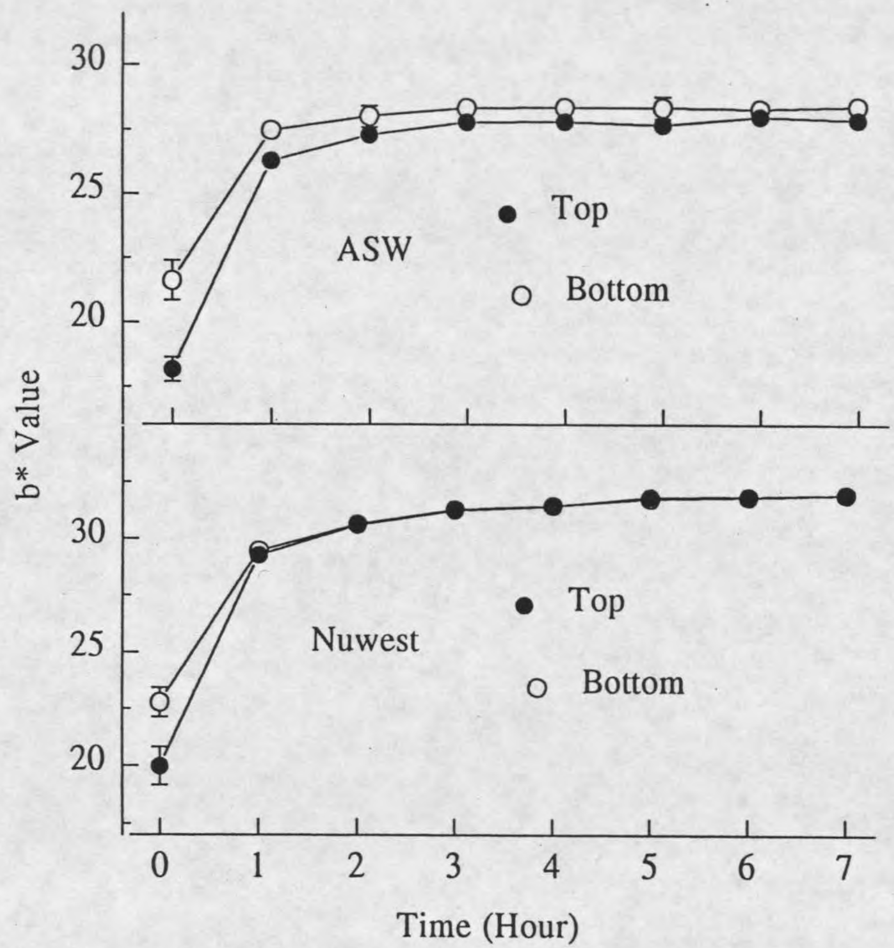

Fig. 2. Changes in b* values on top and bottom surfaces of the dough during storage.

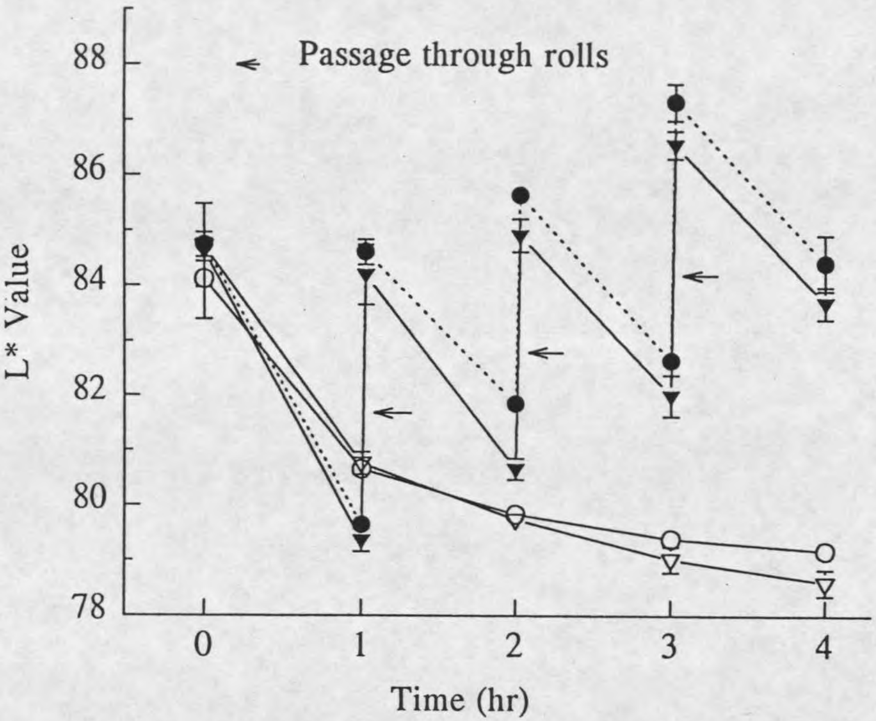

Fig. 3. Changes in L* values of doughs produced from Nuwest (○) and ASW (▽) during storage (control) and changes in L* values of doughs produced from Nuwest (●) and ASW (▼) which occurred as a result of repeated passage through the rolls of the noodle machine during storage.

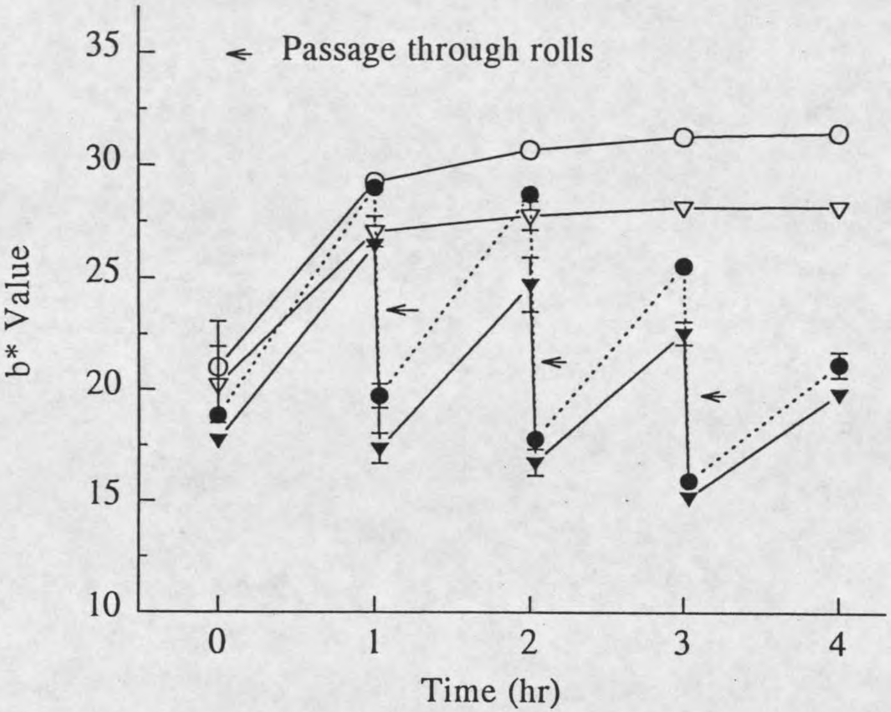

Fig. 4. Changes in b* values of doughs produced from Nuwest (○) and ASW (▽) during storage (control) and changes in b* values of doughs produced from Nuwest (●) and ASW (▼) which occurred as a result of repeated passage through the rolls of the noodle machine during storage.

The initial L* and b* values of the doughs were recorded immediately after the doughs were made (Fig. 3). The L* values decreased quickly after 1 hr but increased after doughs were folded lengthwise, passed through the rolls at a gap size of 6 mm (Fig. 3.). The L* values of the same doughs decreased during the second hour of storage but increased after the dough was again folded and passed through the rolls at a gap size of 6 mm. The same phenomenon was observed during the third hour of storage. The b* values, on the other hand, increased during first hr of storage and decreased after the dough was passed through the rolls of the noodle machine (Fig. 4). The same phenomenon held true during the second and third hr of storage. The b* values of the same doughs increased during the second and third hr of storage but decreased after the doughs were folded and passed through the noodle machine rolls. Both ASW and Nuwest produced similar results.

Color Changes during Storage

To examine the influences of color changes occurring within the dough during the resting period, a dough piece (8 mm thick) formed after the initial compression series in the noodlemaking process was cut into four equal size pieces. The first piece was passed through the reduction series of the noodlemaking process to a final thickness of 1.6 mm at 0 hr and the L* and b* values were recorded for the resulting dough sheet. The second dough piece was allowed to rest in a sealed bag at 30°C and 85 % rh for 1 hr and was then passed through the reduction series to a final thickness of 1.6 mm. The L* and b* values were recorded for the resulting dough sheet. The third and fourth dough pieces were passed through the reduction series at 2 and 3 hr respectively and their L* and b* values recorded (Figs. 5 and 6). The L* and b* values for the first dough piece (control) recorded each hr (Figs. 5 and 6) indicate the changes in those values which occur over the 3 hr after the dough is made if no further machining takes place. The color changes in both L* values and b* values decrease if the dough is passed through the rolls of the noodle machine during the resting period. The color differences between dough pieces which were passed through the rolls of the machine during the resting period and the control were caused by unknown reasons, but these changes are not likely related to enzymatic activity. If the changes in color were caused by enzymatic activity, all doughs would exhibit the same color changes over time. These results indicate that surface color changes which take place during the first hr after the dough is made are not due to enzymatic activity occurring throughout the dough. Rather, the surface color changes appear to be related to physical phenomenon which are influenced by the machining of the dough.

To determine the length of time the color changes caused by machining would persist, a big single dough piece which had been processed through the compression series in the noodlemaking process was cut into three equal size pieces. The first piece was passed through the reduction series to a final dough thickness of 1.6 mm at the 0 hr. The dough was then placed in a plastic bag and rested for 7 hr at 30°C and 85% rh. The L* and b* values were recorded hourly (Figs. 7 and 8). The other two dough pieces were placed in plastic bags and rested at 30°C and 85% rh. After 1 hr of resting, the second