NOTE

DURUM WHEAT AND PASTA

Effect of Bleaching on Durum Wheat and Spaghetti Quality[1]

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ABSTRACT

Durum wheat samples bleached by adverse weather conditions during the 1992 harvest were evaluated for their physicochemical characteristics and their pasta quality. Two sets of wheat samples were tested. The first set, which consisted of 173 samples, was divided into four groups (sound, sound but nonvitreous, bleached, and severely weather-damaged). Because of their small size, these samples were composited for milling and pasta processing. The second set included five large wheat samples, also from the 1992 crop year. These samples were approximately half bleached and half sound, and each sample was manually sorted into sound and bleached fractions. The bleached wheat from both sample sets showed lower test weight and 1,000-kernel weight than the sound wheat. The falling number decreased slightly, but not significantly; while the vitreousness, protein, ash, and hardness values were nearly the same as those obtained for the sound wheat. The physicochemical characteristics of the severely weather-damaged wheat were adversely affected, except for gluten strength. The nonvitreous and the severely weather-damaged wheat showed a decrease in semolina extraction, semolina protein, and wet gluten. Minor bleaching, involving only the discoloration of the kernel seed coat, did not affect the semolina properties or the spaghetti color and cooking quality.

Wheat quality is closely related to its suitability for a particular end use. The ability to transform wheat into a number of highly desirable products depends largely on harvesting the wheat when it is fully ripe, sound, and free of grain that is diseased or weather-damaged. Occasionally, because of the untimely rains at harvest, damage to the kernels may occur before the wheat can be harvested. This damage can range from minor to severe and can be assessed by different indicators: kernel seed coat discoloration or bleaching, test weight, falling number, and other factors. Mild weather damage, which was the main focus of this study, can bleach or lighten the seed coat of the kernels, but whether or not this bleaching modifies the grain kernel structure is unknown.

The objective of this research was to investigate the degree to which this damage affects the physicochemical properties of durum wheat and pasta. Little information has been published on the effect of bleaching of durum wheat on pasta quality. Shuey (1969) evaluated three varieties of sound, naturally and artificially bleached wheat. The results indicated that both the artificially and the naturally bleached wheat showed a decrease in test weight, no effect on 1,000-kernel weight, and only a small effect on milling value. Falling number and test weight also decreased following weathering damage (Clarke et al 1986).

Simmonds (1989) stated that severe weather damage, apart from affecting the appearance of the grain and making it seem bleached, can have a devastating effect on the quality of wheat products, owing to synthesis and release of a number of enzymes that attack the starch, protein, and lipid reserves of the grain. He also reported that excessive amylase and protease in weather-damaged wheat affected the rheological properties of the sheeted noodles by increasing dough stickiness and by decreasing dough elasticity to a degree where the noodles could not remain on the sticks during the drying stage. The eating quality of the noodles also was adversely affected. Some studies have reported that severely weather-damaged or sprouted wheat had an adverse effect on pasta quality (Harris 1943, Maier 1980, Kruger and Matsuo 1982). Other workers (Dick et al 1974, Donnelly 1980, Matsuo et al 1982, Dexter et al 1990) have found that most of the physicochemical characteristics of durum wheat and pasta quality were not adversely affected by weather damage (sprout). Derera (1989) reported that severely weather-damaged wheat with low falling number can be better tolerated in spaghetti than in Cantonese noodle processing.

MATERIALS AND METHODS

Wheat Samples

The durum wheat used in this study included 173 samples selected from the 341 samples collected during the 1992 regional durum wheat quality survey (North Dakota, South Dakota, Montana, and Minnesota) and five commercial samples (~50 lbs each) from the same crop year. The 173 samples were divided into four groups according to grain color and soundness by a Federal Grain Inspector Service (FGIS) inspector: group 1–fully vitreous and sound; group 2–nonvitreous in appearance, but otherwise sound; group 3–bleached in appearance; and group 4–bleached and severely weather-damaged.

The crop survey samples were too small to be processed individually into pasta, so they were composited. The composites from each group were made by randomly taking 10 samples (1-kg each) at a time and blending together 500 g of wheat removed from each of the 10 samples. Since the first three groups each had 50 samples and the fourth group had only 23, a total of 17 composites was obtained.

The five commercial samples selected were approximately half bleached and half sound. The bleached and sound kernels from each sample were manually separated, and a total of 10 fractions obtained. The advantage of having a large sample is that it can be milled and processed into pasta without compositing.

Wheat Analysis

The moisture, test weight, ash, protein, and falling number were determined according to the AACC methods 44-15A, 55-10, 08-01 46-11A, and 56-81B, respectively (AACC 1983). The 1,000-kernel weight was determined by counting the number of kernels in 10 g of clean wheat sample, using an electronic seed counter (Seedburo Equipment Co., Chicago, IL).

The vitreousness was determined with a farinator, a device that allows 50 wheat kernels to be held firmly while a blade is moved through to cut them transversely. The percentage of vitreous kernels is determined by examining the cross-section of the kernels. Vitreous grain appear dark and translucent, while opaque and nonvitreous grain appear yellow and starchy. Percent vitreousness represents the average of the 50 kernels multiplied by 2.

Wheat hardness was determined by near infrared reflectance (NIR) and by particle size index (PSI) according to the AACC

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methods 39-70A and 55-30, respectively (AACC 1983).

The wheat samples were tempered to 17.5% moisture and milled on a Buhler experimental mill, model MLU 202, designed for milling durum wheat as reported by Seyam et al (1974).

The moisture, protein, ash, and wet gluten were determined on the semolina samples according the AACC methods 44-15A, 46-11A, 08-01, and 38-12, respectively (AACC 1983). Mixograph evaluation of semolina was determined according to the AACC method 54-40A (AACC 1983) with some modifications: the semolina samples were mixed for 8 min at constant water absorption of 5.8 ml, using a spring setting of 8. The mixographs were scored by comparing them to reference mixographs (Dick and Young 1988).

Pasta Processing and Drying

A 1-kg sample of each semolina was mixed in a Hobart mixer (Hobart Mfg. Co., Troy, OH) at high speed until the desired dough consistency was obtained. The dough was transferred to a DeMaco semicommercial scale pasta extruder. The following processing conditions were used for all the samples. The water temperature and absorption during mixing were 40°C and 31.5%, respectively; the extruder shaft speed, barrel temperature, and vacuum were 25 rpm, 45°C, and 457 mm Hg, respectively. The dough was pressed through an 84-strand Teflon-coated spaghetti die with 0.157 cm diameter according to the procedure of Walsh et al (1971). The extruded spaghetti samples were dried using the two-stage Buhler high-temperature drying cycle shown in Figure 1.

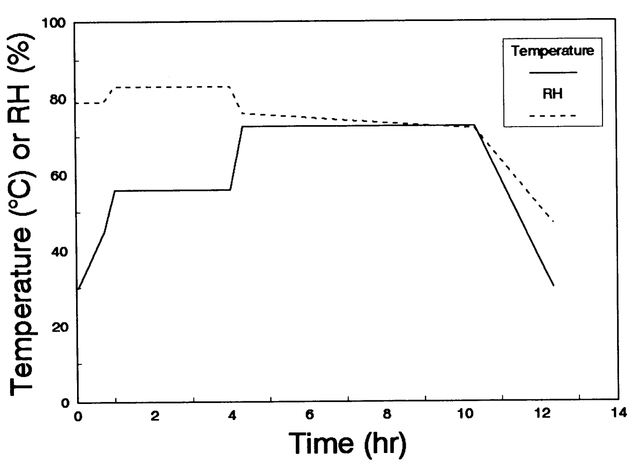

Fig. 1. Buhler two-stage high-temperature drying cycle.

Spaghetti Analysis

Spaghetti color scores were determined by light reflectance using a Minolta color difference meter (model CR 310, Minolta Camera Co., Japan) according to the AACC method 14-22 (AACC 1983).

The spaghetti samples were cooked according to the procedure described by Dick et al (1974). Cooked weight was determined by weighing the drained and rinsed spaghetti and reporting the results in grams. Cooking loss of the cooking and rinse waters collected from each sample was determined by evaporating to dryness in an air oven at 115°C. The residue was weighed and reported as percentage of the original spaghetti sample.

Spaghetti firmness was measured by shearing two cooked spaghetti strands with a specially designed plexiglass tooth attached to an Instron universal testing instrument as described by Walsh (1971).

Statistical Analysis

The data were analyzed statistically using the ANOVA procedure of the Statistical Analysis System (SAS 1986). One-way and two-way ANOVA were used for the crop survey and the commercial samples, respectively. Duncan's multiple range test was also applied to compare mean values.

RESULTS AND DISCUSSION

Physicochemical Characteristic of Wheat

The physicochemical characteristic of the wheat samples are shown in Table I. The 173 samples selected from the 1992 North Dakota Crop Quality Survey and the five commercial samples are represented by groups 1–4 and fractions 1 and 2, respectively. Duncan's multiple range test showed that the bleached wheat (group 3 and fraction 2) had significantly lower test weight and 1,000-kernel weight than the sound wheat. Shuey (1969) found a similar trend for test weight but no difference in 1,000-kernel weight. Dick and Matsuo (1988) stated that wheat samples with low kernel weight tend to give low test weight. A strong relationship between test weight and 1,000-kernel weight was also reported by Dexter et al (1987). Based on this relationship, a trend could be expected between these two parameters as shown by the results of Matsuo and Dexter (1980). The falling number decreased slightly but not significantly; the vitreousness, protein, ash, and hardness values were nearly the same as those obtained for the sound wheat. The severely weather-damaged wheat (group 4) showed the lowest values for all the quality parameters tested, except for the gluten strength, measured by the micro-sedimentation procedure. Dexter et al (1990) also found that durum wheat gluten strength was not adversely affected by sprout damage.

TABLE I
Effect of Bleaching on the Physicochemical Characteristics of Durum Wheat

	Quality Parameter[b]								
Wheat[a]	TWT (lb/bu)	TKW (g)	VIT (%)	MSD (mm)	PRT[c] (%)	Ash[c] (%)	FNB[d] (%)	HPSI (%)	HNIR
Group									
1	61.5 a[e]	43.5 a	96 a	40 a	13.8 a	1.58 b	365 a	5.8 b	139 a
2	61.5 a	42.7 ab	84 b	37 a	12.4 b	1.56 b	341 a	6.7 a	134 b
3	60.2 b	42.0 b	93 a	39 a	13.7 a	1.60 b	340 a	5.8 b	139 a
4	58.3 c	39.6 c	71 c	40 a	12.3 b	1.70 a	229 c	6.7 a	122 c
Fraction									
1	62.5 a	41.9 a	92 a	37 a	13.5 a	1.55 a	447 a	6.5 a	127 a
2	61.2 b	40.2 b	91 a	35 a	13.5 a	1.59 a	424 a	6.7 a	125 a
LSD (0.05)[f]	1.25	1.62	1.10	1.60	0.04	0.02	23.70	0.19	1.40

[a] Group: 1 = sound wheat (n = 50), 2 = sound but nonvitrous wheat (n = 50), 3 = bleached wheat (n = 50), 4 = severely weather-damaged wheat (n = 23). Fraction: 1 = sound, 2 = bleached.

[b] TWT = test weight, TKW = 1,000-kernel weight, VIT = vitreousness, MSD = micro-sedimentation, PRT = protein, FNB = falling number, HPSI = hardness determined by the particle size index method, HNIR = hardness determined by the near-infrared method.

[c] Results are expressed on 12.0% moisture basis.

[d] Results are expressed on 14.0% moisture basis.

[e] Means followed by the same letter in each column are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

[f] Least significant difference; comparison of two means.

Milling Performance and Semolina Properties

The milling of durum wheat is designed to obtain a maximum amount of good quality semolina and a minimum amount of flour. First-grade semolina is milled from sound, fully vitreous wheat of highest grade. The bleached wheat (group 3) showed a significant decrease in semolina extraction and a nonsignificant decrease in total extraction (semolina and flour). This difference was due to a slight increase in flour yield for the bleached wheat. (Table II). These results agree with the findings of Shuey (1969).

The nonvitreous and severely weather-damaged wheat samples (groups 2 and 4, respectively) showed a significant decrease in semolina extraction and a significant increase in flour yield. The effect of nonvitreous starchy kernels on milling yield still remain a controversial subject. The total milling yield (semolina and flour) appears according to the present study (Table II) and to other investigations (Bolling and Zwingelberg 1972, Matsuo and Dexter 1980, Dexter and Matsuo 1981) not to be adversely affected by the presence of starchy kernels. It is, however, well-documented that starchy kernels reduce semolina extraction and increase flour production (Matveef 1963, Donnelly 1979, Matsuo and Dexter 1980, Dexter and Matsuo 1981). Since the primary objective of durum milling is to maximize semolina yield and minimize flour production, and since semolina commands a higher selling price than flour (Dick and Matsuo 1988), wheat vitreousness still remains an important grading and quality factor. Semolina quality parameters are presented in Table III. Duncan's multiple range test showed that bleaching did not have a significant effect on semolina protein, ash, mixograph characteristic, wet gluten, speck count, and color. Protein and wet gluten were significantly lower for the nonvitreous and severely weather-damaged durum wheat samples (groups 2 and 4). The decrease in protein content in starchy kernels has also been documented by several workers (Matsuo and Dexter 1980, Dexter and Matsuo 1981, Dexter et al 1988). Semolina speck count and color were also negatively affected by weather damage as previously reported (Dick et al 1974, Donnelly 1980, Dexter et al 1990).

TABLE II
Effect of Bleaching on the Milling Performance of Durum Wheat

Wheat[a]	Semolina Extraction (%)	Total Extraction (%)	Flour Yield (%)
Group			
1	60.0 a[b]	69.4 a	9.4 b
2	58.7 b	69.5 a	10.8 a
3	59.3 b	68.8 a	9.8 b
4	57.9 c	68.5 a	10.7 a
Fraction			
1	64.7 a	71.7 a	9.6 b
2	63.5 b	71.5 a	10.4 a
LSD (0.05)[c]	0.84	0.12	0.75

[a] Groups 1–3 include each 5 composites ($n = 10$ for each composite), and group 4 includes 2 composites ($n = 10$ for each composite). Fraction: 1 = sound, 2 = bleached.
[b] Means followed by the same letter in each column are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.
[c] Least significant difference; comparison of two means.

TABLE III
Effect of Bleaching on the Physicochemical Characteristics of Semolina

Wheat[a]	Quality Parameter[b] PRT (%)[c]	Ash (%)[c]	MXS[c]	WGT (%)[c]	SCTSI	SCS
Group						
1	12.8 a[e]	0.63 b	7 a	40.1 a	60 b	10.5 a
2	11.7 b	0.60 c	6 a	34.4 b	56 b	10.4 a
3	12.7 a	0.62 bc	7 a	40.2 a	60 b	10.3 a
4	11.6 b	0.69 a	6 a	35.9 a	73 a	9.5 b
Fraction						
1	12.8 a	0.70 a	7 a	39.7 a	58 a	9.3 a
2	12.6 a	0.71 a	7 a	39.0 a	58 a	9.2 a
LSD (0.05)[d]	0.24	0.01	0.30	0.65	0.10	0.10

[a] Groups 1–3 include each 5 composites ($n = 10$ for each composite), and group 4 includes 2 composites ($n = 10$ for each composite). Fraction: 1 = sound wheat, 2 = bleached wheat.
[b] PRT = protein, MXS = mixograph score, WGT = wet gluten, SCTSI = speck count per ten square inches, SCS = semolina color score.
[c] Results are expressed on 14.0% moisture basis.
[d] Least significant difference; comparison of two means.
[e] Means followed by the same letter in each column are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

Spaghetti Quality

Spaghetti color is an important quality parameter that influences consumer acceptance. Generally, consumers prefer spaghetti with a bright yellow color. Color scores of 8.5 or higher are considered good. Bleaching did not have any significant effect on spaghetti color as shown by the Duncan's multiple range test. As reported by Harris (1943), severe weather damage to wheat (group 4) had a detrimental effect on spaghetti color. Donnelly (1980) and Matsuo et al (1982) found no effect of severely weather-damaged or sprouted wheat on pasta color. However, it should be stressed that the severely weather-damaged wheat (group 4) used in this study might have also included some diseased kernels in addition to the sprouted kernels. The cooking characteristics, which include cooked weight, cooking loss, and firmness, are also, like color, important quality factors and constitute the ultimate tests that segregate the good and poor quality pasta. This quality is measured by testing how the product holds up to cooking, how much water is absorbed, the loss of solids to the cooking water, and the firmness. Firm spaghetti is preferred to soft or mushy spaghetti.

Table IV shows no significant effect of bleaching on pasta cooked weight, cooking loss, and firmness. The weather-damaged wheat showed a decrease in cooked weight and an increase in cooking loss. These results support the conclusions of Kruger and Matsuo (1982) and Matsuo et al (1982). The results also show a significant decrease in firmness for the nonvitreous and weather-damaged durum wheat samples. Dexter and Matsuo (1981) also reported a deterioration in spaghetti cooking quality as starchy kernel content increased.

CONCLUSION

Bleaching of wheat is caused by rain at harvest. Depending on the amount of these rains, the damage can be minor, resulting only in the discoloration of the outer layer of the kernel or major damage affecting the whole kernel structure.

The results of this study showed that bleaching had an adverse effect on test weight and 1,000-kernel weight and no effect on semolina properties and spaghetti quality. When the wheat was severely weather-damaged, most of the quality parameters tested on wheat, semolina, and spaghetti were negatively affected.

TABLE IV
Effect of Bleaching on Pasta Color and Cooking Characteristics

Wheat[a]	Color Score	Cooked Weight (g)	Cooking Loss (%)	Firmness (g/cm)
Group				
1	10.4 a[b]	32.1 a	6.8 b	6.1 a
2	10.8 a	32.2 a	7.1 b	5.5 b
3	10.6 a	32.0 a	6.7 b	6.0 a
4	9.7 b	31.5 b	7.8 a	5.0 c
Fraction				
1	8.8 a	31.7 a	6.3 a	6.6 a
2	8.7 a	31.4 a	6.1 a	6.5 a
LSD (0.05)[c]	0.15	0.31	0.12	0.04

[a] Groups 1–3 include each 5 composites ($n = 10$ for each composite), and group 4 includes 2 composites ($n = 10$ for each composite).
[b] Means followed by the same letter in each column are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.
[c] Least significant difference; comparison of two means.

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