Effect of Starchy Kernels, Immaturity, and Shrunken Kernels on Durum Wheat Quality[1]

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ABSTRACT

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The effect of starchy kernels, various degrees of immaturity, and shrunken kernels on durum wheat characteristics and end-use quality was investigated. As starchy kernel content increased, semolina granulation became finer and more flour was produced during milling. Protein content decreased with increased starchy kernel content, resulting in a deterioration in spaghetti cooking quality. The main effect of immature, grass green, and frosted green kernels was to increase ash levels, which led to duller and browner spaghetti. The presence of shrunken kernels caused reduced test weight, high ash, reduced milling yield, higher speck count, and poorer spaghetti color quality.

Unfavorable weather conditions during the growth and harvest of cereals can result in considerable crop damage. Not only does the appearance of the grain become less desirable, but the end-use quality often is adversely affected. To establish a fair market value for grains, and to ensure that foreign buyers get consistent quality from shipment to shipment, producing countries must adopt a grading system.

The effectiveness of the Canadian grading system is aptly illustrated by the superior milling quality, color characteristics, and spaghetti cooking quality of the top grades of Canadian durum wheats compared to those of the lower grades (Canadian Grain Commission 1979). The quality differences between grades are usually a result of the combined effects of many degrading factors. However, very little published information is available on the effect of individual degrading factors on durum wheat quality. We therefore determined the quality differences attributable to some of the common degrading factors associated with the 1979 Canadian durum wheat crop. This article reports the effect of starchy kernels, various degrees of immaturity, and shrunken kernels on durum wheat quality. Subsequent reports will deal with some of the other major degrading factors.

MATERIALS AND METHODS

Sample Preparation

To determine the effect of starchiness and immaturity on durum wheat quality, samples were prepared such that quality differences could be attributed to the degrading factors rather than to environmental or varietal effects. Envelope samples from the 1979 Canadian durum wheat crop survey were segregated according to the type of degrading factor present. For each type of degrading factor, each envelope sample was handpicked to yield two or more samples of equal weight: a control essentially free of the degrading factor and one or more samples enriched in the degrading factor by various amounts. At least 20 envelope samples of controls and of corresponding enriched samples were bulked to yield a series of samples weighing at least 600 g.

To determine the effect of shrunken kernels on durum wheat quality, three large individual farm samples possessing various levels of shrunken kernels were obtained from the Grain Inspection Division. For each sample, the shrunken kernels were sieved out and reintroduced in varying proportions to yield a series of 1-kg samples with a fairly wide range of shrunken kernels.

Grading

Each composite was graded by the Grain Inspection Division of the Canadian Grain Commission. Where possible, the extent of each degrading factor was quantitated. Degrading factors were assessed according to the Official Grain Grading Guide (Canadian Grain Commission 1980).

Table I lists the minimum test weight and hard vitreous kernel content and the maximum content of grass green kernels and shrunken kernels tolerated for each grade of Canada Western amber durum. Weight per hectoliter was determined with an Ohaus 0.51-L measure and cox funnel. Hard vitreous kernels were defined as whole, reasonably sound kernels that exhibited the natural amber color of amber durum wheat without dissection of kernels. Nonvitreous kernels included grass green or badly damaged kernels

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and kernels having a starch spot of any size. Grass green kernels ranged from thin shrunken green kernels to well-formed plump green kernels. The estimate for overall maturity of the samples was fairly subjective, based on terms like "reasonably well matured," "fairly well matured," and "excluded from higher grades on account of immature...kernels." Shrunken kernels, which are often associated with drought, stem rust, or root rot, were defined as whole, reasonably sound kernels that passed through a No. 1 (1.79 × 12.70-mm) slotted sieve.

TABLE I
Quality Tolerances for Hectoliter Weight, and for Hard Vitreous, Grass Green, and Shrunken Kernels for Canada Western (CW) Amber Durum Wheat Grades

Grade	Minimum Hectolitre Weight (kg)	Kernels (%) Minimum Hard Vitreous	Maximum Grass Green	Maximum Shrunken
1 CW	80	80	0.75	6
2 CW	78	60	2	10
3 CW	76	40	4	12
4 CW	71	NL[a]	10	NL
5 CW	NL	NL	NL	NL

[a] No limit.

TABLE II
Mean and Standard Deviation for Each Analytical Test Used: Results Based on 10 Single Determinations on a Representative Sample

Test	Mean	SD
Wheat		
Test weight (kg/hl)	83.24	0.11
1,000-kernel weight (g)	50.14	0.96
Ash (%)	1.464	0.012
Yellow pigment (ppm)	5.23	0.16
Protein (%)	14.68	0.12
SDS-sedimentation (ml)	45.2	1.11
Particle size index (%)	14.76	0.21
Milling yield (%)	69.62	0.42
Semolina		
Gluten strength (N)	1.249	0.08
Dark Specks (per 250 cm^2)	46.2	5.90
Farinograph mix time (min)	5.75	0.29
Spaghetti		
Pigment loss (%)	30.88	2.50
Purity (%)	62.30	0.40
Brightness (%)	41.16	0.13
Dominant wavelength (nm)	578.21	0.11
Cooking score (sec/mm × 10^{-3})	15.10	1.85

Wheat and Semolina

Ash and yellow pigment contents were determined as described by Dexter and Matsuo (1978). Protein contents were determined by the Kjeldahl method (N × 5.7) as modified by Williams (1973). The sodium dodecyl sulfate (SDS)-sedimentation test of Axford et al (1979) was used as one measure of gluten strength. Where differences were noted in the SDS-sedimentation test, the gluten breaking strength test of Matsuo (1978) was performed on semolina wet gluten. Kernel hardness was estimated in a KT 34 grinder (Falling Number AB) by the particle size index (PSI) test of Symes (1965) as modified by Williams and Thompson (1978).

Wheat samples (at least 500 g) were milled in a three-stand Allis-Chalmers laboratory mill as described by Matsuo and Dexter (1980a). This milling process yields granulars (semolina and first clear flour), but for simplicity the product will be referred to as semolina unless otherwise specified. Speckiness was measured by pouring semolina between two sealed glass plates and counting the number of dark specks in a 250-cm^2 area. The definition of dark specks was somewhat subjective. Light bran specks that would not be conspicuous in the spaghetti were not counted. Semolina particle size distribution was determined as described by Matsuo and Dexter (1980a). Farinograms were obtained at 31.5% absorption in a 50-g bowl using the rear (1:5) sensitivity setting (Irvine et al 1961).

Spaghetti

Spaghetti samples were processed by a micro-macaroni method (Matsuo et al 1972). Spaghetti color was determined on whole strands of spaghetti in a Beckman Color DB-G spectrophotometer (Dexter and Matsuo 1977b), using the Ten Selected Ordinates method (Hardy 1936).

Spaghetti was cooked as described previously (Dexter and Matsuo 1977a), and cooking quality was determined on the Grain Research Laboratory spaghetti tenderness apparatus (Matsuo and Irvine 1969, 1971) at optimal time (12 min) and after overcooking for 10 min. The firmness indicator (tenderness index) and the elasticity indicators (compressibility and recovery) were combined into a cooking score by taking the ratio of recovery to the product of compressibility and tenderness index. Elasticity of overcooked spaghetti was derived using a lighter compression weight than for optimally cooked spaghetti because many of the overcooked samples were completely compressed and exhibited no recovery under the heavier weight. Therefore, although all spaghetti samples became less elastic and softer when overcooked, overcooking scores often were comparable to or greater than scores for spaghetti cooked to optimal time.

Precision of Analytical Methods

Results for test weight, ash, milling yield, and spaghetti color

TABLE III
Effect of Starchy Kernels on Durum Wheat Quality

Sample	Grade[a]	Starchy Kernels (%)	Protein[b] (%)	SDS-Sedimentation Test (ml)	Particle Size Index (%)	Milling Yield[c] (%)
Starchy enriched	3 CW	56	10.5	24.0	9.4	68.7
Control I	2 CW	33	11.1	25.5	8.7	66.4
Vitreous enriched	1 CW	5	11.5	27.0	7.6	70.9
Starchy enriched	2 CW	39	12.5	29.8	8.8	70.0
Control II	2 CW	28	12.8	32.0	8.8	67.9
Vitreous enriched	2 CW	16	12.8	32.0	8.1	67.3
Starchy enriched	2 CW	40	11.5	24.8	9.3	70.0
Control III	2 CW	24	11.9	27.3	9.0	69.2
Vitreous enriched	1 CW	8	12.5	30.5	8.4	69.7
Starchy enriched	3 CW	55	10.5	22.0	10.4	69.7
Control IV	3 CW	32	11.2	24.5	9.0	67.9
Vitreous enriched	2 CW	24	11.4	26.3	8.3	69.3

[a] CW = Canada Western.
[b] Computed as N × 5.7 on a 14% moisture basis.
[c] Includes semolina and clear flour.

were based on single tests. All other tests were performed at least twice for each sample. Table II lists all the analytical tests employed in the current study and the precision of each test based on 10 single determinations of a representative sample.

RESULTS AND DISCUSSION

Starchy Kernels

Four series of three samples each were prepared to study the effect of starchy kernels on durum wheat (Table III), semolina (Table IV), and spaghetti (Table V). Variations in grade within a series (Table III) were entirely the result of differences in hard vitreous (nonstarchy) kernel contents. In agreement with previous studies on hard red winter (Pomeranz et al 1976) and durum wheat (Matsuo and Dexter 1980b), protein content increased with increased vitreousness in each series. Whereas the 1979 Canadian durum wheat crop averaged well over 13% protein (Canadian Grain Commission 1979), the four vitreous enriched samples from the current study averaged only about 12% protein. Thus, even the fully vitreous kernels within the starchy samples were apparently lower than average in protein.

The SDS-sedimentation test, which is an excellent indicator of gluten strength for durum wheat (Dexter et al 1980), increased with increased vitreousness (Table III). However, when the gluten breaking strength test was performed on semolina wet gluten, results indicated that vitreousness had no effect on gluten strength (Table IV). The effect of vitreousness on the SDS-sedimentation test probably was at least partly due to the effect of vitreousness on kernel hardness. The PSI test demonstrated a definite increase in kernel hardness as vitreousness increased (Table III). Further confirmation of this trend was obtained from a hand-picked 100% starchy sample (results not shown) that yielded a PSI of 14%, compared to the normal range of 7–8% for a fully vitreous durum wheat sample.

Wheat ash, test weight, and kernel weight were unaffected by starchiness (results not shown). Yield of granulars from durum wheat has been shown to be influenced mainly by test weight and kernel weight (Irvine 1964). This explains why milling yield in the current study was not affected by vitreous kernel content (Table III). However, particle size distribution showed that the more vitreous samples yielded a milled product with a greater percentage of very coarse particles and less flour than did the more starchy samples (Table IV). These results, which were in agreement with those of Bolling and Zwingelberg (1972), presumably reflected the observed variations in kernel hardness (Table III). Because the more starchy samples generated more flour during milling, they tended to yield less flour-free semolina (Table IV). The only exception was the second series of samples, in which the range in vitreousness and wheat protein was quite narrow (Table III).

Menger (1973) previously had reported that semolina from

TABLE IV
Effect of Starchy Kernels on Semolina Quality

Sample	Particle Size Distribution (percent held on U.S. sieve No.) 40	60	80	100	Throughs	Semolina Yield[a] (%)	Protein[b] (%)	Farinograph Mix Time[c] (min)	Dark Specks (per 250 cm^2)	Ash[b] (%)	Gluten Breaking Strength (N)
Starchy enriched	8.8	59.8	14.9	3.8	12.7	59.9	9.8	9	27	0.66	0.94
Control I	12.1	59.8	13.5	3.6	11.0	59.8	10.3	7	31	0.69	0.99
Vitreous enriched	13.7	60.7	13.3	3.3	9.0	64.6	10.9	7	25	0.67	0.88
Starchy enriched	11.8	60.4	13.4	3.7	10.6	62.6	11.6	6	45	0.70	0.88
Control II	13.5	59.9	14.0	3.6	9.1	61.7	11.9	6.5	46	0.68	1.01
Vitreous enriched	14.6	59.5	13.7	3.3	8.8	61.4	12.1	6	45	0.68	0.96
Starchy enriched	11.5	59.5	13.8	3.9	11.3	62.1	10.8	7	26	0.66	0.74
Control III	12.8	60.2	13.4	3.7	10.0	62.3	11.2	6	22	0.64	0.71
Vitreous enriched	12.2	61.0	13.9	3.5	9.3	63.2	11.4	5	29	0.66	0.79
Starchy enriched	10.3	59.3	14.4	3.8	12.2	61.2	9.6	7	35	0.68	1.11
Control IV	10.8	59.9	14.4	3.7	11.2	60.3	10.2	7	31	0.68	0.96
Vitreous enriched	12.8	61.2	13.5	3.5	9.0	63.1	10.7	6.5	37	0.70	0.92

[a] Includes only material held on U.S. No. 100 sieve.
[b] 14% moisture basis.
[c] Performed at 31.5% absorption.

TABLE V
Effect of Starchy Kernels on Spaghetti Quality

Sample	Color: Brightness (%)	Purity (%)	DWL[a] (nm)	Pigment Loss (%)	Cooking Score[b]	Overcooking Score[b]
Starchy enriched	47.4	57.9	577.6	30.6	5.8	4.6
Control I	47.8	59.5	577.4	26.8	4.3	7.7
Vitreous enriched	47.4	59.8	577.4	29.0	6.1	13.8
Starchy enriched	45.9	58.5	577.7	31.4	8.4	7.7
Control II	46.8	59.2	577.6	24.4	8.4	8.0
Vitreous enriched	46.4	59.9	577.5	21.3	10.0	14.1
Starchy enriched	47.1	57.4	577.6	30.8	6.3	8.4
Control III	47.6	58.5	577.6	25.8	7.6	8.9
Vitreous enriched	46.6	57.7	577.6	27.7	7.5	10.2
Starchy enriched	48.9	58.0	577.3	28.0	3.9	6.0
Control IV	49.2	59.3	577.3	24.6	6.2	8.3
Vitreous enriched	47.5	59.8	577.5	23.8	8.2	12.4

[a] Dominant wavelength.
[b] Computed as recovery/compressibility × tenderness index.

starchy durum wheat was lower in protein and exhibited a somewhat slower hydration rate than did semolina from vitreous durum wheats. In agreement with her data, results from the current study revealed a slight decrease in semolina protein with increased starchiness for all four series of samples (Table IV). The farinograph mixing time appeared to decrease with increased vitreousness, although the effect was not noted for one series of samples and was barely detectable for another (Table IV). Had the protein range been greater, the effect on farinograph mixing properties probably would have been more noticeable (Dexter and Matsuo 1977a). The slight difference in semolina granulation within each series might have a slight effect on semolina hydration rate.

No relationship between vitreousness and either semolina speckiness or semolina ash was apparent (Table IV). Previously we showed that spaghetti brightness, a measure of the degree of surface dullness, and spaghetti dominant wavelength (DWL), a measure of color hue, were directly related to semolina ash (Matsuo and Dexter 1980a). Therefore, the absence of a relationship between vitreous kernel content and either spaghetti brightness or DWL was expected (Table V). Purity, a measure of spaghetti yellow pigment, increased slightly as vitreousness increased (Table V). This appeared to be related to a tendency for the more vitreous samples to show less pigment loss during processing (Table V). In view of the greater fineness of the semolina produced from the more starchy samples in this study (Table IV), these data appeared to corroborate Menger's (1973) observation that pigment stability during spaghetti processing was reduced when semolina became finer.

For all four series of samples, cooking quality improved significantly with increased vitreousness (Table V). This was especially true when spaghetti was overcooked and was a result of the higher protein content of the semolina produced from the more vitreous samples (Dexter and Matsuo 1977a).

Immaturity

Four sets of samples, each representing a control and a sample enriched in immature and grass green kernels, were prepared to study the effect of various degrees of immaturity on durum wheat quality (Table VI). Because frost damage is often associated with immaturity, we also prepared a frozen green sample and a control. For the frozen green sample, 65% of the kernels exhibited some degree of frost damage (wrinkling of the bran) and 10% of the kernels exhibited the grayish tinge characteristic of frozen immature kernels. For the other four enriched samples, the percentage of grass green kernels present was quantitated (Table VI), and the remaining kernels were judged subjectively to be either immature (fully formed kernels having a slight pink tinge) or green (fairly well-formed kernels with some hint of greenness).

A previous report has shown that immaturity and frosted kernels cause a decrease in test weight and milling quality of Canadian hard red spring wheat (Malloch et al 1937). In another investigation,

TABLE VI
Effect of Immaturity on Durum Wheat Quality

Sample	Grade[a]	Kernels (%) Green	Kernels (%) Frozen	Kernels (%) Hard Vitreous	Test Weight (g)	1,000-Kernel Weight (g)	Protein[b] (%)	Ash[b] (%)	Particle Size Index (%)	Milling Yield[c] (%)
Control I	1 CW	0	···	93	82.3	42.4	13.7	1.57	7.8	68.0
Immature I	2 CW	2.0	···	90	82.0	40.3	14.0	1.58	7.8	68.9
Control II	1 CW	0	···	91	82.9	42.5	13.8	1.55	7.5	67.4
Immature II	2 CW	1.5	···	89	82.2	41.7	14.0	1.56	7.3	67.5
Control III	1 CW	0	···	87	83.2	43.2	13.9	1.53	7.8	68.5
Green III	3 CW	3.3	···	85	82.9	42.6	13.7	1.53	8.0	68.6
Control IV	2 CW	0	···	92	83.0	43.0	13.4	1.51	8.2	68.4
Green IV	4 CW	6.1	···	86	82.2	43.4	13.3	1.52	8.4	69.0
Control V	1 CW	0	0	97	84.1	43.6	14.7	1.54	7.8	68.6
Frozen Green V	3 CW	10	65	88	81.3	45.7	15.0	1.61	7.2	66.7

[a] CW = Canada Western.
[b] 14% moisture basis.
[c] Includes semolina and clear flour.

TABLE VII
Effect of Immaturity on Semolina and Spaghetti Quality

Sample	Semolina Protein[a] (%)	Semolina Ash[a] (%)	Dark Specks (per 250 cm^2)	Spaghetti Color Brightness (%)	Spaghetti Color Purity (%)	Spaghetti Color DWL[b] (nm)	Cooking Score[c]	Overcooking Score[c]
Control I	12.9	0.70	76	45.1	61.1	578.0	13.6	15.6
Immature I	13.0	0.75	75	43.3	60.1	578.4	14.3	13.2
Control II	13.2	0.69	41	46.3	61.7	577.9	14.0	16.0
Immature II	13.2	0.71	48	45.6	61.2	578.0	11.4	10.8
Control III	12.9	0.71	64	45.1	58.9	577.9	11.6	11.4
Green III	12.9	0.73	69	44.8	59.1	578.0	13.7	12.9
Control IV	12.3	0.68	47	45.6	57.9	577.8	8.5	10.9
Green IV	12.4	0.71	50	45.2	57.1	578.1	10.9	11.0
Control V	13.0	0.68	66	45.2	59.4	577.9	14.0	13.7
Frozen Green V	14.0	0.73	98	43.4	58.2	578.1	16.7	14.4

[a] 14% moisture basis.
[b] Dominant wavelength.
[c] Computed as recovery/compressibility × tenderness index.

samples of durum wheat (cv. Mindum) harvested at four different dates showed increases in protein content, test weight, and macaroni color with increased maturity (Harris et al 1943). In the current study, all the immature samples possessed slightly lower test weights than those of their respective controls. However, only the frozen green sample exhibited evidence of decreased milling yield. No definite trend could be established between immaturity and kernel weight. Although grass green kernels were considered nonvitreous, kernel hardness, as measured by PSI, was unaffected by immaturity. In fact, a hand-picked 100% grass-green sample yielded a PSI of 8.8% (results not shown), which was indicative of a hard vitreous sample.

Table VII summarizes the major effects of immaturity on semolina and spaghetti quality. Because hardness was unaltered by immaturity, no effect was noted on semolina granulation or the proportion of flour generated during milling. In all cases, the immature samples gave values for the SDS-sedimentation test identical to those of their respective controls, indicating that gluten properties also were not affected. Only in the case of the frozen green semolina was a significant difference in protein found between immature samples and their respective controls (Table VII). In view of these results, we were not surprised to find that in all cases, including the frozen green sample, no differences attributable to immaturity could be detected in farinograph mixing properties (results not shown).

The frozen green semolina was considerably speckier than the control because of the grayish hue of frozen green kernels (Table VII). The other immature samples showed no evidence of increased semolina speckiness (Table VII). Except for that of the frozen green sample, wheat ash was little affected (Table VI). However, in all cases, the controls yielded semolina ash slightly lower (Table VII) than that of their respective immature samples. This accounted for the lower brightness values (increased dullness) and longer DWL (increased brownness) of the spaghetti produced from the immature samples (Table VII). However, all differences noted in spaghetti color were very slight.

No significant differences were noted in either semolina pigment levels or pigment loss during processing between the controls and immature samples. However, spaghetti purity values (Table VII) demonstrated that, in all but one case, slightly less spaghetti pigment was present in the immature samples than in the controls.

Cooking quality data (Table VII) suggested that immaturity had very little effect on the texture of cooked spaghetti either at optimal time or after overcooking. This was not surprising in view of the absence of any effect on gluten properties due to immaturity. Similarly, Malloch et al (1937) found that hard red spring wheat baking quality was not related to immaturity or frost.

Shrunken Kernels

Results of preliminary investigations into the effect of shrunken kernels on durum wheat properties and milling quality are summarized in Table VIII. No effect on quality was noticed until the proportion of shrunken kernels exceeded 4%. Thereafter kernel weight and test weight were reduced. This caused the expected

TABLE VIII
Effect of Shrunken Kernels on Durum Wheat Properties and Milling Quality

Sample	Grade[a]	Shrunken Kernels (%)	Test Weight (kg/hl)	1,000-Kernel Weight (g)	Wheat Protein[b] (%)	Wheat Ash[b] (%)	Milling Yield[c] (%)	Semolina Protein[b] (%)	Semolina Ash[b] (%)	Semolina Yellow Pigment[b] (ppm)
Shrunken										
I A	1 CW	0	85.5	47.1	10.7	1.38	70.3	9.6	0.65	6.92
I B	1 CW	0.75	85.2	44.9	10.9	1.44	69.1	9.7	0.64	6.92
I C	1 CW	2.0	85.2	44.7	10.6	1.39	68.4	9.7	0.64	7.03
Control I	1 CW	3.0	85.0	44.3	10.7	1.38	68.4	9.7	0.64	7.04
Shrunken										
I D	1 CW	4.0	85.0	43.7	10.7	1.43	69.6	9.7	0.66	7.17
I E	2 CW	10.0	83.9	40.8	11.0	1.48	67.9	9.7	0.68	7.32
I F	4 CW	20.0	81.9	37.3	11.1	1.50	65.1	9.7	0.69	7.27

[a] CW = Canada Western.
[b] 14% moisture basis.
[c] Includes semolina and clear flour.

TABLE IX
Effect of Shrunken Kernels on Durum Wheat, Semolina, and Spaghetti Quality

Sample	Grade[a]	Shrunken Kernels (%)	Test Weight (kg/hl)	Milling Yield[b] (%)	Semolina Protein[c] (%)	Semolina Ash[c] (%)	Dark Specks (per 250 cm^2)	Pigment Loss (%)	Brightness (%)	Purity (%)	DWL[d] (nm)	Cooking Score[e]	Over-cooking Score[e]
Shrunken													
II A	1 CW	0	82.7	68.6	13.0	0.73	59	17.9	43.3	64.1	578.1	20.3	25.3
II B	1 CW	0.5	82.5	68.5	13.2	0.74	65	19.5	43.0	63.3	578.3	21.1	24.5
Control II	1 CW	3.0	82.0	68.5	13.3	0.73	60	17.5	43.0	63.2	578.0	16.9	23.9
Shrunken													
II C	2 CW	6.0	81.4	67.6	13.2	0.74	75	18.6	43.1	63.3	578.3	19.1	21.9
II D	3 CW	12.0	80.5	67.6	13.4	0.75	74	21.8	43.1	63.3	578.2	19.7	25.4
II E	4 CW	18.0	79.0	66.3	13.3	0.76	89	24.0	42.7	62.2	578.5	16.4	18.7
III A	3 CW	7.0	79.5	67.3	12.0	0.69	109	19.4	43.2	61.4	578.3	10.0	21.3
Control III	4 CW	14.0	78.6	66.2	11.9	0.71	117	20.7	42.5	61.0	578.5	11.2	17.7
Shrunken													
III B	4 CW	28.0	76.5	65.5	12.3	0.72	120	22.3	42.5	60.8	578.5	10.3	17.4
III C	5 CW	35.0	73.7	64.1	12.3	0.73	127	21.4	42.7	60.9	579.0	11.4	12.3

[a] CW = Canada Western.
[b] Includes semolina and clear flour.
[c] 14% moisture basis.
[d] Dominant wavelength.
[e] Computed as recovery/compressibility × tenderness index.

decrease (Irvine 1964) in milling yield. At levels of shrunken kernels above 4%, wheat ash also increased somewhat, resulting in higher semolina ash. Semolina granulation and farinograph properties were unaffected (results not shown). Wheat protein appeared to increase slightly with greater amounts of shrunken kernels, but semolina protein remained constant (Table VIII).

Unfortunately the very low protein associated with this series of samples made them poorly suited for the preparation of good spaghetti. Therefore, the effects of shrunken kernels on durum wheat quality, including spaghetti quality, were investigated further with two other series of samples possessing more normal protein levels (Table IX).

Again, test weight and milling yield decreased with increased levels of shrunken kernels, whereas semolina ash increased (Table IX). Semolina speckiness also appeared to increase due to shrunken kernels. As found in the preliminary study, semolina protein, pigment, granulation, and farinograph mixing properties were not affected significantly (results not shown).

When processed into spaghetti, pigment loss appeared to increase with increasing amounts of shrunken kernels (Table IX). This resulted in a slight decrease in spaghetti pigment, as shown by decreased spaghetti purity at high levels of shrunken kernels. Spaghetti brightness also decreased slightly as a result of the higher semolina ash associated with shrunken kernels. However, the most noticeable effect on spaghetti color was a pronounced shift in DWL for the most shrunken samples, characteristic of an undesirable brownish hue.

When cooked to optimum cooking time, spaghetti cooking quality was not affected by shrunken kernels for either series of samples. However, when overcooked, a definite tendency towards poorer cooking quality was found with higher levels of shrunken kernels in each series.

SUMMARY

Results of the current study demonstrated that starchy kernels, immaturity, and shrunken kernels were all detrimental to end-use quality. The fairly subtle nature of the quality differences noted in some cases probably was because each degrading factor was considered alone. Under normal circumstances, several degrading factors would be present at once, each contributing to quality deterioration. The grades given to the samples in the current study by the Grain Inspection Division proved to be an accurate prediction of the relative quality of the samples.

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