Influence of Environment on Canadian Hard White Spring Wheat Noodle Quality

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Wheat-based noodles account for 30–40% of the cereal diet in most Asian countries, second only to rice dishes (9). As such, the Asian market is a cornerstone for countries that export wheat, such as the United States, Canada, and Australia. Hard white wheat is suitable for a wide variety of products, ranging from pan breads (7) to hamburger buns (17), steamed breads (14), and noodles (16), and it continues to gain importance in the international marketplace. The flour color advantage associated with a white seed coat compared with a red seed coat provides strong technological and economic impetus for its use worldwide. The hard white wheat seed coat offers millers the quality attributes associated with premium hard red wheat while maintaining flour and end-product color at extraction rates 6% higher than corresponding red wheat (2,3). Research by Hatcher and Symons (11,12) has demonstrated that noodles prepared from white wheat offer a significant advantage in noodle appearance over red wheat due to the presence of fewer specks that are not as dark as for red wheat.

There are two major noodle types: yellow alkaline noodles (YAN) and white salted noodles (WSN). Various subtypes are manufactured to suit national and regional preferences (9). YAN, which require high protein (11.5–14.5%) and good quality gluten, are an ideal match for Canadian hard wheat. YAN are prepared from flour, water, and alkaline salts. The presence of alkaline ingredients toughens the noodles, resulting in a firmer texture when cooked and imparts a distinctive yellow coloration.

Sodium and potassium carbonates (1–3%, w/w) are used in most areas, with the ratio of these salts adjusted to meet local consumer preferences. Sodium hydroxide, however, is commonly used in Singapore and throughout Malaysia as an alternative. Depending on the region, manufacturers may also include up to 1% NaCl in the formulation. The choice of flour quality parameters, such as protein content and degree of refinement (ash content and color), influence the quality of noodles and are instrumental in the selection of wheat to tailor the product to achieve the attributes desired within a region. Discoloration due to phenolic compounds modified by endogenous enzymes such as polyphenol oxidase or peroxidase, in combination with autooxidization, seriously decreases consumer acceptance (4,10,18,22).

The Asian marketplace accounts for >50% of Canada's wheat exports and is vitally important to the success of any new Canadian wheat class. Canada has successfully overcome the initial problem associated with white wheat, which was susceptibility to premature sprouting, by developing sprout-resistant hard white wheat lines. Currently, Canada has two registered Canada Western Hard White Spring (CWHWS) lines, AC Snowbird and AC Kanata, which are double-haploid lines developed from the cross between the white derivative of RL4137 and AC Domain hard red spring wheat. The objective of this study was to evaluate and compare YAN quality derived from new CWHWS varieties with those derived from Canada Western Red Spring (CWRS) varieties grown in different soil types at four locations across western Canada for three years.

MATERIALS AND METHODS

Wheat

Hard white spring wheat varieties AC Snowbird and AC Kanata and the breeding line BW275, plus CWRS varieties AC Barrie (the most widely grown CWRS variety at the time of this study) and AC Domain (a parent of the white varieties), were grown in Saskatchewan in field plots in Indian Head, Melfort, Swift Current, and Kernen in 1999, 2000, and 2001. BW275, while meeting the quality requirements of the class, was not registered as a variety due to slightly poorer agronomic performance. Two plots for each variety were grown at each site. Melfort is located in a black soil zone, Kernen is located in a dark brown soil zone, and Melfort and Swift Current are located in brown soil zones. Due to variable growing conditions such as drought and disease, not all sites were available each year, but a minimum of three sites per year were included in the study.

Flour

Wheat from each individual plot was milled following a random design on a GRL tandem Buhler mill. A 60% extraction patent flour was prepared as in Martin and Dexter (19). Flour protein content (% N × 5.7) was determined by combustion nitrogen analysis using a CNA analyzer (model FP-248, Dumas Leco Corp., St. Joseph, MI) calibrated with EDTA; flour ash was determined by AACC International Approved Method 08-01 (1). Both are expressed on a 14% mb. Flour-grade color was measured using a color grader (Series IV, Satake UK, Stockport, United Kingdom) expressed in Satake units (8).

Noodles

YAN were prepared from flour from each individual plot in a randomized manner as in Kruger and coworkers (15). Flour (200 g) was mixed for 5.5 min in a Hobart mixer with an alkaline salt solution consisting of sodium and potassium carbonates (9:1) to yield a 1%, w/w, salt concentration on a flour weight basis corrected to 14% mb at a final water absorption level of 32%. Noodles were prepared on a noodle machine (Ohtake, Tokyo, Japan) in a temperature (24°C) and relative humidity (50%) controlled room with the roll sheets maintained at 28°C. The gap setting for the initial pass through the rolls was 3 mm to convert the dough crumb into a coarse, thick sheet. The sheet was subsequently folded in half and passed a second time through the 3-mm gap to simulate the commercial

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Table I. Flour protein, ash, and grade color values by year and variety across sites

Year	Variety	Flour Protein (%) Mean	Flour Protein (%) SD	Flour Ash (%) Mean	Flour Ash (%) SD	Flour-Grade Color[a] Mean	Flour-Grade Color[a] SD
1999	AC Barrie	13.12	1.01	0.35	0.02	–3.26	0.58
	AC Domain	13.60	1.10	0.36	0.02	–2.83	0.89
	AC Kanata	13.52	0.85	0.36	0.02	–2.64	0.89
	AC Snowbird	13.02	1.07	0.35	0.02	–3.48	0.78
	BW275	13.60	1.65	0.36	0.03	–3.24	0.96
2000	AC Barrie	13.53	1.70	0.39	0.04	–3.37	0.20
	AC Domain	14.12	1.72	0.38	0.03	–3.01	0.39
	AC Kanata	13.77	1.82	0.38	0.02	–3.00	0.57
	AC Snowbird	13.40	1.74	0.37	0.03	–3.43	0.56
	BW275	14.10	1.97	0.38	0.04	–3.25	0.64
2001	AC Barrie	14.43	0.27	0.37	0.04	–3.36	0.07
	AC Domain	14.51	0.57	0.38	0.04	–3.03	0.18
	AC Kanata	14.33	0.78	0.38	0.05	–2.89	0.11
	AC Snowbird	13.85	0.53	0.37	0.03	–3.72	0.21
	BW275	14.68	0.62	0.37	0.03	–3.34	0.21

[a] Satake units.

lamination process. The dough sheet was further reduced through seven reduction passes, the last of which had a gap setting of 1.1 mm. The final noodle sheet was cut into two pieces: one piece was used for color and image analyses, and the other was passed through the cutting rolls to yield noodles. Noodles were prepared in duplicate from each flour in a completely randomized design that incorporate year, variety, plot, and site data.

Color analyses were performed at 2 and 24 hr after preparation; the dough sheet was stored in a sealed container at 25°C between measurements (11). Raw noodle color was measured with a spectrocolorimeter (LabScan II, HunterLab, Reston, VA) equipped with a D65 illuminant, using the CIE 1976 L^*, a^*, and b^* color scale as in Kruger and coworkers (15). Measurements were taken in triplicate on at least two different sites on the noodle sheet, and the results were averaged.

Images of raw noodles (5 cm × 5 cm) were captured at 1, 2, and 24 hr after preparation using a flat-bed scanner (model Scanmaker 4700, Microtek, Redondo Beach, CA) set at 800 dpi as in Hatcher and coworkers (13). Individual images were analyzed by software developed in-house based on KS400 software (Carl Zeiss Vision, Hallbergmoos, Germany) using a minimum speck size of 7,000 μm^2 and a detection threshold limit (delta gray) of 5 units (11).

Raw noodles were optimally cooked, with optimum being defined as the point at which the central core disappeared when crushed between two transparent plates. Five individual noodles, selected at 1-min cooking intervals, were placed between two sheets of glass and crushed. Optimum cook was achieved when at least four of the five noodles no longer displayed a central core. Cooked noodles were immersed in a continuous stream of distilled water (20°C) for 1 min, shaken dry, and stored in a sealed plastic container. Individual testing protocols, consisting of maximum cutting stress (MCS), compression recovery (REC), re-

Table II. ANOVA *F* values of raw noodle color and appearance across sites for 1999–2001[a]

Variable	DF[b]	Brightness (L^*) 2 hr	Brightness (L^*) 24 hr	Redness (a^*) 2 hr	Redness (a^*) 24 hr	Yellowness (b^*) 2 hr	Yellowness (b^*) 24 hr
Year (Y)	2	16.8***	2.0	17.9***	56.5***	47.9***	127.8***
Location (L)	2	41.9***	34.5***	143.3***	293.3***	180.9***	241.3***
Y × L	4	77.8***	47.6***	87.4***	80.6***	43.1***	58.4***
Variety (V)	12	11.7***	21.0***	59.2***	56.2***	12.0***	25.8***
Y × V(L)	24	2.7**	2.4**	3.1***	3.43***	1.72*	2.6**

[a] *, **, and *** indicate values are significant at $P = 0.05$, 0.0010, and 0.0001, respectively.
[b] Degrees of freedom.

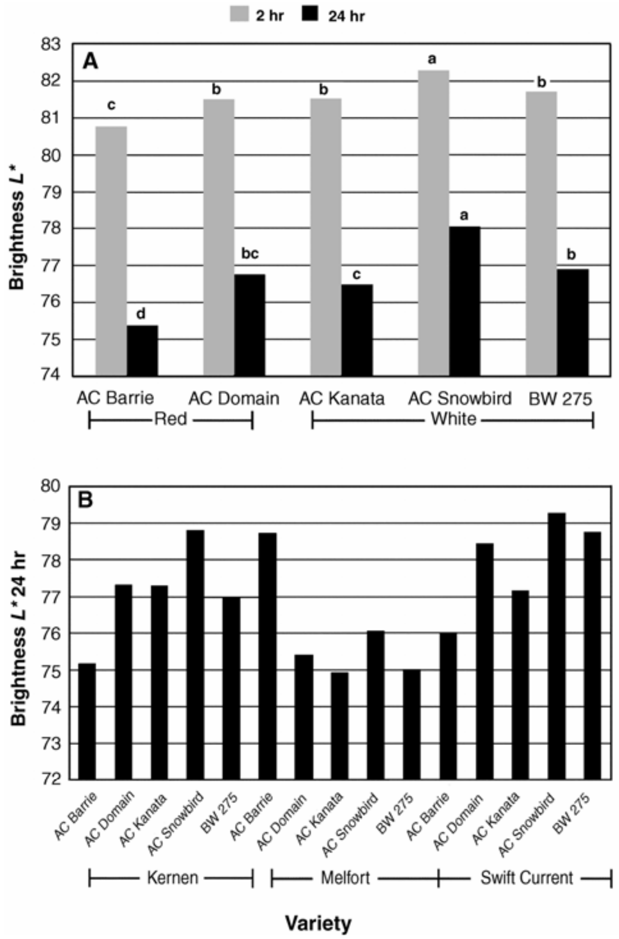

Fig. 1. A, Mean values for noodle brightness (L^*) across sites and years at 2 and 24 hr after production. **B,** Mean values for noodle brightness 24 hr after production by variety and site for 1999.

sistance to compression (RTC), and texture profile analyses (TPA), were performed at 10, 15, and 20 min after optimum cooking time, respectively. The methods employed were derivatives of Oh and coworkers (21), as modified by Kruger and coworkers (15) and Bourne (6).

Statistical Design

Varieties were grown in duplicate plots at each site using a randomized design and milled following a random selection process that encompassed all three sites for a given year. Noodles were prepared in duplicate from flour from each plot using a randomized design. Statistical analysis software was used to calculate ANOVA using Proc GLM and Proc Mixed programs (version 8.2, SAS Institute, Cary, NC) in which varieties were nested within location. Significance was defined as $P = 0.05$ unless otherwise noted.

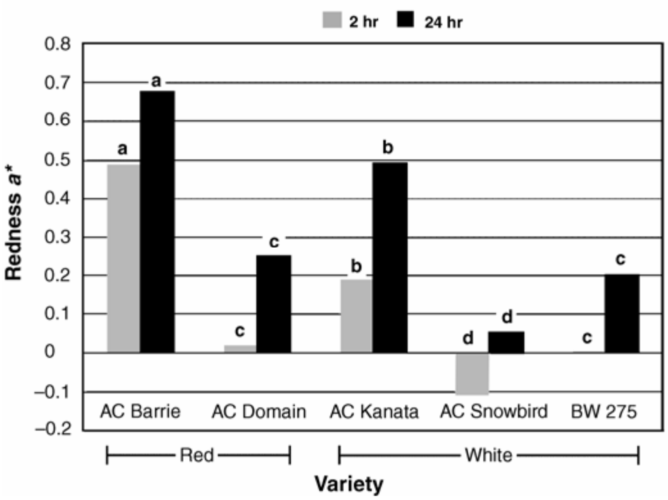

Fig. 2. Mean values for noodle redness (a^*) across sites and years at 2 and 24 hr after production.

RESULTS AND DISCUSSION

Analyses of the flour samples (Table I) indicated a wide range of protein content at 11.2–16.0%. Significant differences ($P < 0.0001$) were noted: AC Snowbird generally displayed the lowest protein content across all sites and years (13.2%), while BW275 displayed the highest (14.2%). Variation in flour ash content was 0.33–0.44%, yet there was no significant difference ($P > 0.05$) in mean ash content averaged across all sites and years. A wide variation in flour-grade color was observed, with values ranging from –1.65 to –4.22. Examination of ANOVA data (not shown) indicated that year and site were each highly significant factors ($P = 0.0001$) influencing protein, flour-grade color, and ash content. However, while variety significantly affected protein content and flour-grade color, it did not influence flour ash content ($P = 0.658$). The year–location interaction term was significant ($P < 0.001$) in influencing protein and ash contents, but it was not significant for flour-grade color. As reported previously for CWRS wheat (23), flour protein content and color were significantly correlated ($r = 0.53$, $P = 0.0001$). Ash content and flour color were not significantly correlated ($P = 0.54$) in this study, supporting the suggestion of Barnes (5) that the negative impact of protein content on flour brightness is due to lower starch content rather than bran contamination.

Raw Noodle Color

ANOVA results (Table II) indicated that the main effects (variety, year, and location), with one exception (L^* at 24 hr), as well as the various interaction terms, significantly influenced the color components (L^*, brightness; a^*, redness; and b^*, yellowness) of the raw noodles at both 2 and 24 hr.

Raw noodle brightness (L^*) is the key criteria by which consumers initially assess the quality of a product. The L^* values recorded at 2 hr after production for the different varieties across sites and years are summarized in Fig. 1A. The CWHWS variety AC Snowbird displayed significantly higher L^* values than all other varieties, while the agronomically popular CWRS variety AC Barrie displayed significantly lower brightness than the other varieties. The higher L^* values for AC Snowbird were consistent with its generally lower protein content compared with the other varieties. It was interesting that the CWRS parent to the white lines, AC Domain, displayed an L^* value equivalent to those of both AC Kanata and BW275.

Noodle manufacturers who do not sell their daily production within a single day normally combine material from the previous day's production with the current day's material to minimize waste. As such, retention of noodle brightness for 24 hr is an important flour and noodle quality assessment tool. Examination of the summarized data for L^* after 24 hr of storage (Fig. 1A) indicated that CWHWS variety AC Snowbird remained significantly brighter than all other varieties. Consistent with observations at 2 hr, CWRS variety AC Domain retained an L^* value equivalent to those of both AC Kanata and BW275, while AC Barrie displayed a significantly lower L^* value than all other varieties after 24 hr.

The significant influence of variety, year, and location is shown in Fig. 1B, which characterizes the wide range of L^* values across sites and varieties for 1999. AC Barrie, while having the lowest L^* values at Kernen and Swift Current in 1999, had the highest L^* value at Melfort, equivalent to that of AC Snowbird at the other two sites. As expected, there were significant negative correlations between L^* values and flour protein content at both 2 and 24 hr (–0.58 and –0.57, respectively), which is consistent with the findings of Miskelly (20). A strong negative correlation also was observed between flour-grade color and L^* at both 2 and 24 hr (–0.78 and –0.71, respectively).

Raw noodle redness (a^*) is indicative of undesirable polymerization products formed by either the action of enzymes, such as polyphenol oxidase, or complexation reactions occurring due to the auto-oxidation of endogenous phenolic compounds. Examination of Fig. 2 indicated that at 2 hr, a significantly lower, and therefore more desirable, a^* value was observed for AC Snowbird, followed by BW275 and AC Domain, which in turn were significantly better than AC Kanata. CWRS variety AC Barrie showed the highest a^* value at 2 hr, significantly higher than all other varieties.

As anticipated, storing the noodles for 24 hr allowed for much greater complexation between labile quinones and proteins within the noodle matrix, yielding much higher a^* values than were observed at 2 hr (Fig. 2). AC Snowbird, however, displayed a minimal increase in a^* values, remaining significantly better than all other varieties. BW275 and CWRS variety AC Domain remained equivalent to each other and displayed significantly lower a^* measurements than both AC Kanata and AC Barrie. AC Barrie continued to show the poorest (highest) a^* value, significantly higher than all other varieties. Analyses indicated that flour-grade color was significantly correlated with a^* values at both 2 and 24 hr (r = 0.64 and 0.69, respectively). No significant relationship was observed between ash content and a^* values for noodles. A significant but low correlation between flour protein content and a^* values at 2 hr ($r = 0.44$, $P = 0.0024$) was observed, whereas the correlation between flour protein content and noodle a^* values at 24 hr was not significant ($P > 0.05$). Examination of individual varieties and sites over the three-year period showed desirable lower a^* values for both AC Snowbird and BW275 (data not shown).

The yellowness (b^*) of alkaline noodles is the result of a chromophoric shift that occurs when endogenous flavonoids, normally colorless at neutral pH, are mixed with an alkaline solution. The summarized data presented in Fig. 3A indicated that varieties AC Snowbird, AC Domain, and AC Barrie, while equivalent, displayed significantly higher b^* values at 2 hr than AC Kanata and BW275.

It was interesting to observe that storing for 24 hr further discriminated b^* differences between the varieties (Fig. 3A). AC Snowbird retained a significantly higher b^* value than AC Domain, which was higher than those for AC Barrie and BW 275. Variety AC Kanata displayed the lowest b^* value, significantly lower than all other varieties. The wide range in b^* values due to the influence of different environments is clearly visible in Fig. 3B, exemplified by an almost 3-unit range between sites for AC Barrie and BW275 in 2000. Weak but significant correlations were detected between b^* values (yellowness) for the raw noodles and protein (r = –0.36 to –0.54) and flour-grade color (r = –0.44 to –0.55) at 2 and 24 hr.

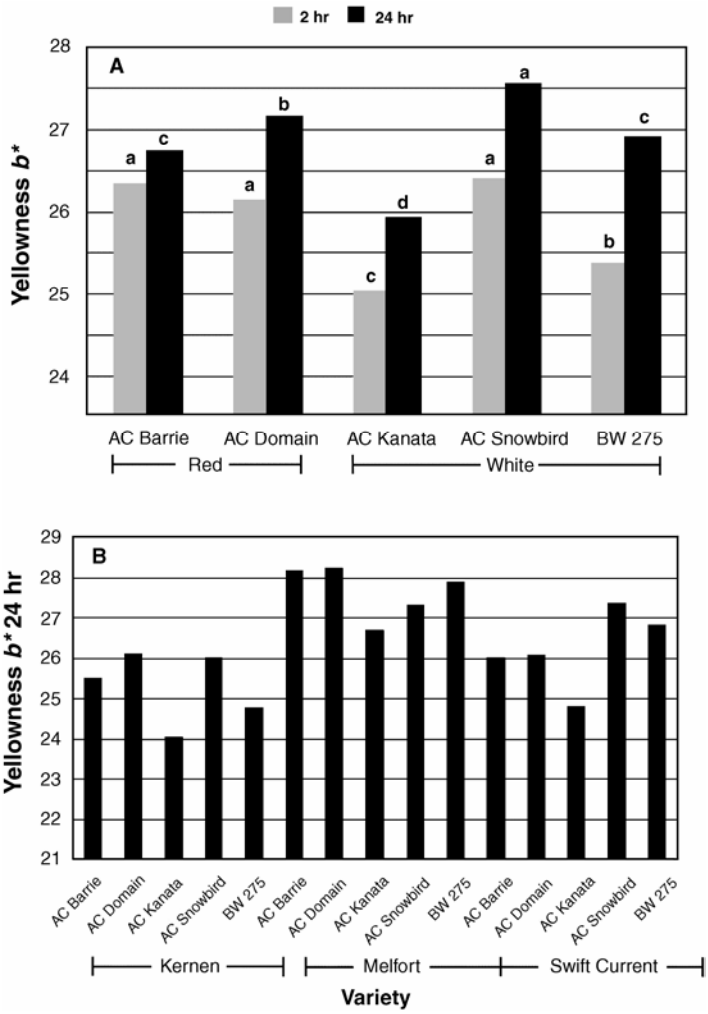

Fig. 3. A, Mean values for noodle yellowness (b^*) across sites and years at 2 and 24 hr after production. **B,** Mean values for noodle yellowness 24 hr after production by variety and site for 2000.

Table III. ANOVA F values for raw noodle speckiness and speck darkness at three time intervals across sites for 1999–2001[a]

		Speckiness			Speck Darkness		
Variable	**DF[b]**	**1 hr**	**2 hr**	**24 hr**	**1 hr**	**2 hr**	**24 hr**
Year (Y)	2	8.3**	14.0***	15.4***	219.6***	183.1***	202.0***
Location (L)	2	4.6*	3.0	33.0***	8.9***	9.63***	20.1***
Y x L	4	4.6*	7.0***	17.7***	107.8***	96.1***	91.7***
Variety (V)	12	196.7***	227.9***	42.5***	23.5***	20.4***	39.3***
Y × V(L)	24	6.0***	6.6***	1.1	5.1***	6.1***	6.1***

[a] *, **, and *** indicate values are significant at P = 0.05, 0.0010, and 0.0001, respectively.

[b] Degrees of freedom.

Although noodle color is an important component of consumer acceptance, noodle speckiness and speck darkness are also invaluable appearance criteria. Colorimeters only offer an average assessment of the entire viewing area and present data as a single mean value. Previous research within our laboratory has highlighted the benefits of detailed image analysis of noodle sheets for discerning meaningful differences in noodle specks (11–13).

ANOVA results (Table III) indicated that both variety and year significantly affected noodle speckiness at the three time periods examined (1, 2, and 24 hr), whereas location was significant at only 1- and 24-hr postproduction. All of the interaction terms were significant for the number of specks for two of the three time periods examined.

Quantifying the number of specks in a 5 cm × 5 cm portion of the noodle sheet at 1-hr postproduction highlighted the benefits of white seed coat wheat over red seed coat wheat (Fig. 4A). CWRS variety AC Barrie displayed the greatest number of specks, significantly higher than AC Domain. Neither CWRS variety approached the significantly lower values displayed by the three white coat varieties. These results confirm previous work in our laboratories that demonstrated that noodles prepared from white wheat were less specky than noodles prepared from red wheat (2).

Table IV. ANOVA *F* values for cooked noodle texture measurements across sites for 1999-2001[a]

Variable	DF[b]	MCS[c] (g/mm^2)	RTC[d]	REC[e]	Chewiness	Springiness
Year (Y)	2	368.8***	51.7***	67.7***	320.5***	525.4***
Location (L)	2	72.2***	1.7	61.4***	1.9	2.5
Y × L	4	290.5***	69.0***	114.5***	80.6***	3.7*
Variety (V)	12	46.7***	11.4***	37.3***	8.8***	2.4*
Y × V(L)	24	10.6***	4.2***	11.3***	4.6***	2.5**

[a] *, **, and *** indicate values are significant at $P = 0.05$, 0.0010, and 0.0001, respectively.

[b] Degrees of freedom.

[c] Maximum cutting stress.

[d] Resistance to compression.

[e] Recovery.

Storing the noodle sheet for an additional 1 hr resulted in a ≈15% increase in the speckiness of both CWRS varieties, with no appreciable change in any of the white varieties (Fig. 4A). Measurement of the number of specks at 24 hr revealed that the number of detectable specks had increased dramatically in all varieties. AC Barrie continued to show a significantly greater number of specks than AC Domain. In turn, AC Domain was significantly more specky than either AC Kanata or BW275, which were equivalent. AC Snowbird, however, displayed a significantly lower number of specks than all other varieties.

Although the number of specks is critical to noodle appearance, speck darkness is also crucial to consumer perception. Small but very dark specks are perceived to be more detrimental to noodle appearance than larger lighter specks. Image analysis offers the ability not only to quantify the number of specks present but to measure darkness intensity.

ANOVA evaluation of mean speck darkness at 1, 2, and 24 hr is shown in Table III. Variety, location, and year exhibited significant influence on speck darkness at each time period. The various interaction terms also exerted a highly significant ($P = 0.0001$) influence on speck darkness.

Examination of specks on the 25-cm^2 noodle sheet at 1-hr postproduction (Fig.

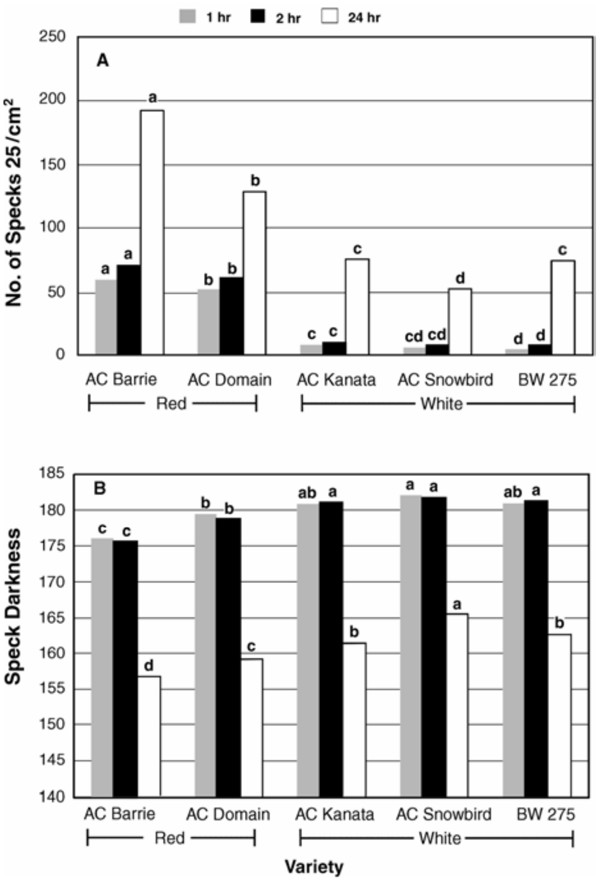

Fig. 4. A, Mean values for noodle speckiness (specks/25 cm^2) across sites and years at 1, 2, and 24 hr after production. **B,** Mean values for noodle speck darkness across sites and years at 1, 2, and 24 hr after production (the lower the value, the darker the speck).

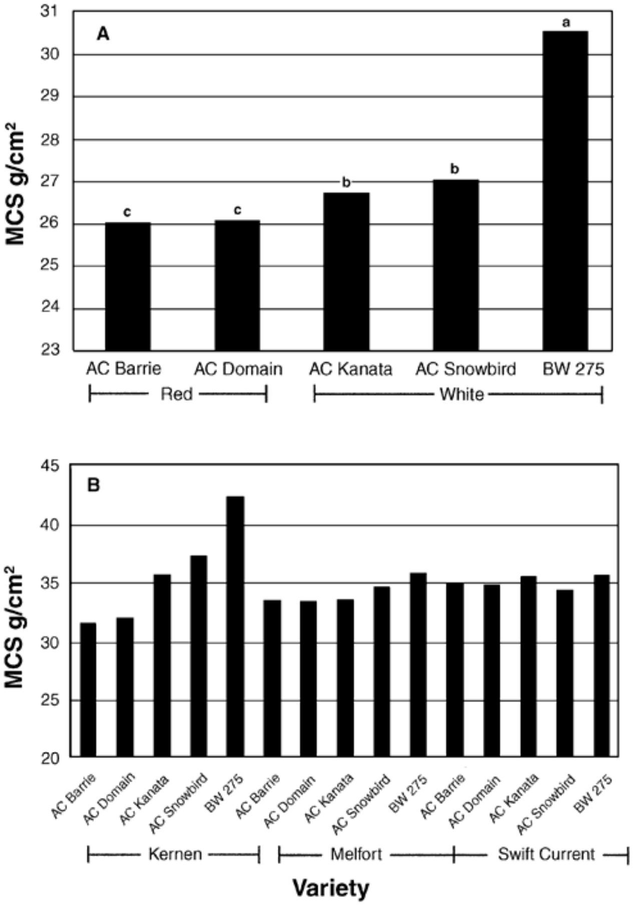

Fig. 5. A, Mean values for cooked noodle bite as determined by maximum cutting stress (MCS) across sites and years. **B,** Mean values for cooked noodle bite by variety and site for 2000.

4B) indicated that CWRS varieties AC Domain and AC Barrie yielded the darkest specks (lowest value); AC Barrie was significantly darker than all other varieties. There was no significant difference in speck darkness for the three white seed coat varieties. This pattern remained consistent with aging for 2 hr, although both AC Barrie and AC Domain were distinct from the white wheats (Fig. 4B). After aging for 24 hr, all specks, regardless of variety, displayed greater darkness intensity than at 1 and 2 hr. The white seed coat varieties all exhibited significantly lighter specks than the red coat varieties. AC Snowbird specks were significantly lighter than either of the two other white varieties.

Cooked Noodle Texture Characteristics

YAN are often consumed steamed, fried, or in hot soups. In many cases the taste of the noodle is masked by a wide variety of condiments. The texture of the noodle however is pivotal to consumer acceptance. High-quality YAN are made from hard wheats with a minimum of 12% protein content to ensure adequate texture attributes. A summary of the influence of environment on noodle texture can be seen in Table IV. Variety and year exerted a significant effect on all texture attributes measured, while location was significant for only two attributes (MCS and REC). The various interaction terms also exhibited a significant effect on all texture attributes.

Noodle bite, as determined by the front teeth, provides the first indication of the texture of the cooked product. This characteristic is objectively measured by the maximum cutting stress (MCS) method of Oh and coworkers (21), in which a 1-mm V-shaped blade cuts through cooked noodle strands. High-quality YAN should demonstrate strong bite characteristics when optimally cooked. Examination of the summary data across sites and years demonstrated that BW275 displayed significantly higher MCS values than the other varieties (Fig. 5A), which was consistent with its generally higher protein content (21). Surprisingly, AC Snowbird displayed the lowest mean protein content, and AC Kanata, with protein content equivalent to the CWRS varieties, exhibited significantly better bite than either of the CWRS varieties. The variability in MCS values across varieties and sites in 2000 (particularly Kernen compared with the others) is evident in Fig. 5B. The dominance of BW275 across sites was evident.

Once cut, mastication involves a two-stage process in which the back molars of the mouth compress and then release the cooked noodle. The two stages of this process are captured objectively by the initial resistance to compression (RTC) and subsequent recovery (REC) measurements of Oh and coworkers (21). A flat blade with a surface 1 cm wide is used to mimic the molar surface. Examination of RTC values (Fig. 6A) indicated there were small but significant differences between varieties. AC Kanata, AC Domain, and BW 275 displayed RTC values that were significantly greater than those exhibited by AC Barrie. AC Snowbird displayed the lowest RTC value and was significantly poorer than AC Barrie.

As the molars come apart, consumers can discriminate the degree of noodle recovery (REC) after the initial compression. All five varieties displayed very good, but significantly distinct, REC values (Fig. 6B). BW275 displayed the highest REC value, followed by AC Domain. AC Snowbird, followed by AC Kanata, exhibited significantly better REC values than the currently dominant CWRS variety, AC Barrie. This was unexpected due to the lower protein content of AC Snowbird.

Texture profile analysis (TPA) as outlined by Bourne (6) offers an alternative means to assess noodle texture. Unlike the methods described above, TPA is based on the force response measurements of two repetitive compressions on the same noodle site to mimic the mastication process. In this study, noodle chewiness and springiness were evaluated by the two-step process and compared with single-stage mea-

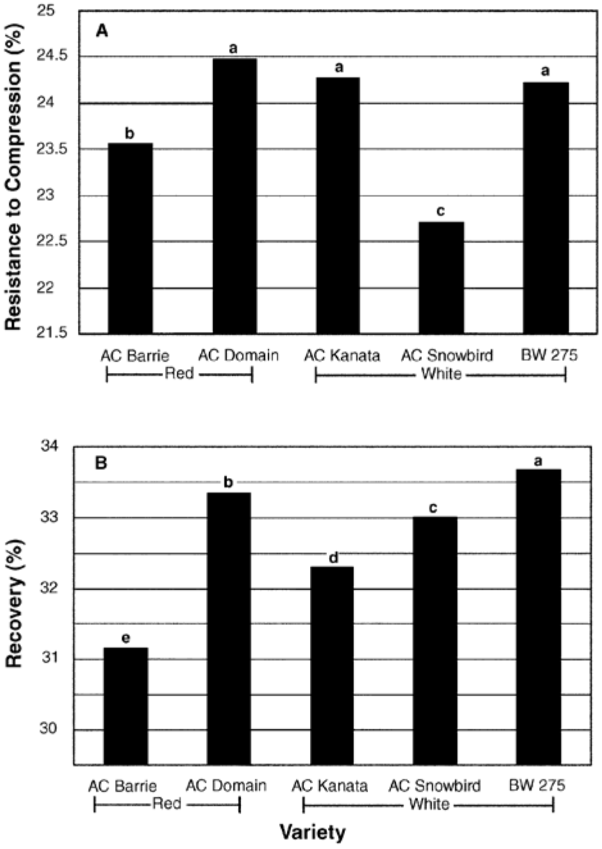

Fig. 6. A, Mean values for cooked noodle resistance to compression (RTC) across sites and years. **B,** Mean values for cooked noodle recovery (RTC) across sites and years.

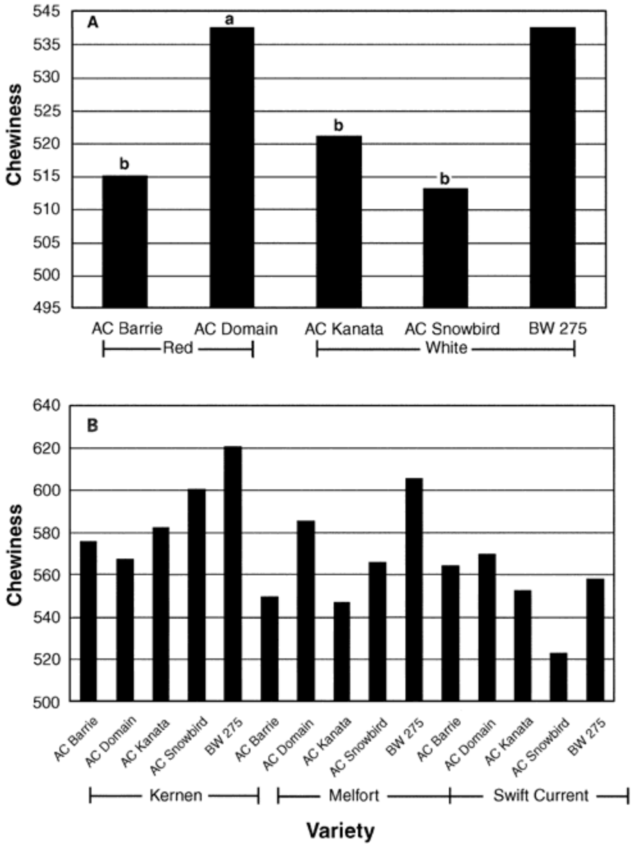

Fig. 7. A, Mean values for cooked noodle chewiness as determined by texture profile analysis (TPA) across sites and years. **B,** Mean values for cooked noodle chewiness by variety and site for 2000.

surements. The highest chewiness force values obtained for AC Domain and BW275 were significantly higher than for AC Barrie, AC Kanata, and AC Snowbird, which were all equivalent (Fig. 7A). This was consistent with the measurements obtained for REC and RTC using single-stage compression. The significant influence of location on chewiness was very noticeable in BW275 for the 2000 crop year (Fig. 7B).

Evaluation of TPA springiness indicated that AC Snowbird and BW275 white wheats displayed significantly better springiness values than the remaining varieties, which were equivalent (data not shown).

CONCLUSIONS

The western Canadian prairies have a diverse mixture of soil zones and environments (length of growing season, temperature, and precipitation) that influences the quality traits of the wheat grown. The data presented in this study demonstrate that varieties registered in Canada's newest wheat class, CWHWS, are equivalent to or better than red seed coat CWRS for most quality characteristics associated with the production of YAN. The ability of CWHWS to produce excellent quality noodle products when grown under diverse environments is consistent with their origin from CWRS germplasm of proven quality. Although the benefits of white seed coat color were anticipated for noodle appearance, the excellent cooked noodle texture characteristics of AC Snowbird compared with that of the dominant CWRS variety, AC Barrie, despite slightly lower protein content in AC Snowbird, suggests the new class is well suited for expansion across western Canada.

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