Evaluation of Durum Wheat Fine Flour for Alkaline Noodle Processing

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ABSTRACT

Fine flour milled from No. 2 Canada Western Amber Durum (CWAD) wheat was evaluated for the production of two major types of yellow alkaline noodles. For raw ramen alkaline noodle processing, the durum flour was compared with patent flours of 60% extraction rate milled from No. 1 Canada Western Red Spring (CWRS) and No. 1 Canada Western Hard White Spring (CWHWS) wheats. In terms of color, ramen noodles from the durum flour were brighter and exhibited a much more yellow color than the noodles from either CWRS or CWHWS. The *b** values at 3 and 24 hr were 39.6 and 38.1, 25.5 and 24.5, and 27.8 and 26.0 for the CWAD, CWRS, and CWHWS noodles, respectively. The corresponding *L** values for 3 and 24 hr were 75.4 and 70.1, 75.9 and 71.3, and 78.3 and 73.4, respectively. Overall textural characteristics of the cooked durum ramen noodles were similar to those of the CWRS noodles. For partially boiled Hokkien noodles, durum flour was compared with patent flour milled from a low-protein CWHWS. Hokkien noodles made from CWAD were very bright, with an extremely strong lemon yellow color, a very desirable appearance that is impossible to achieve with common wheat flour. Durum Hokkien noodles are firmer, with slightly less cooking gain than those made from CWHWS. Overall, alkaline noodles made from durum fine flour had superior color and better texture than those made from CWRS or CWHWS. Fine flour milled from durum wheat can produce smooth and uniformly hydrated alkaline noodles like those produced from high-quality common wheat flours. There was no need to make any adjustments to formulation and processing when using durum fine flour for making noodles.

Asian noodles and Western pasta products have been consumed by humans for many centuries and are popular worldwide (5). They are a mealtime staple year round. Asian noodles are usually made from common wheat fine flour using a process of sheeting and cutting, as opposed to pasta products that are generally processed by extrusion using coarse semolina milled from durum wheat. The differences in raw materials and processing methods render the two products easily distinguishable in appearance and texture. Although pasta products have a dense structure and firm texture with a strong yellow color, Asian noodles are usually much softer but more elastic and range from white or creamy white to moderately yellow in appearance.

Wheat flour noodles exist in two distinct categories based on the presence or absence of alkaline salt. White salted noodles (WSN) are produced using flour, water, and regular salt (NaCl) only, and yellow alkaline noodles (YAN) are produced with the addition of alkaline salt. WSN originated in northern China and are widely consumed in China, Japan, and Korea, but represent only a very small proportion of the total noodles produced in Southeast Asia. WSN should be bright with a clean color ranging from white to creamy white and have a smooth, glossy surface after boiling (9). Most Japanese and Korean people prefer boiled WSN that are soft and elastic with a smooth surface. The majority of Chinese people, however, prefer WSN with a relatively firm, elastic, and chewy texture.

The application of alkaline salt in noodle making originated in the Canton and Hokkien provinces of southern China. YAN were introduced in Southeast Asia by Chinese immigrants and were widely adopted into local cuisines. There are many types of YAN in southern China and Southeast Asia. The most popular types are fresh (Cantonese style), partially boiled (Hokkien style), and fresh or steamed with whole egg or egg white as an ingredient (wonton noodles). Although YAN were introduced into Japan from China much later than WSN, YAN now have a

Table I. Tempering time and milling moisture of wheat samples[a]

	No. 2 CWAD	No. 1 CWRS	No. 1 CWHWS-1	No. 1 CWHWS-2
Milling moisture (%)	16.5	16.4	16.5	16.6
Tempering time (hr)	48	23	28	22
PSI (%)[b]	35.2	46.8	47.3	44.2

[a] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1 and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring samples 1 and 2, respectively.
[b] Particle size index as determined by AACC International Method 55-30.

Table II. Flours used for yellow alkaline noodle evaluation

Flour[a]	Extraction (%)	Protein[b] (%)	Ash[b] (%)	Starch Damage[b] (%)	Farinograph Absorption (%)	Farinograph Stability (min)
No. 2 CWAD	63	13.5	0.66	9.8	70.9	5.1
No. 1 CWRS	60	12.1	0.41	6.8	63.5	18.1
No. 1 CWHWS-1	60	12.8	0.40	6.6	62.9	44.3
No. 1 CWHWS-2	60	11.9	0.38	6.7	64.1	19.6

[a] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1 and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring samples 1 and 2, respectively.
[b] 14% moisture basis.

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slightly higher market share than WSN in Japan, where the most popular types are fresh noodles (ramen) and high-moisture steamed noodles (yakisoba).

The unique color, texture, and flavor of alkaline noodles are due to the inclusion of alkaline salt, a quantitatively minor but qualitatively very important ingredient in noodle processing (8). The most commonly used alkaline salts are sodium and potassium carbonates. Other alkaline reagents, such as sodium hydroxide and bicarbonates, are also used in some countries. The yellowish color associated with alkaline noodles is attributed to the presence of natural flavonoid pigments in the flour, which are colorless at acidic pH levels but turn yellow at alkaline pH levels (6). Noodle doughs become tougher, tighter, and less extensible with the addition of alkaline reagents (8). This results in a firmer texture for YAN than for WSN. The characteristics of high-quality YAN include a bright yellow appearance with a clean background and a moderately firm, smooth, and elastic texture. Wheat quality requirements for YAN processing include a sound, dry, clean, semi-hard to hard kernel texture, medium-high to high-protein content, and kernels that are high in yellow pigments and low in enzymatic activities involving noodle discoloration (4,7).

In general, durum wheat is much higher in yellow pigments (mainly xanthophylls) and lower in lipoxygenase and peroxidase activities than is common wheat (2,3,11). Durum wheat is very hard and suitable for the production of semolina, a coarse granular product of endosperm particles. Results of several trials in our laboratory showed, however, that durum semolina is not suitable for YAN processing using traditional sheeting and cutting processes. YAN made from durum semolina are very streaky, have a rough surface, and are difficult to process because of slow hydration of the coarse particles. There are no reports in the literature about the application of durum fine flour for Asian noodles. This study was conducted to explore the feasibility of using durum fine flour for Asian noodle processing. Fine flour was generated by milling durum wheat in a mill used for common wheat with some modifications. The durum flour was then tested for hydration properties during the mixing and dough sheeting process. Once the hydration was confirmed to be acceptable for YAN processing, the durum flour was evaluated for noodle texture, color, and color stability.

MATERIALS AND METHODS

Wheat Samples and Their Flours

Four wheat samples were milled in a pilot flour mill: one No. 2 grade Canada Western Amber Durum (No. 2 CWAD), one No. 1 grade Canada Western Red Spring (No. 1 CWRS), and two No. 1 grade Canada Western Hard White Spring (No. 1

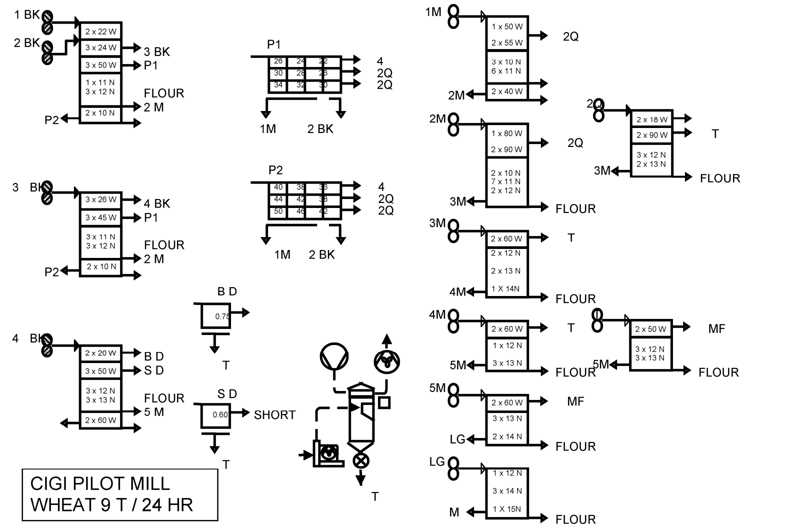

Fig. 1. Flour milling diagram of the Canadian International Grains Institute (CIGI) pilot mill.

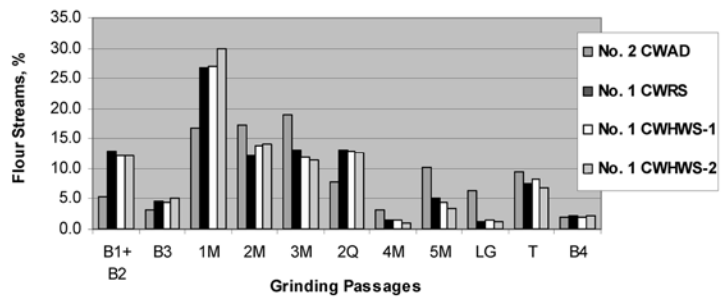

Fig. 2. Comparative flour stream percentages. No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1 and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring samples 1 and 2, respectively.

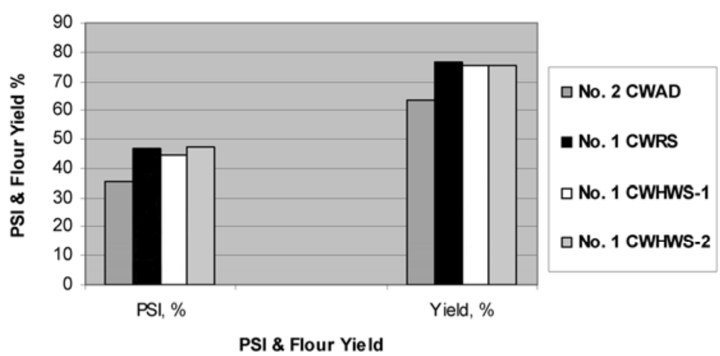

Fig. 3. Wheat kernel texture and total flour yield. No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1 and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring samples 1 and 2, respectively.

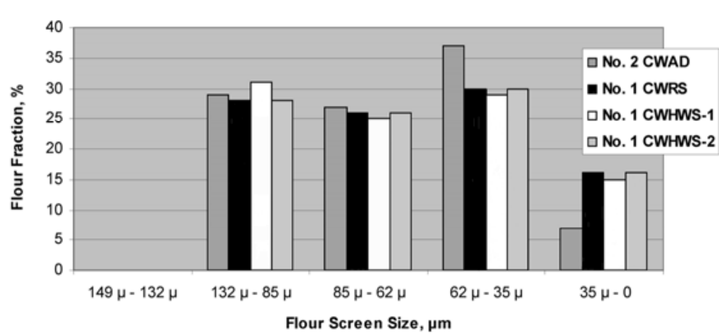

Fig. 4. Flour particle size distribution. No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1 and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring samples 1 and 2, respectively.

CWHWS-1 and No. 1 CWHWS-2). All wheat samples were cleaned and tempered in the Canadian International Grains Institute (CIGI) pilot mill using tempering time and milling moisture as shown in Table I.

The four wheat samples were milled in the pilot mill as shown in Fig. 1. As can be seen from the mill flow sheet, there are four break passages using corrugated grinding rolls that become progressively finer and eight reduction passages using smooth grinding rolls. The total of 12 grinding passages provides 11 flour streams; the first and second break flour streams are combined into one.

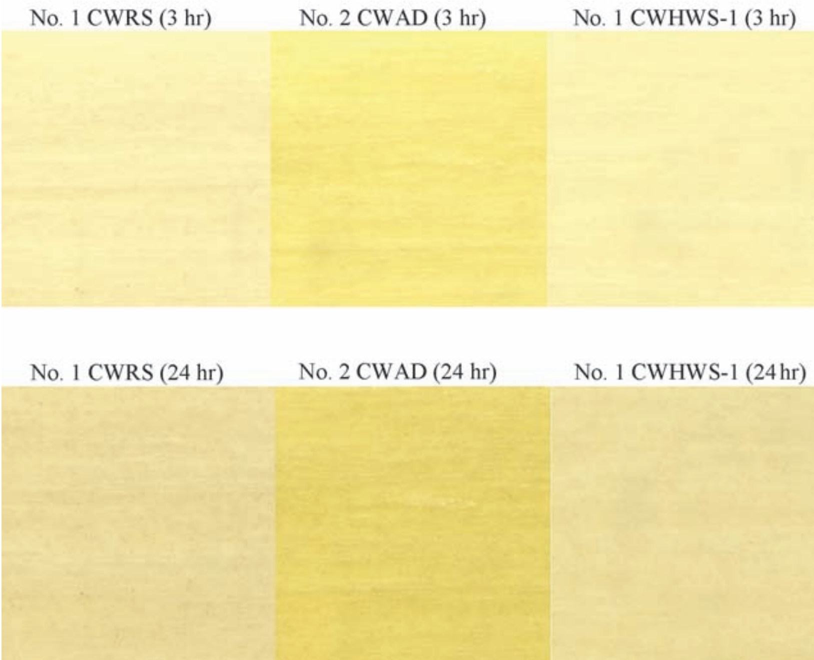

Fig. 5. Ramen noodle sheets 3 and 24 hr after processing. No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1: No. 1 Canada Western Hard White Spring sample 1.

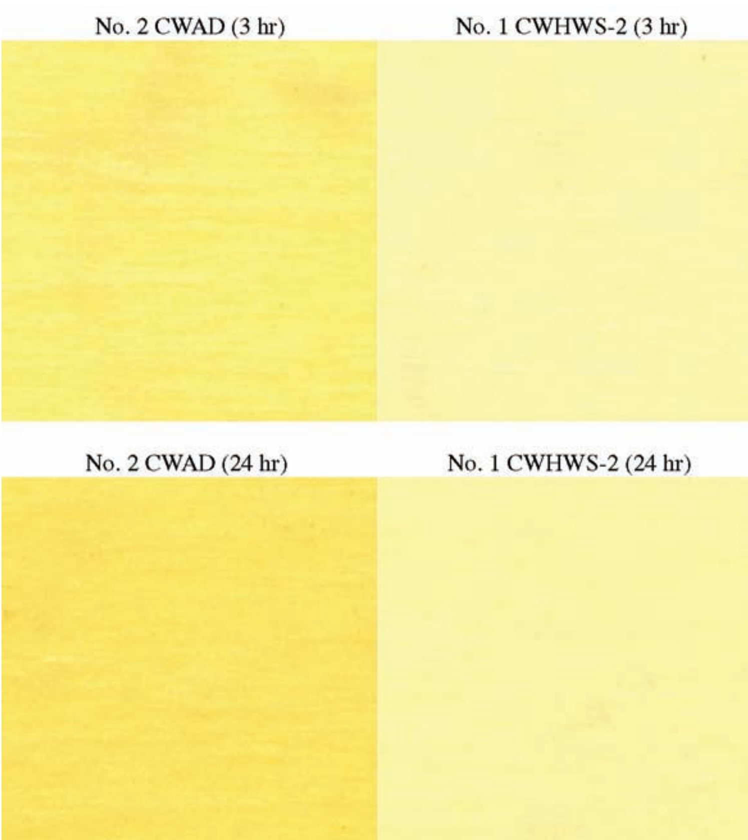

Fig. 6. Raw Hokkien noodle sheets 3 and 24 hr after processing. No. 2 CWAD: No. 2 Canada Western Amber Durum; and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring sample 2.

The total fine flour extraction rates were 63.3, 76.6, 75.2, and 75.1% for No. 2 CWAD, No. 1 CWRS, No. 1 CWHWS-1, and No. 1 CWHWS-2, respectively. Patent flours of 60% extraction rate were prepared by combining selected flour streams of No. 1 CWRS, No. 1 CWHWS-1, and No. 1 CWHWS-2. Straight-grade flour milled from durum wheat and 60% extraction patent flours from common wheat were used for noodle evaluation. Table II shows the basic analytical results for the flours used in this project. Flour ash content was determined by AACC International Method 08-01 (1), flour protein was quantified using combustion nitrogen analysis (AACC International Method 46-30 [1]), and starch damage was determined using the Megazyme test kit (AACC International Method 76-31 [1]). Dough properties were characterized by farinograph (AACC International Method 54-21 [1]).

Noodles were processed in an Ohtake laboratory noodle machine. The temperature of the sheeting rolls was controlled at 30 ± 1°C by circulating water inside the rolls.

Raw Ramen Alkaline Noodles

Salt (NaCl) and alkaline salts (K_2CO_3/Na_2CO_3 = 6:4, [w/w]) dissolved in water were added to the flour (1.0 kg) in amounts of 1 and 1.3% (flour weight), respectively. Constant water absorption of 34% (14% moisture basis and mass balance) was used for all flours. Mixing was performed at 100 rpm for 10 min in an Ohtake vertical mixer, followed by 15 min of dough resting. The mixture was sheeted with an initial gap setting of 3.5 mm. The resulting dough sheet was folded and sheeted again with the same gap setting. After resting for 30 min, the dough sheet was subjected to four reduction passes (2.5, 1.8, 1.3, and 1.0 mm). A 100-cm long section was cut from the noodle sheet for color and speck evaluation. The remaining dough was sheeted one more time before cutting. The final gap setting was adjusted for each sample to ensure that the resulting noodle strands had a thickness of 1.4 mm. Noodle strands were cut using a No. 10 or No. 20 cutter to produce noodles with a width of 3.0 or 1.5 mm, respectively.

The size and handfeel of the dough crumb were evaluated after mixing. During the sheeting process, uniformity of hydration, surface smoothness, and stickiness of the dough sheet were assessed.

A chroma meter (Minolta CR-310) equipped with a C illuminant using the *L**, *a**, and *b** color scale was used to measure the color of the noodle dough sheet. The dough sheet was folded into six layers and stored in a covered container at room temperature (22 ± 1°C) over a 24-hr examination period. Measurements were made at five spots on the dough sheet surface at 3 and 24 hr after mixing started. Specks were counted visually under a magnifier lamp (×10) and by software on the basis of scanned images of dough sheets.

Cooked noodle strands were assessed for maximum cutting stress with a TA-XT2 texture analyzer (Texture Technologies, Scarsdale, NY). Noodle samples were measured after cooking for 3.5 and 7.0 min. Test parameters were set as follows: pretest speed = 2.0 mm/sec; test speed = 0.2 mm/sec; post-test speed = 1.0 mm/sec; and trigger force = 5 g.

Partially Boiled Hokkien Noodles

The formulation for partially boiled Hokkien noodles was 34% water, 1% NaCl, and 0.75% NaOH based on flour weight. Mixing (1.0 kg of flour) was performed at 100 rpm for 5 min in an Ohtake vertical mixer. The mixture was sheeted with an initial gap setting of 3.5 mm immediately after mixing. The resulting dough sheet was folded and sheeted again with the same gap setting. Without resting, the dough sheet was subjected to two reduction passes (2.5 and 1.8 mm). Two 15-cm long sections were cut from the noodle sheet for color evaluation (one partially boiled for 1 min and the other in the raw state). The remaining dough was sheeted with a 1.35-mm gap setting one more time before cutting. Noodle strands were cut with a No. 18 cutter to produce noodles with a width of 1.67 mm.

A chroma meter (Minolta CR-310) equipped with a C illuminant using the L^*, a^*, and b^* color scale was used to measure the color of the raw and partially boiled noodle dough sheets. The dough sheets were stored in a covered container at room temperature (22 ± 1°C) over a 24-hr examination period. Measurements were made at five spots on the dough sheet surface at 3 and 24 hr after mixing started.

Noodles were partially boiled for 1 min, drained in a plastic strainer, rinsed in ice water for 1 min to stop cooking completely, and drained again. Excess water was removed by tapping the plastic strainer 20 times. Cooking yield was calculated on the basis of noodle weights before and after boiling. The partially boiled noodles were mixed evenly with 2% cooking oil (based on boiled noodle weight). They were assessed by sensory evaluation for texture after 2 hr of resting at room temperature.

At a minimum, all processing and evaluations were conducted in duplicate. Instru-

Table III. Sensory evaluation results for ramen noodle processing properties[a]

	Dough Crumb		Dough Sheet		
Flour[b]	**Size**	**Handfeel**	**Surface**	**Stickiness**	**Hydration**
No. 2 CWAD	V. good	V. good	M. smooth	None	M. uniform
No. 1 CWRS	V. good	V. good	S. smooth	None	M. uniform
No. 1 CWHWS-1	V. good	V. good	M. smooth	None	M. uniform

[a] V: very; M: moderately; and S: slightly.

[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1: No. 1 Canada Western Hard White Spring sample 1.

Table IV. Chroma meter readings for ramen noodle sheets[a]

	3 hr			24 hr		
Flour[b]	***L****	***a****	***b****	***L****	***a****	***b****
No. 2 CWAD	75.4 ± 0.4b	–1.04 ± 0.08c	39.6 ± 0.2a	70.1 ± 0.3c	–0.56 ± 0.05c	38.1 ± 0.1a
No. 1 CWRS	75.9 ± 0.2b	–0.22 ± 0.01a	25.5 ± 0.2c	71.3 ± 0.1b	0.08 ± 0.02a	24.5 ± 0.1c
No. 1 CWHWS-1	78.3 ± 0.3a	–0.53 ± 0.04b	27.8 ± 0.2b	73.4 ± 0.1a	–0.08 ± 0.02b	26.0 ± 0.2b

[a] Means ± standard deviation, different letters within same column denote significant differences ($P \leq 0.05$).

[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1: No. 1 Canada Western Hard White Spring sample 1.

Fig. 7. Raw and cooked ramen noodles 3 hr (left panel) and 24 hr (right panel) after processing. No. 1 CWRS: No. 1 Canada Western Red Spring; No. 2 CWAD: No. 2 Canada Western Amber Durum; and No. 1 CWHWS: No. 1 Canada Western Hard White Spring sample 1.

ment analysis was applied wherever possible. Because of their empirical nature, certain noodle processing and quality aspects were assessed by sensory evaluation.

RESULTS AND DISCUSSION

Milling of Durum Wheat for Fine Flour

Proper tempering or conditioning of wheat is an integral part of the milling process that helps facilitate the clean separation of the bran from the endosperm. Additionally, the process mellows the endosperm enough so it may be reduced to fine flour particles without having to exert excessive pressure during grinding. The kernel texture of durum wheat is much harder than that of common wheat. Therefore, when durum wheat is milled to produce fine flour, it is imperative to mellow the kernel texture enough to ensure relatively easy grinding of the flour without inflicting excessive levels of physical starch damage, which may otherwise adversely affect the processing or the end-product quality.

Figure 2 shows the percentages of flour from each of the flour streams. Durum flour streams displayed a different yield distribution (percent) than did the common wheat samples. This is indicative of the harder kernel texture.

The kernel texture and its influence on flour yield percentages are also evident from the chart shown in Fig. 3. The lower flour yield from durum wheat was attributed to its harder kernel texture despite a very long tempering time. This meant a relatively higher percentage of the endosperm that could not be reduced to flour particle size ended with by-products (shorts).

Kernel texture also influenced particle size distribution in the finished flours. Figure 4 shows the particle size distribution of the three common wheat flour samples together with the durum wheat flour sample. Durum flour had a higher percentage of fraction in the 62–35 µm particle size range and a lower percentage of the finest fraction in the particle size range of 35 to 0 µm compared with the common wheat flours. For the coarser fractions (132–62 µm), however, the durum wheat flour and common wheat flours were comparable. In general, the overall particle size distribution for durum wheat flour is similar to those of common wheat flours. It only showed somewhat higher levels of coarser particles in the finer particle size ranges. This result is mainly because of the difference in hardness between durum wheat and common wheat. Longer tempering of durum wheat does not seem to be helpful for obtaining fine flour fractions.

An alternative method of processing would involve obtaining a higher percentage of fine durum semolina using a traditional durum milling system and then carefully remilling the semolina on a longer milling system to gradually produce fine particles of flour without unduly increasing physical damage to the starch, as is practiced in some semolina milling systems in Italy and other parts of the world.

Ramen Alkaline Noodles

Noodle processing is typically made up of dough mixing, formation of dough sheets, sheet thickness reduction by rolling, and noodle strand formation by passing the dough sheet through a pair of cutting rolls. The amount of water required for noodle processing is optimized to ensure that there is enough to hydrate the flour and develop a uniform dough sheet, yet not so great that the formed dough causes problems in handling and sheeting because of surface stickiness. Sufficient and uniform hydration of flour particles is critical to ensure the development of a continuous protein matrix with a good balance of elasticity and extensibility in the noodle sheet. This matrix in turn ensures good processing properties and eating quality of the finished product. Unfortunately, no objective instrument method currently exists for the evaluation of noodle processing properties (10). In our laboratory, noodle processing properties are subjectively evaluated by visual examination. For dough crumb after mixing, size (7-point scale from very small to very large) and handfeel (7-point scale from very dry to very wet) are evaluated. For noodle sheet properties during sheeting, surface (6-point scale from very rough to very smooth), stickiness (4-point scale from none to very sticky), and hydration (6-point scale from very streaky to very uniform) are evaluated.

Results (Table III) indicated that flour milled from No. 2 CWAD wheat can produce smooth, uniformly hydrated noodle sheets similar to noodle sheets made from flours of top-grade CWRS and CWHWS wheats. The reduction in particle size from semolina to fine flour greatly improved the noodle processing property of durum wheat, eliminating the streakiness and roughness of the noodle sheet surface (Figs. 5 and 6).

Color is the first sensory quality by which noodles are judged. A bright yellow color with a clean background is preferred for YAN. The rate of darkening of fresh YAN is important because the noodles may not be consumed until one or more days after manufacture. Darkening of noodles has been attributed to the presence of bran specks and enzymatic browning by polyphenol oxidases, peroxidases, etc. These enzymes oxidize phenols to quinones that are subsequently converted to dark colored pigments (melanoids) by self-polymerization and resonance stabilization of the aromatic ring structure or by interacting with amino groups or proteins (6). The discoloration process begins once enzymes are activated when water is added to the flour at the start of mixing. Ramen noodle sheets were measured at 3 and 24 hr after mixing started with a chroma meter (Minolta CR-310). Results are shown in Table IV.

The b^* and a^* values for the noodle sheets indicate that ramen noodles made from durum fine flour have a vivid, strong, yellow color. The b^* values for the durum noodle sheets were more than 10 units higher than for the CWRS and CWHWS noodles. The higher brightness of the durum noodle sheets was clearly evident in the scanned images (Fig. 5). In this case, the L^* values, however, failed to reflect the differences in brightness between noodle sheets made from durum and common wheat samples. This result might be due to the high b^* value of the durum sample. The photos of raw and cooked Ramen noodles at 3 and 24 hr (Fig. 7) also show the outstanding bright yellow appearance of the noodles made from the No. 2 CWAD wheat sample.

Discolored spots have a great impact on consumer perception of overall noodle appearance and quality. When quality is an issue, the majority of markets prefer noodles made from high-quality patent wheat flours with low ash content. The reduction in

Table V. Specks in ramen noodle sheets[a]

	Sensory Count		Instrument Count	
Flour[b]	**3 hr**	**24 hr**	**3 hr**	**24 hr**
No. 2 CWAD	4 ± 1a	11 ± 2c	5 ± 1b	13 ± 2c
No. 1 CWRS	6 ± 1a	25 ± 3a	10 ± 1a	28 ± 2a
No. 1 CWHWS-1	1 ± 1b	17 ± 2b	3 ± 1b	22 ± 2b

[a] Number of specks per square centimeter. Means ± standard deviation, different letters within same column denote significant differences ($P \leq 0.05$).
[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1: No. 1 Canada Western Hard White Spring sample 1.

Table VI. Maximum cutting stress (g/mm^2) of cooked ramen noodles[a]

Flour[b]	3.5-min Cooking	7.0-min Cooking	Retention (%)
No. 2 CWAD	33.4 ± 0.3b	22.2 ± 0.1b	66.6a
No. 1 CWRS	32.3 ± 0.5b	20.4 ± 1.1b	63.2b
No. 1 CWHWS-1	38.1 ± 0.6a	23.4 ± 0.6a	61.4b

[a] Means ± standard deviation, different letters within same column denote significant differences ($P \leq 0.05$).
[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; No. 1 CWRS: No. 1 Canada Western Red Spring; and No. 1 CWHWS-1: No. 1 Canada Western Hard White Spring sample 1.

visible bran specks and improved flour color should give white seed coat wheat a significant advantage over red seed coat wheat for noodle production. Table V shows that ramen noodle sheets from CWHWS and CWAD had the lowest number of specks at 3 and 24 hr, respectively.

Instrument analysis of noodle texture (Table VI) showed that the maximum cutting stress of ramen noodles made from CWAD was similar to that of CWRS at 3.5 and 7.0 min cooking times. At 7.0 min of cooking, the maximum cutting stress was 66.6, 63.2, and 61.4% of that recorded at 3.5 min of cooking for CWAD, CWRS, and CWHWS-1, respectively. These results indicated that CWAD noodles had the best texture retention properties during cooking.

Hokkien Alkaline Noodles

Durum fine flour was also evaluated for Hokkien noodle processing quality compared with flour milled from No. 1 CWHWS-2. Figure 6 shows the scanned images of Hokkien noodle sheets. Hokkien noodles made from durum were very bright, with a vivid lemon yellow color, whereas those made from No. 1 CWHWS-2 were bright, but the yellowness was not very strong. Chroma meter readings of the raw and partially boiled noodle sheets confirmed the visual observations (Tables VII and VIII).

Partially boiled Hokkien noodle texture was evaluated using a 10-point scoring system (surface stickiness: 1 = very sticky and 10 = not sticky; firmness: 1 = soft and 10 = firm; and chewiness: 1 = not chewy and 10 = very chewy). This system was developed through various technical exchange programs with experienced technical staff from many flour mills in Malaysia. Surface stickiness is the extent to which two noodle strands adhere to each other as they are separated and is usually correlated with the degree of surface swelling. Firmness is the force required by the teeth to cut through the noodles. Chewiness is the length of time required to masticate the noodle to a state suitable for swallowing.

The sensory results (Table IX) showed that Hokkien noodles made from durum fine flour had better textural qualities than those made from CWHWS-2. Hokkien noodles made from durum flour were very firm and chewy, with little surface stickiness and swelling. Although cooking gain was slightly lower (but statistically not significant) for durum Hokkien noodles, this result can be improved easily by slightly extending the boiling time during the partial cooking process.

CONCLUSIONS

Fine flour milled from durum wheat can produce smooth and uniformly hydrated alkaline noodles similar to those produced with high-quality common wheat flours. There was no need to make any adjustments to formulation or processing when using durum fine flour for noodle processing. Ramen alkaline noodles made from the durum flour were brighter and exhibited a more intense yellow color than the noodles from either CWRS or CWHWS. The overall textural characteristics of cooked durum ramen noodles were similar to noodles produced from CWRS but with better texture retention properties for CWAD. Durum Hokkien noodles were very bright, exhibiting a very desirable strong lemon yellow color that is impossible to achieve with common wheat flour without artificial additives. Sensory evaluation indicated durum Hokkien noodles made from CWAD were firmer than those made from CWHWS. Alkaline noodles made from fine flour milled from CWAD had better color and texture than those made from CWRS or CWHWS wheat flours and offer a viable novel alternative in the marketplace.

Table VII. Raw Hokkien noodle sheet color[a]

Flour[b]	3 hr			24 hr		
	*L**	*a**	*b**	*L**	*a**	*b**
No. 2 CWAD	75.6 ± 0.1b	–1.59 ± 0.05b	42.4 ± 0.3a	72.3 ± 0.3b	–0.48 ± 0.35a	44.4 ± 0.4a
No. 1 CWHWS-2	78.3 ± 0.2a	–1.39 ± 0.04a	30.2 ± 0.3b	75.9 ± 0.3a	–0.55 ± 0.17a	30.8 ± 0.2b

[a] Means ± standard deviation, different letters within same column denote significant differences ($P \le 0.05$).
[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring sample 2.

Table VIII. Partially boiled Hokkien noodle sheet color[a]

Flour[b]	3 hr			24 hr		
	*L**	*a**	*b**	*L**	*a**	*b**
No. 2 CWAD	76.2 ± 0.2b	–2.83 ± 0.11a	43.7 ± 0.3a	76.5 ± 0.3b	–2.91 ± 0.10a	42.9 ± 0.3a
No. 1 CWHWS-2	77.6 ± 0.3a	–2.95 ± 0.08a	31.4 ± 0.2b	78.1 ± 0.4a	–2.98 ± 0.08a	30.7 ± 0.3b

[a] Means ± standard deviation, different letters within same column denote significant differences ($P \le 0.05$).
[b] No. 2 CWAD: No. 2 Canada Western Amber Durum; and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring sample 2.

Table IX. Cooking yield and texture of partially boiled Hokkien noodles

Flour[a]	Cooking Yield (%)[b]	Surface Stickiness	Firmness	Chewiness
No. 2 CWAD	148.1 ± 1.0a	9	10	10
No. 1 CWHWS-2	151.0 ± 0.1a	8	8	8

[a] No. 2 CWAD: No. 2 Canada Western Amber Durum; and No. 1 CWHWS-2: No. 1 Canada Western Hard White Spring sample 2.
[b] Means ± standard deviation, different letters within same column denote significant differences ($P \le 0.05$).

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