Hard Red Winter Wheat/Nutrim-OB Alkaline Fresh Noodles: Processing and Texture Analysis

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ABSTRACT: Nutrim was added at 10%, 20%, and 30% to Hard Red Winter wheat flour to increase soluble fiber content of fresh noodles to a minimum of 0.75 g/noodle serving (one noodle serving is 42 g or 40 g db (dry basis). The effect of Nutrim on the dough characteristics and noodles quality was tackled. The presence of Nutrim increased the final water absorption and dough toleration as measured by Farinograph whereas the dough stability was decreased. The DSC (Defferential scanning Calorimetry) data showed that Nutrim increased the onset or peak temperatures while the ΔH was reduced by 25%. The resilience of Nutrim-enriched noodles was not significantly affected. The chewiness and hardness were reduced by Nutrim added at 20% and 30%, while cohesiveness was significantly increased by all 3 Nutrim levels. RVA (RapidVisco Amylograph) profile showed higher peak viscosity in the presence of Nutrim. The 20% and 30% Nutrim levels increased the soluble fiber of the final product from 1.13% to 1.67% and 2.47%. The yellow color of noodles became darker with higher Nutrim amounts added. The addition of Nutrim produced dough with a more compact image with less space between the starch granules as measured by scanning electron microscopy when compared with the control. The rheological testing showed that the presence of Nutrim decreased flour suspension elastic properties.

Keywords: Nutrim, Hard Red Winter wheat (HRWW), fresh alkaline noodles, DSC, texture, rheology

Introduction

Water absorption during pasta and noodle processing is primarily influenced by starch damage and protein content (Yamazaki 1955; Bushuk 1966). However, the influence of non-starch polysaccharides (pentosans and [1 → 3][1 → 4]-β-glucan) cannot be ignored. Farinographic studies showed distinct increase in the Farinograph water absorption in the presence of both water soluble and insoluble pentosans (Kulp 1968; Jelaca and Hlynka 1971; Hanh and Rasper 1974; Kim and D’Appolonia 1977; Sefa-Dedeh and others 1977).

Nutrim is a soluble fiber found in a layer between seed cover cells of barley and oats. β-glucan is the main soluble fiber component of Nutrim, which has been proven to lower cholesterol when consumed in a low fat diet. A health claim can be made as allowed by the Food and Drug Administration when β-glucan is ingested at 3 g/d (Food and Drug Administration, Food Labeling 1997) or 0.72 g per serving (one noodle serving is 42 g).

Noodles are classified by the presence of salts or alkaline and salts in their formulation (Ross 1997; Akashi and others 1999). Salted noodles are formulated with NaCl at a pH of 6.2 to 7.0, while alkaline noodles contain alkaline salts with pH 9.9 to 11.5 (Ross 1997). Dough formulation with alkaline salts showed higher resistance to extension, pasting temperature, and peak viscosity as well as altered mixing properties (Lorenz and others 1994; Sung and others 1996).

Sung and Sung (1993) and Sung and others (1996) have reported greater breaking and cutting forces, increased shear force and compression with added alkaline salt. Moss and others (1986) reported firmer and elastic noodles and higher water uptake and yield when alkaline salts were used. Noodles formulated with salt and alkali gave a desirable yellow color and higher breaking force than with salt alone (Sung and others 1996).

Legume, such as cooked and raw yellow pea, defatted soy protein, and green beans were used as fortifiers in noodle formulation. They were added to wheat flour at 5%, 10%, and 20%. The 5% to 10% levels, depending on the legume used, were found to produce good noodles (Jeffers and others 1979). Kruger and others (1998) reported that the addition of rye flour to Canadian red winter and red spring flours, decreased noodle brightness L* and yellowness b*. The texture quality of noodles was decreased by incremental addition of rye flour. Psyllium that contained 84% to 87% dietary fiber was added to noodles flour at 2%, 4%, and 8%. At the 2%, data showed discolored noodles but did not affect the textural quality or taste (Czuchajowska and others 1992).

A high correlation coefficient (0.88) was found between Instron Universal Testing Instrument and sensory evaluation of firmness and chewiness of noodles (Oh and others 1983). Textural properties of noodles were affected by protein quantity and quality (Lee and Lee 1985; Oh and others 1985; Miskelly and Moss 1985; Moss 1971; Rubico and others 1995; Ross 1997; Crobbie and others 1999; Eun and others 1999). Flour protein content has been negatively related to cooking loss and positively related to damaged starch content (Eun and others 1999). Monkore and Einen (2003) reported significant correlation between sensory evaluation and mechanical testing methods using Texture Analyzer (TA-XT2) in a way similar to the Instron Universal Testing Instrument.

The objectives of this work were to increase the amount of solu-
ble fiber in fresh noodles to a minimum of 0.75 g (1.17%) per serving and determine the effect of Nutrim on the dough characteristics and noodle quality.

**Material and Methods**

**Material**

Hard Red Winter wheat (HRWW) flour was obtained from Shanee Milling Co., Shanee, Okla., U.S.A. Nutrim-oat bran hydrocolloid was prepared, according to Inglott 1991, as follows: To 5100 mL deionized water in a 19-L (5-gallon) container, 900 g of oat bran (OB) concentrate (Quaker Oats Co., Chicago, Ill., U.S.A.) was added and mixed at about 10000 rpm with a dispersator (Premier Mill Corp., Reading, Pa., U.S.A.; PMC Model 90, high viscosity head) to generate a temperature in the range of 80 to 95 °C. Continuous shear force was applied to maintain this temperature for 30 min before adding 6 L of boiling water. The slurry was steam jet-cooked at 138 to 141 °C and 40 to 45 psi. The hot slurry from the cooker was immediately passed into a Sweco separator (Sweco Intl., Florence, Ky., U.S.A.) with 50 and 80 steel mesh sieves to recover the hydrocolloid liquid. The wet fiber solids from the sieves were collected, reslurried with boiling water, and recollected on the sieves. The liquid was combined with the hydrocolloid liquid before drum drying the liquid to give oat bran hydrocolloid, 536 g. The combined wet fiber solids were oven dried to give 175 g. Nutrim-OB is commercially produced by Future Ceutical Co., Momence, Ill., U.S.A. Throughout the paper, Nutrim-OB will be called Nutrim.

**Protein and ash analysis**

Flour protein and ash content were measured using AACC Method 39-11 (AACC 2000a) in a near infrared reflectance instrument (NIR System 6500, FOSS North America, Eden Prairie, Minn., U.S.A.). The percentages were calculated on a 14% moisture basis. Two independent measurements per sample were recorded.

**Noodle preparation**

Alkaline noodles were prepared from 300 g flour and 30 mL alkali solution containing 0.5% Na2CO3 and 2% NaCl with water absorption levels adjusted to obtain optimum sandy dough ranging from 31% to 33%. The water absorption of the flour containing different levels of Nutrim was adjusted to obtain optimum dough characteristics (final water absorption was adjusted based on flour and Nutrim moisture content). Nutrim was added to the 300 g control flour at 10%, 20%, and 30%. Noodles were processed with a Texture Analyzer, TA-XT2i (Stable Micro Systems, Surrey, U.K.). The amount of Nutrim was added as an addition to the control in db to be consistent with the way Nutrim was added to the blend used to make noodles. Samples were held at 50 °C for 1 min, heated to 95 °C in 3.7 min, held at 95 °C for 2.5 min, cooled to 50 °C in 3.8 min, and maintained at 50 °C for 2 min. Measurements were performed in duplicate. The control flour and samples were tested by Farinograph according to AACC Method 54-21 (AACC 2000b).

**Differential scanning calorimetry**

Both the cooked and uncooked noodles were freeze-dried and milled using a coffee grinder (Varco Inc., 228-113, France) and sieved to pass through 45 mesh sieve. Three milligrams sample were placed in DSC aluminum pan where the moisture adjusted to 65% by adding the appropriate amount of water. Samples were equilibrated for 1 h before the run. The 65% water content was selected to ensure that there was enough water for the starch to completely gelatinize. The DSC (TA Instrument 2920: dual cell and single cell runs (TA Instrument, Newcastle, Del., U.S.A.) conditions were set at 10 °C/min from ambient to 110 °C with sensitivity set at 2 μW/s. The dual cell DSC allows running 2 samples, each run together, with the reference pan saving time without compromising reproducibility of the runs. The DSC was calibrated against an indium standard. During each run nitrogen flow rate was 24 cm^3/min. The onset or peak temperatures and ΔH were calculated for each run. These parameters were calculated using TA instrument software where the onset, peak temperatures, and the end of the transition were determined and the area under the curve was integrated and used as the ΔH.

**Color analysis**

After sheeting, 4 (approximately 10 cm square) raw pieces of the dough were saved for color evaluation and stored in zip-locked plastic bags at room temperature (approximately 25 °C). The L* (brightness), a* (redness), and b* (yellowness) color space values were measured in a Minolta Spectrophotometer Model CM-3500d using D65 light source (Minolta Ltd., Osaka, Japan) using 4 layers of the raw dough at room temperature. Three observations were recorded from each piece of dough. The color was measured at 0, 2, and 24 h.

**Texture properties**

Fresh (undried) noodles (35 g) were cooked in boiling tap water for 2 min, rinsed, drained by tapping 10 times, stored in water, and immediately analyzed. Cooked noodle texture characteristics of hardness, cohesiveness, chewiness, and resilience were measured with a Texture Analyzer, TA-XT2i (Stable Micro Systems, Surrey, U.K.). These properties were calculated by taking 2 compressions using a flat end cylindrical plunger (5-mm probe) descending to 70% compression in the noodles. Crosshead speeds of 4.0, 1.0, and 1.0 mm/s were used for pretest, test, and posttest settings respectively. Five observations were made using 5 cooked noodles (2 cm long) placed side by side.

**Scanning electron microscopy**

Samples of raw (uncooked) and cooked noodles were freeze-dried and analyzed using a scanning electron microscope model JXM 6400 (JEOL Ltd., Tokyo, Japan) at accelerating voltages 10 KV. Briefly, the samples were mounted on specimen stubs using silver paint (Fullman Inc., Latham, N.Y., U.S.A.) and coated under vacuum with gold-palladium at approximately 200/min.

**Rheological test**

Flour samples suspension (20% W/W) in 0.05 M sodium phos-
phate buffer with 3 M urea (pH 7.0 at 25 °C) was used as a control. A suspension with (20% W/W) of the flour and Nutrim blend was prepared for rheological testing. Rheological properties of the suspensions were measured using a rheometric ARES strain-controlled fluid rheometer with a 50-mm cone-and-plate geometry. The angle of the cone was 0.04 radians. The sample chamber was enclosed in a humidity-controlled chamber to avoid evaporation. The temperature was controlled at 25 ± 0.1 °C in the experiment chamber using a water circulation system. The linear dynamic rheological measurements were conducted according to the method described by Xu and others (2001). Basically, small-amplitude oscillatory shear experiments were conducted over a frequency (\(\beta\)) range of 0.1 to 100 rad/s, yielding a shear storage (\(G'\)) and loss (\(G''\)) moduli. The storage modulus represents the nondissipative component of mechanical properties. The loss modulus represents the dissipative component of the mechanical properties and is characteristic of viscous flow. The phase shift or phase angle (\(\delta\)) is defined by \(\delta = \tan^{-1}(G''/G')\), and indicates whether a material is solid with perfect elasticity (\(\delta = 0\)), or liquid with pure viscosity (\(\delta = 90^\circ\)), or somewhere in between. The nonlinear rheological steady shear experiments were conducted over a shear range of 0.01 to 1000 s\(^{-1}\). Measurements of the shear viscosity were obtained throughout the course of the experiment.

Statistical analysis

A \(t\) test was used to compare the effect of each level of Nutrim on the textural properties of the control. A completely randomized design was used to examine the effect of Nutrim on the color analysis of HRWW noodles. \(t\) tests were used for the textural properties (hardness, chewiness, springiness, cohesiveness, gumminess, and resilience) and RVA (peak viscosity, final viscosity, and setback) responses as a function of varying amounts of Nutrim added to noodles. Weighted regression equations were calculated for color analysis characteristics, \(L^*\), \(a^*\), and \(b^*\) of raw noodles fortified with 0%, 10%, 20%, and 30% Nutrim at 3 different time periods (0, 2, and 24 h). Weighted regressions were computed to compensate for variance heterogeneity of the replicates at each level of Nutrim addition, ranging from 0% (control) to 30% Nutrim in increments of ten. All analyses were performed on transformed data where applicable, but results are presented using untransformed data for ease of interpretation. PROC REG from SAS PC Windows Version 8.2 (SAS Inst. 2002) was the statistical software used for all analyses.

Results and Discussion

Proximate analysis of the flour used showed 12.7 ± 0.1% moisture, 10.7 ± 0.5% protein, and 0.39 ± 0.4% ash. The Nutrim hydrocolloid composition in percentages is as follows: moisture, 6.7; ash, 2.2; fat (ether extraction), 1.1; protein (nitrogen X 6.25), 9.7; crude fiber, 0.25; and \(\beta\)-glucan, 10.0. The pH of a 10% slurry was 5.5 to 6.5.

The texture characteristics of cooked noodles are shown in Table 1. Resilience is the description of the rubbery state (recovery of their energy) of noodles, which is influenced by the overall gluten protein network. Resilience data of the Nutrim-enriched noodles were not significantly different from the control except for the 30%, where significantly higher values than the control were observed (\(P < 0.05\)). The presence of Nutrim at 10% and 20% did not influence the rubbery characteristic of the control. Resilience and springiness could be valuable texture attributes depending on customer preference. Samples enriched with 10% Nutrim showed hardness values comparable to the control, while those enriched with 20% and 30% showed lower hardness, possibly due to Nutrim high water-holding capacity, which could cause looser protein matrix and thus lower hardness values. The viscous nature of \(\beta\)-glucan found in Nutrim allows the formation of a semisolid structure distinct from the protein network, which results in weakening protein network and thus softer noodles. The 20% and 30% Nutrim addition reduced the chewiness by 50% whereas the 10% Nutrim level had no significant effect on the control. Cohesiveness of noodles is defined as the extent of the 2nd deformation of cooked noodle strands, and it can also be related to the sensory characteristics of noodles, that is, bite. The presence of Nutrim at all 3 levels significantly increased the cohesiveness of the control by 7% to 14%. The reason for the increase could be the viscous nature of \(\beta\)-glucan found in Nutrim and its ability to absorb and hold water. The plasticizing effect of water changed the flow dynamic properties of the system and thus changed the cohesiveness. Significantly lower chewiness is noted except with the 10% Nutrim-enriched samples. The presence of Nutrim contributed to a weaker gluten matrix relative to the control.

Flours with higher starch peak viscosity were correlated with desirable texture of white salted noodles properties (Panozzo and McCormick 1993; Ross 1997), whereas good texture in alkaline yellow noodles was correlated with lower peak viscosity and breakdown (Miskelly and Moss 1985). The RVA peak viscosity values shown in Table 1 are lower than the values reported in the literature for white salted noodles. Black and others (2000) reported values up to 290 RVA peak viscosities for white salted noodles. The peak viscosity of the control flour decreased by 7% when 10% and 20% Nutrim was added whereas 30% added Nutrim caused a 2.7% decrease, all of which are significantly lower than the control (\(P < 0.05\)). The presence of the 10% or 20% Nutrim that replaced the starch found in the control could be the cause of the lower viscosity, but the presence of more \(\beta\)-glucan with the addition of 30% Nutrim may have caused the increase in the peak and final viscosity (Table 1). The peak time was decreased with the increase in the amount of Nutrim added due to gluten dilution. The final viscosity was not significantly different from the control with all 3 Nutrim fortification levels. The RVA setback value with 10% Nutrim added was not significantly different from the control while 20% and 30% increased the setback significantly indicating more amylase retrogradation as the system is cooled (\(P < 0.05\)) (Table 1).

The targeted minimum amount (0.72 g/serving) of soluble fiber is 1.71% of 1 serving (40.0 g) db. The amount of soluble fiber in noodles prepared with 20% and 30% Nutrim was 1.67% and 2.47%, which is a high enough amount to make a health claim (Table 1). The 10% Nutrim addition can still be recommended as a good source for soluble fiber (1.40%) because noodles are usually consumed with other types of food where the recommended daily soluble fiber can be met.

Noodles prepared with the control flour required 32% water absorption to form dough with optimum consistency. Farinograph was used to show the effect of Nutrim on the water absorption and dough properties of the flour. The low water content needed for noodles makes it difficult to examine the dough rheology. That is why the Farinograph testing was included, despite the difference in the amount of water between the 2 systems. The presence of Nutrim increased the Farinograph water absorption when compared with the control, as shown in Figure 1. The dough mixing tolerance index was also increased in the presence of Nutrim, where the 10% Nutrim showed the highest value (Figure 2a). The mixing tolerance index is the difference in Brabender Units (BU) between the top of the peak and 5 min later (Figure 2b), where a larger difference indicates a larger influence from Nutrim compared with control. Further increase in Nutrim amounts decreased the control dough tolerance, but there was little difference between 20% and 30%. Dough stabil-
Noodle processing and texture . . .

Table 1—Textural properties, RVA, and soluble fiber content of Nutrim fortified noodles

<table>
<thead>
<tr>
<th>Texture/sample</th>
<th>Control</th>
<th>10% Nutrim</th>
<th>20% Nutrim</th>
<th>30% Nutrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>1719 ± 53</td>
<td>1129 ± 21</td>
<td>788 ± 40p</td>
<td>528 ± 20p</td>
</tr>
<tr>
<td>Chewiness</td>
<td>1174 ± 189</td>
<td>904 ± 26</td>
<td>669 ± 18p</td>
<td>449 ± 16p</td>
</tr>
<tr>
<td>Springiness</td>
<td>0.97 ± 0.01</td>
<td>0.97 ± 0.01</td>
<td>0.98 ± 0.01</td>
<td>0.97 ± 0.0</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>0.77 ± 0.01</td>
<td>0.83 ± 0.3p</td>
<td>0.87 ± 0.01b</td>
<td>0.88 ± 0.01b</td>
</tr>
<tr>
<td>Gumminess</td>
<td>1214 ± 189</td>
<td>931 ± 16b</td>
<td>684 ± 25b</td>
<td>462 ± 18b</td>
</tr>
<tr>
<td>Resilience</td>
<td>0.52 ± 0.02</td>
<td>0.58 ± 0.04</td>
<td>0.63 ± 0.02</td>
<td>0.63 ± 0.01b</td>
</tr>
<tr>
<td>RVA Peak</td>
<td>143.9 ± 0.3</td>
<td>132.6 ± 2.7p</td>
<td>132.8 ± 2.5b</td>
<td>139.5 ± 0.3b</td>
</tr>
<tr>
<td>Final viscosity</td>
<td>91.2 ± 1.2</td>
<td>86.3 ± 3.9</td>
<td>90.1 ± 0.3</td>
<td>96.1 ± 2.1</td>
</tr>
<tr>
<td>Set back</td>
<td>60.6 ± 2.0</td>
<td>61.4 ± 1.3</td>
<td>65.8 ± 0.3b</td>
<td>70.5 ± 1.6b</td>
</tr>
<tr>
<td>Soluble Fiber</td>
<td>1.13 ± 0.09</td>
<td>1.40 ± 0.04</td>
<td>1.67 ± 0.06</td>
<td>2.47 ± 0.05</td>
</tr>
</tbody>
</table>

a Values are means ± standard deviation.
b Indicates significant difference from the control at P ≤ 0.05.
c % soluble fiber/serving (one serving = 42 g or 40.0 db; the 0.72 g soluble fiber is 1.71% of 1 serving).

ity was reduced by 83.5% in the presence of Nutrim (Figure 2b and Figure 3). Dough stability is the difference in minutes between the time where the top of the curve reaches 500 BU and the time where it leaves 500 BU. The increase in the amount of Nutrim did not have further influence on the dough stability.

As the amount of Nutrim is increased from 0% to 30%, color becomes significantly darker, indicated by decreasing L* values (Table 2). The best fit weighted regression equations used for predicting color analysis characteristics (L*, a*, and b*) from Nutrim fortification (X variable) and time (T variable) are

\[ L^* Z = 87.942 - 2.735\sqrt{X} - 1.667\sqrt{T} \quad (R^2 = 0.98) \]

\[ a^* Z = 1.155 + 0.105\ln(X + 0.1) + 0.169\sqrt{T} + 0.0014X\cdot T \quad (R^2 = 0.92) \]

\[ b^* Z = 17.699 + 1.071\ln(X + 0.1) + 0.333\ln(T) + 0.0014X\cdot T \quad (R^2 = 0.97) \]

All equations were statistically significant in explaining color attributes responses from Nutrim fortification and time levels (P = 0.0001). β coefficients for all independent X and T variables in the model were also significant (P ≤ 0.05), indicating true, nonzero contribution to the prediction equation. The 95% confidence inter-

Figure 1—Farinograph results of water absorption as a function of % Nutrim added

Figure 2—(a) Farinograph results of dough tolerance as a function of Nutrim added; (b) Farinograph profile examples of Hard Red Winter Wheat with no Nutrim and 20% Nutrim. The mixing tolerance index and dough stability are marked.
vals on the mean predicted values were used as a multiple comparison test to determine where the Nutrim and time interaction means differed from the others (Table 2). The dark color is associated with polyphenol oxidase activity (Park and others 1997). The higher amounts of added Nutrim seemed to provide additional substrate for the enzyme. Color becomes increasingly darker as time is increased from 0 to 24 h for noodles within Nutrim treatments. As the amount of Nutrim increased, there is significantly higher yellowness or redness intensity, indicated by increasing $b^*$ and $a^*$ values, respectively. As time is increased from 0 to 24 h, significantly higher intensity yellowness or redness is observed for noodles within Nutrim treatments.

The DSC data showed that the onset and peak temperatures of the freeze-dried uncooked noodles increased from 59 to 64 °C and from 68 to 71 °C, respectively, in the presence of Nutrim. The ΔH of the freeze-dried uncooked Nutrim-enriched noodles was decreased to 6 J/g when compared with the control (8 J/g). The effect of Nutrim on the thermal properties of noodles is possibly the result of lesser amount of water available for starch gelatinization. The freeze-dried cooked noodles showed a 72% ΔH value reduction of the control (freeze-dried raw) while Nutrim-enriched noodle ΔH values were reduced by 82%.

The scanning electron microscope images of the raw (Figure 4a, 4b, and 4c) and cooked noodles (Figure 4d, 4e, and 4f) were prepared as shown in Figure 4. The image of the raw noodle showed clear starch granules not covered by protein (Figure 4a). The gluten matrix in noodles is not fully developed because of the inadequate dough mixing and low water content, which is how noodle dough should be to facilitate processing. Starch granules covered with Nutrim network are obvious in Figure 4b and 4c, indicating the effect of Nutrim on the flow properties of the dough. The image of the noodles prepared with Nutrim was more compact with less clear starch granules not covered by protein (Figure 4a). The gluten structure of the noodles in the presence of Nutrim were more obvious after cooking (Figure 4d, 4e, and 4f).

Ross (1997) reported a correlation between starch peak viscosity and noodle quality, as mentioned earlier. Dynamic rheological tests were included here to assist in the interpretation of the effect of Nutrim on flour dough and to establish possible indirect connection between wheat flour rheological profile and noodle quality. These tests were done on the flour, and owing to the high sensitivity of dynamic rheometry, they may be used as early wheat varieties screening to detect attributes related to noodles quality. The use of urea in this test was to ensure the development of a homogeneous and stable suspension throughout the testing time, which is important for utilization of maximum rheometer sensitivity. All of the samples used in rheological measurements were well suspended in sodium phosphate buffer with 3 M urea. Urea (3 M) causes the breaking of hydrogen bonds (Wu and Dimler 1964; Xu and others 2001) without affecting the other components of the flour. The linear dynamic frequency sweep results for the suspensions with and without Nutrim are shown in Figure 5. The storage moduli or elasticity (G’) for suspension of flour without Nutrim were higher than those with Nutrim. The plateau of G’ was 79 Pa for flour suspension without Nutrim blending. The phase shifts (δ) were 17 to 25 degrees within the range of measured frequencies (data not shown). The phase shifts (δ) for flour suspensions blended with 10%, 20%, and 30% Nutrim and unblended flour were all 14 to 26 degrees. However, the plateaus of G’ were 42 Pa, 35 Pa, and 30 Pa for flour suspensions blended with 10%, 20%, and 30% Nutrim, respectively. The added Nutrim made suspensions exhibit slight lower elasticity. The addition of more Nutrim lowered the G’ values further. The nonlinear viscoelastic properties of the suspensions showed the same trend as above (Figure 6). All of the suspensions exhibited shear-thinning behavior as the shear rate increased. The suspensions of flours blended with Nutrim had lower viscosities than the control (Figure 6), but the results noted above showed that the viscoelastic behavior of the flours with Nutrim did not change much when up to 30% Nutrim was added. The results gave a trend of shifting viscoelastic properties. According to these results, it could be predicted that the process of noodle making and the viscoelastic properties of noodles using flours blended with up to 30% Nutrim would be similar to those of unblended flour.

**Conclusions**

Soluble fiber content of fresh alkaline noodles can be increased to 1.67% by adding at least 20% Nutrim, which is very close to the targeted value of 1.71% needed to make the health claim. The

| Table 2—Predicted mean color attribute of raw noodles fortified with 10%, 20%, and 30% Nutrim from individual weighted regression equations |
|-----------------|---------|---------|
|                 | $L^*$   | $a^*$   | $b^*$   |
| **Control**     |         |         |         |
| 0 h             | 87.5 ± 0.26a | 1.01 ± 0.08f | 15.46 ± 0.65h |
| 2 h             | 86.6 ± 0.38b | 1.08 ± 0.13ef | 15.56 ± 0.94gh |
| 24 h            | 82.6 ± 1.12 c | 1.36 ± 0.25bcd | 16.80 ± 0.61g |
| 10% Nutrim      |         |         |         |
| 0 h             | 79.8 ± 1.20c | 1.30 ± 0.17de | 19.60 ± 0.95f |
| 2 h             | 77.1 ± 0.85d | 1.67 ± 0.25bc | 21.53 ± 0.38e |
| 24 h            | 70.5 ± 0.40g | 2.93 ± 0.06a | 23.63 ± 0.25bc |
| 20% Nutrim      |         |         |         |
| 0 h             | 76.5 ± 0.80d | 1.33 ± 0.12cd | 20.57 ± 0.58ef |
| 2 h             | 73.2 ± 0.46e | 1.77 ± 0.15b | 22.03 ± 0.70d |
| 24 h            | 66.2 ± 0.98h | 2.73 ± 0.17a | 23.73 ± 0.31ab |
| 30% Nutrim      |         |         |         |
| 0 h             | 73.6 ± 0.58ef | 1.53 ± 0.06cd | 21.30 ± 0.44de |
| 2 h             | 70.6 ± 0.64g | 1.87 ± 0.12b | 22.57 ± 0.32cd |
| 24 h            | 64.1 ± 0.40h | 3.03 ± 0.06a | 23.27 ± 0.12a |

*S* = lightness, higher values indicate lighter color; a* = redness and b* = yellowness, higher color intensity is indicated by higher values.

b * = yellowness, higher color intensity is indicated by higher values.

a L * = lightness, higher values indicate lighter color; a * = redness and

Table 2—Predicted mean color attribute of raw noodles fortified with 10%, 20%, and 30% Nutrim from individual weighted regression equations
quality characteristics of the Nutrim-enriched noodles are somewhat acceptable considering the amount of soluble fiber delivered. This project is another way of delivering soluble fiber, which is desired because of its medicinal value. White wheat grown in areas such as Washington State is exported to Asia mostly for noodle products. The data presented here could further the sales of the nontraditional U.S. wheat exported for noodles products, such as Hard Red Winter wheat.

Figure 4—Scanning electron microscope images of raw and cooked noodles with and without Nutrim. (a) Raw control noodle; (b) raw 10% Nutrim noodle; (c) Raw 30% Nutrim noodle; (d) cooked control noodle; (e) cooked 10% Nutrim noodle; (f) cooked 30% Nutrim noodle (Magnification = 400×)
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References


