Textural and Other Quality Properties of Instant Fried Noodles as Affected by Some Ingredients

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ABSTRACT

The effects of varying the proportion of three noodle dough components (water, gum, and starch) on the texture (maximum load and strain at break), amount of fat absorbed, and percent rehydration of instant fried noodles were studied. The Instron Universal testing machine was used to measure noodle texture, whereas quality attributes were determined using fat absorption and rehydration parameters. The results showed that changes in maximum load, strain at break point, fat absorption, and rehydration% of instant noodles depended on interactions between the ingredients. Increasing the gum content, starch content (for amounts >4% kg/kg of flour) and moisture content (35–40% kg/kg of flour) enhanced the elasticity and extensibility of cooked instant fried noodles. Addition of starch decreased fat absorption but showed mixed effect on rehydration%. The effect of gum addition at 0.1, 0.2, and 0.3% on fat absorption was significant but reduced considerably or showed a reverse effect at higher starch addition levels. Increasing moisture, and gum contents increased rehydration% of cooked instant noodles. Appropriate combinations of gum, starch and moisture contents could be used to optimize textural and quality characteristics of fried instant noodles.

Instant noodles originated from the traditional Oriental noodle and are gaining popularity in the North American market. This is partly due to ease of preparation (short rehydration time) and partly due to texture. Kubomura (1998) described the texture of instant noodles as rubbery, firm, or smooth. Based on research (Oh et al 1983; Lee et al 1987; Hou et al 1997), two general sensory and instrumental methods can be used for direct textural evaluation of noodles. A chemical method has also been reported as an indirect method for textural evaluation of noodles (Dexter et al 1985; D'Egidio et al 1993). Sensory evaluation of noodle quality is the ultimate method for evaluating the quality of final products. Nevertheless, sensory evaluation may be subjective, laborious, and expensive. Therefore, quicker and more accurate methods are required to evaluate the quality of noodles (Hou 2001).

Instrumental measurement of cooked noodle texture could be a reliable and convenient alternative to the sensory method (Oh et al 1983; Lee et al 1987; Hou et al 1997; Kovacs et al 2004). Two basic instrumental methods are commonly used: compression, including simple compression and texture profile analysis (TPA), and tensile tests. Oh et al (1983) gave the basis of how to perform cutting and compression tests on cooked noodles. They reported that the maximum cutting stress and the resistance to compression of cooked dry noodles were highly correlated with sensory noodle firmness and chewiness, respectively. Several tests were conducted by other authors using either these methods or modifications (Baik et al 1994; Yun et al 1997; Hou et al 1997; Hatcher et al 1999).

The TPA method was first presented by Peleg (1976). Baik et al (1994) used the TPA method to evaluate the effect of starch and protein on noodles. They found that high starch pasting properties and swelling power may be responsible for the high quality of Japanese noodles, but the properties may be less critical for the quality of Cantonese and instant noodles. The tensile test is also useful and commonly used in noodle studies. Bhattacharya et al (1999) and Srinivasan et al (2000) used tensile test to determine the elasticity and extensibility of rice noodles and tortillas, respectively. Although these texture parameters are important for instant noodles, not much has been reported about their measurement.

The objectives of this study were to determine the influence of three ingredients (water, starch, and guar gum) on textural (tensile test) and other quality properties (fat absorption and rehydration) of instant fried noodles.

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MATERIALS AND METHODS

Materials

Unbleached, baker's patent flour, milled from a Canadian Hard Red Spring wheat was used in the experiment. Flour composition (kg/kg of flour) was 14% water, 0.53–0.58% ash, and 13.0–14.0% protein. The granulation of the flour was 100% finer than 149 µm (U.S. 100 mesh). The starch was a food-grade specialty acetylated potato starch (CLEARRAM PGHV, Roquette Frères, Lestrem, France). The starch had a high Brabender viscosity compared with other starches (such as native potato, maize, tapioca, wheat, and waxy maize starches). The starch also had low gelatinization temperature of ≈57°C, good dispersion in cold, lipid, and hot liquids, and a low tendency to retrogradation. The guar gum (TICOLV, TIC Gum, Belcamp, MD) was in the powder state and first distributed in water with a stirrer (stirrer/hotplate, PC-520, Corning, Corning, NY) at room temperature. It was then stored for ≈12 hr at room temperature and stirred again until distributed uniformly.

Preparation of Instant Fried Noodles

The instant noodle dough was formulated by mixing 100% flour, 1.5% (kg/kg of flour) salt, 0.1% alkaline salt (potassium carbonate and sodium carbonate mixed 1:1), 0–0.37% gum, 0–9.2% starch, and 27.3–40.7% water. The quantities of salt and alkaline salt were based on an industrial recipe. The noodle dough was mixed using an electric pasta machine (ATLAS 182 Electric Pasta Maker, OMC Marcato, Italy). Flour (300 g) was mixed with starch in the mixing chamber of the pasta machine. Water containing dissolved salts and guar gum was slowly added to the flour mixture and mixed thoroughly. The pasta machine was then operated intermittently for 1 and 3 min until the dough was properly and evenly formed. The dough was removed from the pasta machine and cut into three uniform small pieces. The dough was passed through the roller unit attachment with the regulating knob set at position no. 1 (2.5 mm). The resulting sheet was folded in half and passed again through the rollers.

To make instant noodles, the dough sheet was further pressed through the noodle machine with the roller gap gradually reduced to 1.5 mm. The dough sheet was then put through the cutter attachment. The dimension of the sheet was 1.5 mm in width and 1.5 mm in thickness. The resulting noodle strip was placed uniformly into a steam pan and then put into a preheated (100°C) steamer, and cooked for 2 min until the noodle strip had a smooth surface and an elastic texture. The next and final step was frying. A deep fat fryer (Computron 7000, Henny Penny Corp., Eaton, OH) and hydrogenated vegetable oil (liquid frying shortening, CanAmera Foods, Oakville, ON) were used. The frying temperature was 150°C and the frying time was 2 min.

The steamed noodle strips were individually placed in a wire basket and the basket was immersed in frying oil to a depth of 10 cm. The fried noodle strips were allowed to cool after frying and excess oil was drained from the surface. The cooled samples were separately stored in plastic bags for further tests.

Fat Analysis

Fat analysis was performed according to Approved Method 30-25 (AACC 2000) and the operation manual of the fat extractor. The fried noodles were uniformly ground using a homogenizer-blender (model E160B, Proctor-Silex, Picton, ON). Fat extraction was performed with petroleum ether using a solvent extractor (SER148, Velp Scientifica, Usmate, Italy). Three repetitions were made for each measurement and the average data collected was used for statistical analysis.

Noodle Cooking

Six fried instant noodle strands (25 cm long) were added to 400 mL of boiling water in a 500-mL beaker. The fried instant noodles were cooked to the optimum cooking time (4 min) according to the method of Oh et al (1983). After cooking, the noodles were cooled in running tap water (≈17°C) for 1 min. The drained noodles were then stored in a covered plastic container at room temperature (25°C) for 5 min before the tensile test.

Tensile Test

Tensile tests were conducted using the Instron Universal testing machine (model 4201, powered by Series IX software, Automated Materials Testing System, v.5, Instron Limited, England) with a two-grip attachment. Each end of the cooked instant fried noodle strip was wrapped three times around the grip. Friction held the noodle strip to the grip while tensile force was applied. A 0.5-kN load cell was used. Crosshead speed for all tests was 50 mm/min. All tests were performed within 5 min. Several textural parameters including maximum load (ML) and strain at break point (SB) were obtained from the tensile test. ML was taken as the maximum stress absorbed by the noodles before breaking, whereas SB represented the maximum strain absorbed by the noodles before breaking. All experimental conditions were replicated three times and the average values were used for statistical analysis.

Rehydration Test

Fried instant noodle strands were cooked for 4 min until the white inner core disappeared. The cooked noodle strands were then placed in cold water, drained, wiped with paper towels, and kept covered in plastic box. The gain in noodle weight after cooking was recorded as rehydration% according to the method of Beta and Corke (2001).

Experimental Design and Data Analysis

The central composite rotatable design (CCRD) (Box and Draper 1987) was used in this study. The response surface method was used to analyze the effect of variables (water, gum, and starch) on quality properties (ML, SB, fat absorption, rehydration). The experimental design and levels of factors are shown in Tables I and II. The main advantage of the experimental design approach was the ability to reduce the number of experimental runs required to provide sufficient information for statistically acceptable results. The response surface produced from the second-order polynomial model was used as an approximation. The experiments were processed in a random order and the data was analyzed using software (SPSS for Windows, v. 8.0. SPSS Inc., Chicago, IL). The general form of the quadratic polynomial model that was used in this study used three X-variables:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{33} X_3^2 + \beta_{12} X_1 \times X_2 + \beta_{13} X_1 \times X_3 + \beta_{23} X_2 \times X_3 \quad (1)$$

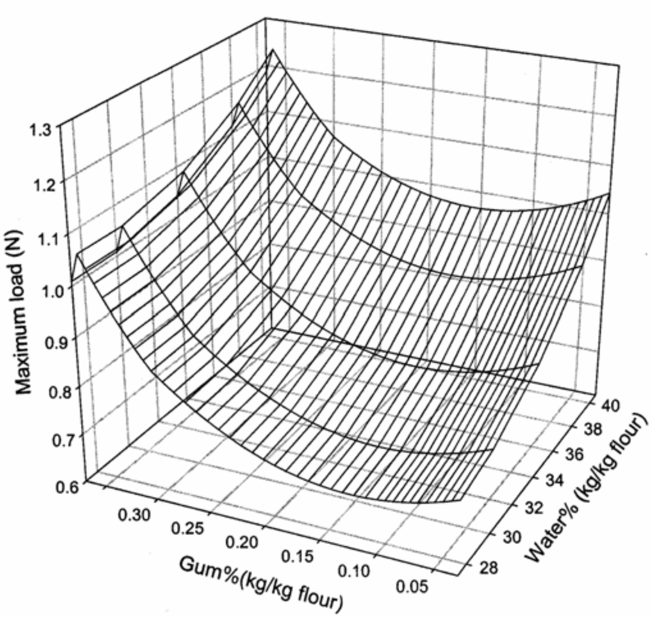

Fig. 1. Effect of water and gum contents on maximum load of cooked instant fried noodle. Starch content was 5% (kg/kg of flour).

TABLE II
Experimental Design and Levels of Factors (%) in Actual Values

	Actual Values of Factors (kg/kg of flour)		
Test	**Water Content**	**Gum Content**	**Starch Content**
1	30	0.1	2.5
2	30	0.1	7.5
3	30	0.3	2.5
4	30	0.3	7.5
5	38	0.1	2.5
6	38	0.1	7.5
7	38	0.3	2.5
8	38	0.3	7.5
9	27.3	0.2	5
10	40.7	0.2	5
11	0	0.03	5
12	0	0.37	5
13	0	0.2	0.8
14	0	0.2	9.2
15	0	0.2	5
16	0	0.2	5
17	0	0.2	5
18	0	0.2	5
19	0	0.2	5
20	0	0.2	5

TABLE I
Experimental Design and Levels of Factors in Coded Values

% (kg/kg of flour)	Coded Factor	–1.682	–1	0	1	1.682
Water content	X1	27.3	30	34	38	40.7
Gum content	X2	0.03	0.1	0.2	0.3	0.37
Starch content	X3	0.8	2.5	5	7.5	9.2

which contains linear terms X_1, X_2, X_3, and square terms X_1^2, X_2^2, X_3^2. The variable X_1 represents water content, X_2 represents gum content, and X_3 represents the amount of starch added. *Y* represents the dependent variable (ML, SB, fat absorption, or rehydration%) to be modeled. The terms β_1, β_2, β_3, β_{11}, β_{22}, β_{33}, β_{12}, β_{13}, and β_{23} are regression coefficients of the model (Table III).

RESULTS AND DISCUSSION

Maximum Load (ML)

Statistical analysis of data showed that the water, starch, and gum significantly ($P < 0.05$) affected ML of cooked noodles. This implied that water, starch, and gum contents influenced the elasticity of cooked instant noodles.

Figure 1 shows response surface for ML for the various levels of water and gum contents. ML increased steadily with increasing moisture content. Statistical analysis of the effect of gum addition at the 0.1, 0.2, and 0.3% (kg/kg of flour) levels, showed significant effect of gum, particularly at the 0.3% level where the ML attained higher values for corresponding moisture content values. This indicated that the addition of gum significantly influenced the relationship between ML and moisture content of cooked instant noodles.

The ML values also increased with increasing starch addition when starch levels are >4% as shown in Fig. 2. The effect of gum addition at 0.1, 0.2, and 0.3% was also significant, particularly at 0.3%, which again recorded the highest value of ML. However, the effect of gum addition diminished considerably at higher starch addition levels. This indicated that both starch and gum performed complimentary roles in enhancing textural quality of instant noodles.

Starch and other ingredients generally play an important role in defining textural quality of different kinds of noodles (Baik et al 1994; Edwards et al 1995; Hatcher et al 2002). The pasting and swelling qualities of starch combined with the binding qualities of gum may have resulted in increased network formation and contributed to the observed effect on ML of cooked instant noodles. Apparently, at lower starch concentration, binding of components and formation of network in the instant noodle was dominated largely by gum. Water acts as a plasticizer in composite materials (Lawton 2004). Insufficient water reduces cohesion of the material components, whereas too much water will dilute the components, resulting in a weak noodle. For the water range used in this study, increasing moisture content apparently resulted in increased cohesion and ML for the cooked instant fried noodle.

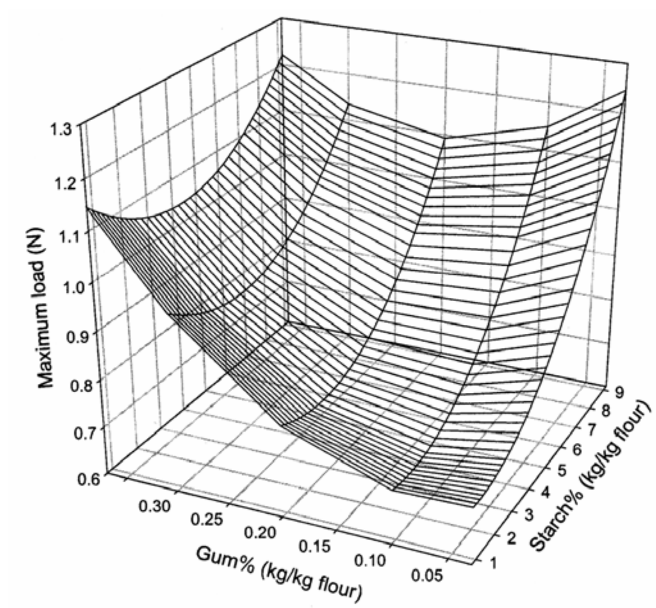

Fig. 2. Effect of starch and gum contents on maximum load of cooked instant fried noodle. Moisture content was 34% (kg/kg of flour).

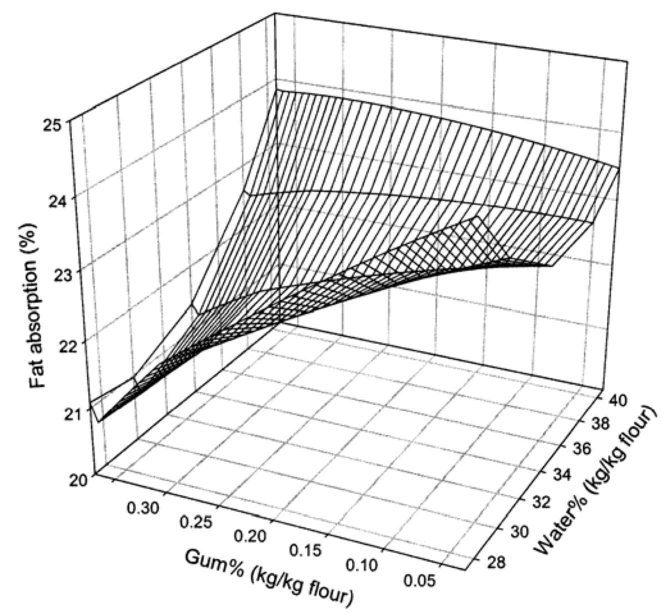

Fig. 3. Effect of changes in water and gum contents on fat absorption in instant fried noodle. Starch content was 5% (kg/kg of flour).

TABLE III
Regression Coefficients of Second-Order Polynomial Models for Responses Analysis Performed Using Coded Units[a]

Factors[b]	Fat Absorption (%)	Rehydration (%)	Maximum Load (N)	Strain at Break (%)
Constant	22.372*	1.452*	0.800*	65.671*
W	0.227	0.053*	0.069*	2.996*
G	–0.480*	0.030*	0.059*	2.881*
S	–0.704*	0.016	0.088*	4.210*
W2	0.370*	–0.005	0.015	2.549*
G2	–0.054	0.020	0.051	2.925*
S2	0.005	–0.020	0.051	1.663
W × G	0.346	0.006	–0.012	0.549
W × S	0.078	0.011	–0.013	1.099
G × S	0.704*	0.006	–0.038	–1.524
R^2	0.832	0.820	0.758	0.868
F-ratio	5.51	5.08	3.58	7.33
Probability of *F*	$P \leq 0.05$	$P \leq 0.05$	$P \leq 0.05$	$P \leq 0.05$

[a] *, $P \leq 0.05$.
[b] W, water content; G, gum content; S, starch content.

Strain at Break Point (SB)

Statistical analysis of data showed that water, gum, and starch addition level significantly ($P < 0.05$) affected the SB of cooked noodles. The SB increased steadily with increasing moisture content at 32–40% (kg/kg of flour). Not much change in SB values was observed at moisture content levels <32%. The effect of gum addition at 0.1, 0.2, and 0.3% was also significant, particularly at 0.3%, where SB attained highest values for corresponding moisture content values. The results showed that the addition of gum in varying quantities significantly influenced the relationship between SB and moisture content of cooked instant noodles.

The response surface analysis of the effect of starch addition and gum on SB showed that the SB increased consistently with the increasing starch addition levels. The effect of gum addition at 0.1, 0.2, and 0.3% was also significant. However, the effect of gum addition reduced considerably, becoming very small at the higher starch addition level of ≈9%. Again, the results indicate that both starch and gum perform complimentary roles in enhancing the extensibility and textural quality of instant noodles. The influences of ingredients on SB were consistent with their influence on ML. The complementary pasting, binding, and plasticizing roles of starch, gum, and water, respectively, contributed to both the mechanical strength and elasticity of cooked instant fried noodles.

Fat Absorption of Instant Noodles

Statistical analysis of data showed that starch and gum addition significantly ($P < 0.05$) affected fat absorption level of instant noodles. The interaction of gum and starch was also significant ($P < 0.05$). There might be some cross-link occurrence between starch and gum during starch gelatinization process that led to an indirect effect of gum on the fat absorption level of instant noodles (Edwards et al 1995; Kim and Wang 1999; Kruger et al 2003).

Fat absorption decreased initially with increasing moisture content at 30–35% and it later increased as moisture content increased further at 35–40% (Fig. 3). The effect of gum addition at 0.1, 0.2, and 0.3% was also significant, particularly at 0.3%, which recorded the lowest value for the fat absorption at lower moisture content values. Hydrocolloids reduce fat absorption in fried food products (Balasubramaniam et al 1997; Albert and Mittal 2002). This effect is attributed to water-binding properties. At the initial increase in moisture content of 30–35%, gum addition at 0.1–0.3% decreased the fat absorption. However, as the moisture content was increased at 35–40%, the effect of gum became less significant with almost no change at 40% moisture content. The result indicated that water apparently diluted and adversely affected the functionality of gum at the higher concentrations.

Fat absorption decreased steadily (for gum content <0.25%) with increasing starch addition as shown in Fig. 4. The effect of starch can be attributed to binding functionality (Kadan et al 2001). The effect of gum addition was also significant at 0.1, 0.2, and 0.3% gum addition for corresponding starch addition levels. Higher gum content, when combined with increasing starch content, showed a tendency to increase fat absorption in instant noodles.

Rehydration% of Instant Noodles

Statistical analysis of data showed that moisture content and gum addition significantly ($P < 0.05$) affected rehydration% of instant noodles. Figure 5 shows the response surface of rehydration% with respect to gum and water contents. Increasing water content increased rehydration% of cooked noodle. Addition of gum at 0.1–0.3% also increased rehydration%. The highest rehydration% was observed at ≈0.3% gum addition for all corresponding moisture (and starch) content values. Changing starch content resulted in only slight change in rehydration%. Gum addition in the presence of adequate moisture content supports higher rehydration% of cooked instant noodles.

CONCLUSIONS

Ingredients of noodle dough such as moisture content, gum content, and starch addition generally influenced the textural characteristics of instant noodles. The addition of gum in varying quantities played a significant role in the relationships between ML, SB point, fat absorption, and moisture content for instant noodles. It was also observed that both starch and gum performed complimentary roles in enhancing the elasticity and extensibility of instant fried noodles. In addition, while gum as a hydrocolloid substance in water reduced fat absorption at low moisture content, it generally increased rehydration% of instant noodles. Increasing starch addition at lower gum contents (<0.25% kg/kg of flour) decreased fat absorption, whereas a reversed effect was observed at higher gum contents. Results of this study could be applied to quantify amount of ingredient combinations for optimal quality of fried instant noodles.

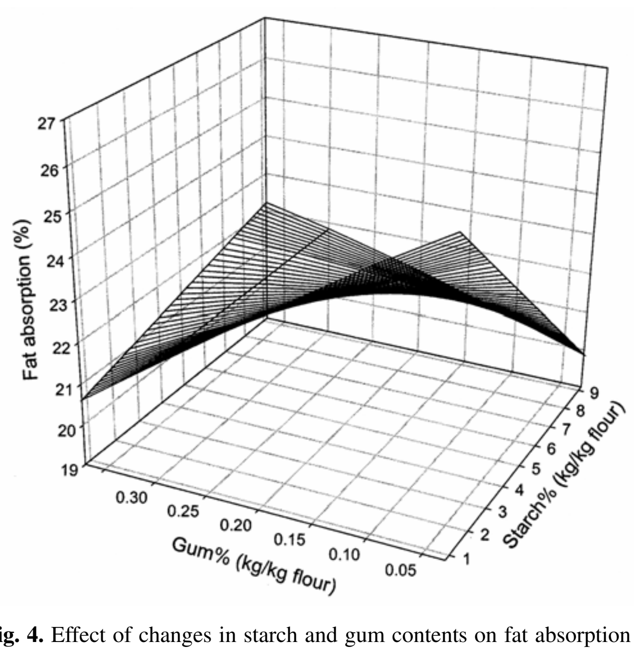

Fig. 4. Effect of changes in starch and gum contents on fat absorption in instant fried noodle. Moisture content was 34% (kg/kg of flour).

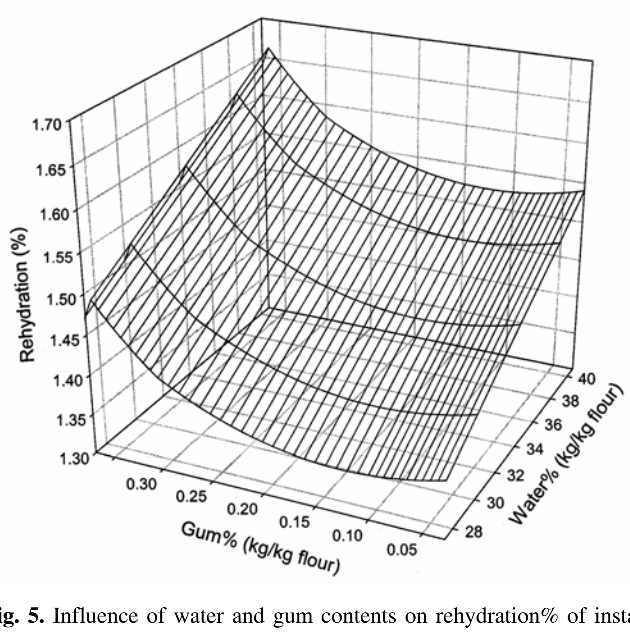

Fig. 5. Influence of water and gum contents on rehydration% of instant fried noodle. Starch content was 5% (kg/kg of flour).

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