Formulation of Pasta Noodles Made with Peanut Flour

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ABSTRACT

Peanut pasta was created by replacing a portion of the durum wheat flour with peanut flour in a basic pasta formulation. Pasta noodles were made using cold extrusion and forced-air oven drying. An improved formulation and approximate ranges for ingredients were determined through a series of functionality tests.

Appropriate water percentage in the dough was found to be 40% for good handling characteristics. A hydrocolloid stabilizer, λ-carrageenan, was useful at levels between 1.5 and 2.9% to enhance dough binding properties and allow the use of peanut flour in greater proportions. The maximum acceptable level for peanut flour replacing durum wheat flour was found to be 50%. Drying pasta to 8% moisture at different temperatures allowed direct comparison of drying temperature effect. Mechanical properties of dried peanut pasta improved with increasing levels of λ-carrageenan in the formula. Peanut pasta containing λ-carrageenan between 2.5 and 2.9% produced the best tensile strength. Pasta color lightness decreased with increasing drying temperature, as well as with increasing levels of peanut flour. An informal sensory evaluation of these products suggested that peanut pasta might be acceptable to consumers and has potential in health food and Asian food markets.

Key Words: Peanut, pasta, λ-carrageenan.

Peanut flours are low fat, high protein functional ingredients prepared from partially defatted, roasted peanut kernels. Peanut flour has the potential to partially substitute durum wheat flour in pasta formulation. The two flours have nutritionally complementary proteins, resulting in a product with improved protein quality (Abdel-Aal and Hucl, 2002; Seligson and Mackey, 1984). Since peanut flour has more protein per gram than durum wheat flour, substitution in formulation also yields an increase in total protein.

Many pasta products have been produced with protein-enhancing ingredients in recent decades, but only one study has involved peanut flours. This previous study reported the use of peanut flour in pasta at a maximum of 15% replacing wheat flour in the formula (Chompreeda *et al.*, 1987). To significantly improve protein quality and increase the total protein in the product, higher levels of peanut flour should be used. Previous studies of fortified durum wheat pasta products have reported that replacement of wheat flour with other sources of protein can result in reduced dough viscosity (Doxastakis *et al.*, 2007; Prabhasankar *et al.*, 2007). This problem is usually related to a damaged gluten network (He *et al.*, 1999; Sissons *et al.*, 2007). Non-viscous pasta dough is difficult to handle, and it presents problems with extrusion equipment. Methods of improving pasta dough functionality have traditionally included the addition of extra wheat gluten to the formulation (Matsuo *et al.*, 1972; Raina *et al.*, 2005; Sissons *et al.*, 2007) or the addition of hydrocolloid gums to bind water and increase viscosity by interacting with starch and proteins (Andres 1976a, 1976b; Raina *et al.*, 2005). In most cases where the dough properties are substandard, the addition of these binding ingredients has been quite successful.

Several physical measurements are indicative of pasta quality. Firmness tests can measure the breaking strength of dry noodles, as well as cooked noodles; and quantification of the cooking loss can indicate whether noodle composition is maintained during the cooking process. Low cooking losses and firm texture are usually indicative of pasta with a strong gluten system, and are usually attributed to products with superior ingredients (Dexter and Matsuo, 1979). Besides lack of strong gluten protein in the fortified formulation, other factors that affect physical properties of pasta include drying conditions (Cubadda *et al.*, 2007; Takhar *et al.*, 2006), cooking time (Dexter and Matsuo, 1979), and addition of functional ingredients (Andres 1976b; Grant *et al.*, 1993).

In this study, the objective was to develop a formulation for pasta noodle using peanut flour as a protein supplement. Physical property tests were conducted to determine the appropriate level of each ingredient in the peanut pasta dough and functionality of pasta ingredients. A preliminary sensory evaluation was conducted to determine the potential for consumer acceptability. The goal was to develop a formula and process that could yield strong pasta dough, as well as fracture-resistant dry noodles, while still maintaining an acceptable flavor profile.

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Table 1. Initial peanut pasta formula.

	Basic pasta recipe		Basic peanut pasta recipe	
	mass (g)	percentage (%)	mass (g)	percentage (%)
durum wheat flour[1]	200	72	150	54
peanut flour[2]	—	—	50	18
water	75	27	75	27
salt[3]	2	1	2	1
total	277	100	277	100

[1]100% durum wheat flour, www.bulkfoods.com

[2]Light roast peanut flour, partially defatted (12% fat), Golden Peanut Company, Alpharetta, GA

[3]Iodized salt, Morton International, Inc., Chicago, IL

Materials and Methods

Peanut flour used for these experiments was a light roast, 12% fat peanut flour provided by Golden Peanut Company (Alpharetta, GA). Peanut pasta was created by modifying a basic pasta recipe, which included durum wheat flour and water. In the initial stage of formulation, peanut flour replaced 25% of the durum wheat flour in the basic recipe (Table 1). Ingredients were mixed with a spoon until evenly distributed and then hand-kneaded into dough. Long, pasta noodles were created by extruding the dough through a small Kitchen Aid® grinder attachment with internal screw movement powered by a Hobart® mixer (model N-50, Troy, OH). To ensure consistency, doughs were extruded through the Kitchen Aid grinder and re-mixed twice before making the final paste. A wooden press (stomper) was used to manually push dough into the attachment, through the screw chamber and out through circular perforations.

Several preliminary experiments were conducted to improve the consistency of the pasta dough. In the first experiment, the amount of water in the formula was adjusted. A higher level of water was expected to help dissolve the dry ingredients and perhaps reduce the crumbly texture. Four different batches of pasta were prepared using the initial formulation with increased water levels to 30, 35, 40, and 45%. A second experiment was conducted to further improve dough functionality. Lambda carrageenan (TIC Pretested® Ticaloid® 780 Stabilizer, TIC Gums, Belchamp, MD) was added (0.3, 0.8, 1.3, 1.8, and 2.3%) to five batches of the formulation with 40% water.

Since the addition of λ-carrageenan improved the functional and textural properties of peanut pasta dough, a third experiment was conducted to determine whether the addition of λ-carrageenan allowed the use of even higher level of peanut flour in the formulation. The formulation was adjusted to include peanut flour at 25, 30, 35, 40, 45, 50, 60, and 70% of the total flour. Dough handling properties for each of the above mentioned formulations were observed as well as color and flavor to determine the maximum acceptable proportion of peanut flour. Noodles of each formulation were prepared for flavor and color evaluation by boiling the fresh pasta noodles in water for 5 min.

Additional experiments were conducted to determine specific effects of λ-carrageenan level (1.5, 1.8, 2.1, 2.3, 2.6, 2.9, 3.2, 3.5, and 3.8%) on the quality of the dried peanut pasta. Samples were prepared with 40% water, and the flour portion was 40% peanut flour and 60% durum flour. Noodles were extruded as described above. Once formed, pasta noodles were placed on a perforated drying pan and dried in a forced-air convection oven (Lindberg/Blue M mechanical oven, model MO1440SC, Industrial and Laboratory Heaters, Asheville, NC) at 121 C for 20 minutes. Percent moisture of the dried product was determined for each sample using a vacuum oven, following AACC method 44–40 (AACC, 2000). Moisture values for each sample type were averaged from triplicate determinations. Water activity of dried pasta was determined using an Aqua Lab® water activity meter (model series 3TE, Decagon Devices, Inc., Pullman, WA). Tensile strength of the dried pasta noodles was determined using a compression test using an Instron® universal testing machine (model 5542, Instron Corporation, Canton, MA). Three strands of pasta were placed on a rubber block, several centimeters under the compression blade. The blade (40.8 mm wide, 1.01 mm thick), which was positioned 6 mm over the rubber block, fractured the noodles as it was lowered at a crosshead speed of 20 mm/min (Chompreeda *et al.*, 1987). The maximum force (Newtons) required to compress/fracture the noodles was recorded. Compression force of each sample type was measured in triplicate. Color measurements were conducted using a HunterLab® MiniScan XE™ colorimeter (model 45/0-L, Hunter Associates Laboratory, Reston, VA). Samples were held inside an anti-reflective glass container, the base of which was positioned against the color scanner. Fifteen-gram samples of pasta in small pieces (enough to completely cover the base of the container), were placed inside the container. The colorimeter was standardized with black and white tiles. Color values were measured in triplicate, rotating the sample container between readings; and measurements were recorded as L* (lightness), a* (red-green), and b* (yellow-blue).

To evaluate the effect of drying time and temperature, pasta samples with 30% water and 2.6% λ-carrageenan were prepared. The flour in these samples consisted of 40% peanut flour and 60% durum wheat flour. Moisture analysis of dry whole wheat and white spaghetti, obtained from a local grocery store, was used to determine a target moisture value for dried peanut pasta. The whole wheat pasta had an average of 6.7% moisture, and the white pasta had an average of 8.5% moisture. Both had an average water activity value of 0.5. The time required to dry peanut pasta to 8% moisture (about 0.5 water activity) was determined at different drying temperatures (60, 74, 77, 82, 88, and 93 C) by removing samples from the drying oven in 15-minute intervals and determining moisture content via AACC method 44–40 (AACC, 2000). Mechanical properties, color, and water activities of samples dried to 8% moisture at each drying temperature were then analyzed using the methods described above.

The effect of flour composition (30, 40, and 50% peanut flour) in the formulation was evaluated by testing dried peanut pasta for moisture, mechanical properties, and color. These samples were made with 40% water and 2.6% λ-carrageenan. Each of these three samples was dried at 60 C for 165 minutes. Mechanical properties, color, and moisture content of dried samples were determined as described above.

To evaluate whether these peanut pasta formulations have potential in the market place, an informal survey based on the potential "home use" of peanut pasta was performed at the 2007 Georgia Peanut Tour in Bainbridge, GA. Dried pasta was distributed to 20 volunteer participants during the Hot Topics seminar. Panelists were each issued a paperboard tube, which contained a sample of dried peanut pasta inside a plastic bag, as well as a control sample of dried whole wheat pasta (Heartland® Whole Wheat Spaghetti, American Italian Pasta Co., Kansas City, MO) in a separate bag. Peanut pasta samples were made with 40% water and 2.6% λ-carrageenan; flour composition included 40% peanut flour and 60% durum wheat flour. These samples were dried at 60 C for 165 minutes. Participants were asked to prepare this pasta sample at home, following the instructions provided. They were suggested to cook pasta samples in two separate saucepans with boiling water, eight minutes for whole wheat pasta and five minutes for peanut pasta. Cooked pasta were then drained and tasted with any sauce they normally eat with pasta. Completed evaluation sheets were returned to the UGA Griffin campus by mail in pre-stamped envelopes.

Results were analyzed using SAS version 9.1 (SAS Institute, 2004). Analysis of variance (ANOVA) was conducted and comparison of means were obtained using Duncan's multiple range tests.

Results and Discussion

Pasta dough made from the initial formulation was coarse and crumbly with limited elasticity. Even when the dough was mixed and extruded multiple times, the dough showed no binding or stretching properties. The dough also had a tendency to clog the extrusion apparatus.

Results from preliminary experiments indicated that the optimum peanut pasta formula should include 40% water and at least 1.8% λ-carrageenan. The preliminary tests showed a water level of 40% in the peanut pasta dough was needed to fully hydrate the flours and eliminate the crumbly dough texture. The improved dough, however, lacked cohesiveness and viscosity, preventing extruded noodles from maintaining their shape. The dough was too easily stretched and deformed; this behavior is unsuitable for extrusion of pasta.

Dough handling properties were improved by the addition of λ-carrageenan, and the minimum functional level was determined to be 1.8%. Peanut pasta dough containing 1.8% or more λ-carrageenan had increased viscosity and cohesiveness, as well as shaping ability, due to the viscous and elastic properties imparted by the stabilizer.

In the experiments to determine peanut/durum wheat flour proportions, pasta was formulated with 58.2% flour, 40% water, and 1.8% λ-carrageenan. The proportion of peanut flour ranged from 25 to 70%. No major differences were observed in the handling characteristics due to the peanut flour compositin. Therefore, from a dough handling perspective, intact fresh noodles could be formed with peanut flour comprising up to 70% of the total flour with the inclusion of 1.8% of λ-carrageenan in the formulation.

The high peanut flour levels, however, adversely affected the flavor and color of the pasta, limiting the amount of peanut flour that could be used. Pasta samples containing up to 50% peanut flour were relatively acceptable in taste and color, but samples with higher portions of peanut flour had an extremely harsh and over-roasted taste, as well as an unpleasant dark color. The maximum level for peanut flour in wheat pasta should be limited to 50% of the total flour.

Lambda Carrageenan levels of 1.8%–2.9% in the formula provided the best performance in this product, creating dough with improved handling

Table 2. Moisture content, water activity, and maximum compression force of dried pasta with different λ-carrageenan levels*.

Lambda-Carrageenan (%)	Moisture (%)	Water activity	Compression force (N)
1.5	12.75	0.752	28.75f
1.8	12.79	0.761	31.63ef
2.1	14.5	0.784	34.00de
2.3	13.62	0.775	34.22de
2.6	14.53	0.798	39.48bc
2.9	14.95	0.793	40.22b
3.2	14.76	0.794	40.77b
3.5	14	0.765	40.05bc
3.8	15.8	0.787	38.41bcd
White pasta			50.10a
Whole wheat pasta			35.49cde

*Pasta dough containing 40% moisture was made with 40% peanut flour and 60% durum wheat flour. Within the same column, means followed by the same letter are not significantly ($p>0.05$) different.

properties and dried pasta with increased tensile strength than formulation without λ-carrageenan. Average moisture, water activity, and breaking force for pasta with different λ-carrageenan levels are shown in Table 2. With increasing levels of λ-carrageenan in the pasta formulation, moisture content of the dried product increased from 12.75% with 1.5% λ-carrageenan to 15.8% moisture with 3.8% λ-carrageenan. Water activity, however, changed slightly from 0.752 and 0.794 with increasing levels of λ-carrageenan (higher moisture content); these data indicate that λ-carrageenan, as expected, binds water within the system. Compression tests demonstrated that increasing the λ-carrageenan level increased the maximum force (N) required to break the dry noodle: 28.75 N at 1.5% λ-carrageenan to 40.77 N at 3.2% λ-carrageenan. Samples made with λ-carrageenan levels greater than 2.9% had a very slimy texture upon cooking; furthermore, mechanical data did not indicate additional increase in firmness when λ-carrageenan level is greater than 2.6%. The maximum level of λ-carrageenan in the formulation was therefore set at 2.6%. Commercial white spaghetti had a firmness value of 50.10 N while whole wheat pasta had a firmness value of 35.49 N.

The time required to dry pasta with 2.6% λ-carrageenan to 8% moisture (matching that of commercial dried pasta) at different drying temperatures is shown in Table 3. Drying time decreased significantly from 165 min to 55 min when drying temperature increased from 60 to 93 C. As expected, the higher the temperature, the shorter the time required to dry the pasta. Drying temperature also had no significant effect on compression force of dried pasta (data not shown). Colorimeter readings, however, showed that increasing the drying temperature significantly reduced the lightness (L*) of peanut pasta (Table 3). Pasta dried at 60 and 74 C had L* values of 61.2 and 61.9, respectively. These L* values were significantly higher ($P \leq 0.05$) than the L* values of pasta dried at 77 C and above (L* values of 54.4 to 56.6). High drying temperatures produced dried noodles that were dark in color (lower L* value), which could negatively influence consumer acceptability.

Table 3. Color lightness and drying time required for peanut pasta containing 2.6% λ-carrageenan to 8% moisture at different temperatures.**

Temperature (C)	Drying time (min)	Lightness (L* value)
60	165	61.2a
74	110	61.9a
77	105	54.4c
82	80	56.6b
88	65	54.8c
93	55	56.0b

**Pasta dough containing 30% moisture and 2.6% λ-carrageenan was made with 40% peanut flour and 60% durum wheat flour. Pasta noodles were dried in a forced-air convection oven at 121 C for 20 min. Within the same column, means followed by the same letter are not significantly ($p>0.05$) different.

When the flour compositions were modified to include higher percentages of peanut flour, increasing level of peanut flour had no effect on moisture or mechanical properties, but they significantly ($P \leq 0.05$) affected the color. The L* value of dried, uncooked noodles decreased from 52.47 at 30% peanut flour to 49.88 at 50% peanut flour (Table 4). Cooked pasta also became darker (lower L* value) when percentage of peanut flour in the paste increased from 30% (L*=62.47) to 50% (L*=56.23).

Results from the preliminary sensory evaluation indicated 77% considered the peanut pasta to be acceptable (rating of 6 or higher on a nine-point hedonic scale), while 15% disliked the product (ratings of 4 or lower). Forty-six percent preferred peanut pasta over the whole wheat, while thirty-nine preferred the whole wheat pasta. Fifteen percent of consumers did not like either sample; these participants specified that they would rather have white pasta. For the consumers who did not prefer the peanut pasta, the reasons indicated were the soft texture or the unusual taste. Alternately, those who preferred peanut pasta stated that they liked the peanut flavor over the bland flavor of regular pasta. Most participants were pleased with the peanut pasta as far as dry noodle intactness,

Table 4. Lightness values for dry and cooked pasta containing different amount of peanut flour.**

Peanut flour (%)	Dry pasta L* value	Cooked pasta L* value
30	52.47a	62.47a
40	51.13ab	60.97a
50	49.88b	56.23b

**Pasta dough used for the studies containing 40% moisture and 2.6% λ-carrageenan. Pasta noodles were dried in forced-air convection at 60 C for 165 minutes. Within the same column, means followed by the same letter are not significantly ($p>0.05$) different.

color of cooked pasta, and flavor intensity. Many of these panelists, however, did not like the texture of the noodles. Several indicated that the peanut pasta was too soft and slimy.

Conclusions

A working formula for peanut pasta was established, starting with a basic durum wheat pasta recipe. In formulation experiments, 30–50% of the durum wheat flour was successfully replaced by peanut flour. It was also found that at least 1.8% λ-carrageenan must be added to the peanut pasta dough in order to maintain the integrity of the pasta noodles. Mechanical properties of dried peanut pasta were improved with increasing levels of λ-carrageenan in the formula. Peanut pasta containing between 2.5 and 2.9% λ-carrageenan had firmness closest to the commercial products evaluated. Pasta color lightness decreased with increasing drying temperature, as well as with increasing levels of peanut flour in the formula. A limited sensory evaluation suggested that consumers might consider peanut pasta acceptable. Potential positive attributes of peanut pasta include its unique flavor, whereas a potential negative attribute seems to be its softer texture upon cooking. However, due to the very limited distribution and participation in the sensory survey, a more extensive survey is necessary to evaluate potential marketability of the peanut pasta.

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