

Pasta products made from sweetpotato fortified with soy protein

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Abstract

Sweetpotato flour (Beauregard cultivar) was treated with sodium hydroxide solution and then fortified with defatted soy flour (DSF) or soy protein concentrate (SPC) at levels of 0, 15, 30, and 45 g/100 g. Pasta made from 100 g/100 g alkaline-treated sweetpotato flour (ASPF) had the lowest cooking loss (9.9 g/100 g) with the highest firmness (1.8 N). Cooking loss increased as levels of DSF and SPC increased (from 9.9 to 16.6 g/100 g). Addition of DSF and SPC increased the lightness (“*L**” value) from 40.6 to 48.7, and decreased the redness (“*a**” value) from 21.6 to 15.2. Substitution of DSF and SPC decreased firmness from 1.8 to 0.4 N, cohesiveness from 0.6 to 0.5 and springiness from 1.2 to 1.1 mm. Pasta made from 100% ASPF had highest β -carotene content (9.0 mg/100 g). The β -carotene contents decreased from 7.9 to 2.7 mg/100 g as the levels of DSF and SPC increased.

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Keywords: Sweetpotato flour; Pasta products; Soy protein; β -carotene; Cooking quality

1. Introduction

Sweetpotato is a great source of carbohydrates, β -carotene (provitamin A), and fiber. It is considered as a staple and co-staple in many Asian and African countries (Woolfe, 1992). Sweetpotato flour has been added in pasta formulation but just used as a minor ingredient (Collado & Corke, 1996; Collins & Pangloli, 1997; Thirumaran & Ravindran, 1992). In wheat pasta, gluten protein contributes the desirable cooking qualities and texture of products (Feillet & Dexter, 1996). Since sweetpotato lacks gluten protein, it is difficult to make the pasta from the whole sweetpotato by applying for the wheat pasta manufacturing method. The production of rice noodles, which are popular in Southeast Asian countries such as Thailand and Vietnam, can be made in the absence of gluten. In these types of products, the starch pasting properties play an important role to the product qualities (Miskelly, 1993).

Chemical modifications were applied to various types of starches to improve physicochemical properties of starches. Sodium hydroxide was used to isolate starch from Legume flour, oat flour, and cowpea flour (Lim, Ling, Seib, & Rao, 1992; Prinyawiwatkul, McWatters, Beuchat, & Phillips, 1997; Schoch & Maywald, 1968). Sodium hydroxide can separate starch by dissolving protein without gelatinization of starch (Schoch & Maywald, 1968). Our previous study did not show significant difference in characteristics of cooked pasta between that made from sweetpotato flour treated with sodium hypochlorite and sweetpotato flour treated with sodium hydroxide. In this study, sweetpotato flour treated with sodium hydroxide was used to produce pasta by an extrusion process. Since the protein content in sweetpotato was low, protein sources such as soy flour and soy protein concentrate (SPC) were added to enhance the nutritive quality of products. The objectives of this study were to develop new pasta from alkaline treated sweetpotato flour fortified with soy proteins and to examine quality of the cooked new pasta product including cooking characteristics, protein content and β -carotene content.

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2. Materials and methods

2.1. Materials

Sweetpotato flour was prepared from sweetpotato roots of jumbo-sized, deep orange color of Beauregard cultivar, which were purchased from Leeland Farm in Leesberg, GA, USA. The roots were washed, hand-peeled, and sliced to 2 mm thickness. Sweetpotato slices were soaked in 0.1 g/100 g sodium metabisulfite before drying at 70 °C for 12 h in an oven. The dried sweetpotato chips were ground in a Super Masscolloider (Masuko Sangyo Co., Ltd., Japan) and subsequently sifting by using a Sweco Separator (Sweco, Inc., Ft. Smith, AR, USA) through 80-mesh sieve sifted. The prepared flour was vacuum-packaged in Cryovac® bags and stored at −18 °C until used. Defatted soy flour (DSF) (Soyafluff® 200W) and SPC (Procon® 2000) were provided by Central Soya Company, Inc. (Fort Wayne, IN, USA). Commercial wheat noodles and rice noodles were purchased from Asian market in Atlanta, GA, USA.

2.2. Preparation of alkaline-treated sweetpotato flour (ASPF)

ASPF was prepared by the modified method of Forssell, Hamunen, Autio, Suortti, and Poutanen (1995). The pH of a 20 g/100 g (db) sweetpotato flour suspension was adjusted to 10.5 with 2 mol/l NaOH solution, stirred for 3 h, and neutralized with 1 mol/l sulfuric acid. The suspension was vacuum-filtered, washed twice with distilled water, dried in an oven at 50 °C overnight, and ground by Ultra Centrifugal Mill Model ZM 100 (F. Kurt Retsch GmbH & Co., Haan, Germany) to pass through 0.5 mm screen.

2.3. Preparation of pasta

Pasta samples were prepared from ASPF with a replacement of DSF and SPC at the levels of 0, 15, 30 and 45 g/100 g. No DSF and SPC substitutes in pasta formulation served as control sample. A mixture of flour and water (50 g/100 g) was mixed in a KitchenAid Mixer (Model KSM50PWH, St. Joseph, MI, USA) for 10 min, and steam-cooked using a steamer with boiling water for 5 min. The cooked dough was kneaded in the KitchenAid Mixer for 2 min in order to distribute the heat to gelatinize the dough which in turn was extruded through 2-mm die using a Chinese noodle maker (Shanxi Manufacturer Co., Shanxi, China). The extruded pasta was dried at ambient temperature with 30 ml/100 ml rh for 4 h until the moisture content reached to approximately 10 g/100 g. The dried pasta had the dimension of 0.6 mm width × 1.0 mm thickness. Each formulation was prepared in triplicates.

2.4. Proximate composition of ingredients

Proximate composition of samples was determined by AOAC (1997) methods as follows: moisture by the vacuum

oven method 925.09; ash by the muffle furnace method 923.03; crude protein by Kjeldahl method 960.52 (using 6.25 as conversion factor); crude fat by petroleum ether extraction method 920.85; crude fiber by ceramic fiber filter method 920.86; and carbohydrate by subtracting percentage of other solids (ash + fat + protein + fiber) from 100 g/100 g.

2.5. Color measurement

The color of ingredients and cooked pasta was measured using a hand-held Minolta Chroma meter (Model CR-200, Minolta Corporation, Tokyo, Japan). Samples were placed in the sample cup for measurement. Color values were recorded as “ L^* ” (lightness), “ a^* ” (redness), and “ b^* ” (yellowness). From a^* and b^* values, the hue angle ($\tan^{-1} b^*/a^*$) and chroma ($((a^{*2} + b^{*2})^{1/2})$) were calculated.

2.6. Cooking quality of pasta

Cooking loss was measured by a modification of AACC (1995) method. Samples (5 g) were cooked in 200 ml boiling distilled water for 5 min, rinsed with 50 ml distilled water and drained for 5 min. The cooking and rinse water was collected, dried in an air oven at 100 °C and then weighted to determine cooking loss, which was expressed as percentage of initial dry matter.

2.7. Texture analysis of cooked pasta

Pasta firmness test was modified from AACC (1995) method. The firmness of cooked pasta was measured using an Instron Universal Testing Machine Model 1122 (Instron Corporation, Canton, MA, USA) equipped with a 50 N load cell and a cutting plexiglass blade. Three strands of cooked pasta were placed on a sample holder parallel to each other. Testing parameters for analysis were set at 5 mm/min crosshead speed. The maximum forces required to shear the sample were recorded. All trials were done in triplicates. The average forces were calculated for one strand of pasta.

A texture profile analysis (TPA) of pasta was conducted to determine adhesiveness (stickiness), cohesiveness and springiness of cooked pasta by using the method of Voisey, Wasik, & Loughheed (1978) and Tang, Hsieh, Heymann, & Huff (1999) with modification. One strand of pasta were placed on a sample holder, which had a 90° groove surface, and compressed to 75 mm/100 mm of the depth of pasta with a flattened cylinder aluminum plunger (5.5 cm diameter) using 5 mm/min crosshead speed. On the force–time curve, adhesiveness was defined as the negative force area after the first compression, representing the work necessary to pull the compressing plunger away from the sample. Cohesiveness was defined as the ratio of the area under the second peak to the area under the first peak. Springiness was defined as the distance at which a deformed sample went back to its nondeformed condition

after the deforming force is removed during the second compression.

2.8. β -Carotene analysis

The method of β -carotene analysis was followed by the method of Zhang (1998) with slight modification. Three grams of dried ground sample were extracted with isopropanol and hexane in the ratio of 5:15, 3:15, and 3:15 ml by using homogenizing (Omni Mixer Homogenizer, Waterbury, CT, USA) for 2, 1, and 1 min, respectively. The process was repeated for three times. One gram of magnesium sulfate was added to the mixture during the first homogenization to remove water. Each extract was vacuum filtered, and the filtrate was brought to volume with hexane containing 0.1 g/100 ml BHT in a 100 ml volumetric flask. One milliliter of each extract was evaporated to dryness under a stream of N_2 , and redissolved in 2 ml of mobile phase, acetonitrile/methanol/tetrahydrofuran (25 ml/28 ml/2 ml).

All-trans- β -carotene was quantified by high performance liquid chromatography (HPLC). A system comprised of a C₁₈218TP54 Vydac column (5 μ m, 4.6 mm $\times$ 25 cm) (vydac, Hesperia, CA, USA), a Thermoseparation pump (Thermo Finnigan, San Jose, CA, USA), and Isco V⁴ Absorbance detector (Isco, Inc., Lincoln, NA, USA) set at 450 nm. The flow rate of mobile phase was adjusted to 1 ml/min. The peak area was determined by using Hewlett Packard integrator Model HP 3395 (Hewlett Packard, Co., Wilmington, DE, USA).

Stock solution of β -carotene was prepared by dissolving 5 mg of *trans*- β -carotene (Fluka Bio Chemika, St. Louis, MO, USA) in hexane in a 25-ml volumetric flask. Absorbance difference at 453 nm was determined to calculate the concentration of stock solution from coefficient of β -carotene ($E_{1\%}^{1\text{cm}} = 2592$) (Bauernfeind, 1981). A working standard solution was prepared by diluting 1 ml of stock solution in a 10 ml volumetric flask with hexane.

2.9. Cooking characteristics of commercial pasta

The experimental pasta products obtained from the control pasta and pasta fortified with DSF and SPC were compared to commercial pasta products. Commercial wheat noodle (Iron-Man[®], Great Wall Enterprise Co., Ltd., Taipei, Taiwan) had the dimension of 0.6 mm width $\times$ 1.0 mm thickness while rice noodle (Asian Best[®], Eastland Food Co., Bangkok, Thailand) had the dimension of 0.4 mm width $\times$ 1.2 thickness. Color, cooking loss, cooking yield and firmness of cooked pasta were measured using the method described above.

2.10. Statistical analysis

Three replications for all the experiments were performed. The general linear models (GLM) procedure was used to analyse the data of pasta quality means from each

treatment. Where significant differences were found, means were separated using the least significant difference with SAS Institute, Inc. (1989).

3. Results and discussion

3.1. Chemical composition of ingredients

ASPF, DSF and SPC had different proximate composition. ASPF has the highest content of carbohydrates (88.3 g/100 g db) followed by DSF (35.5 g/100 g db) and SPC (18.7 g/100 g db). However, SPC has the highest protein content (70.0 g/100 g db) followed by DSF (52.0 g/100 g), while ASPF contains 2.0 g/100 g. Moisture, fat and fiber contents for all ingredients ranged from 8.0 to 10.0 g/100 g, from 0.8 to 1.5 g/100 g, and from 4.0 to 6.1 g/100 g, respectively.

3.2. Color measurement

The color of dried flours is shown in Table 1. The a^* value of ASPF was 12.1, which was higher than those of DSF (−1.6) and SPC (−0.6). The b^* value of ASPF (23.0) was also higher than those of DSF (12.7) and (10.7).

Table 1
Color values of various ingredients

Color values	ASPF	DSF	SPC
Lightness (L^*)	82.7	93.9	92.7
Redness (a^*)	12.1	−1.6	−0.6
Yellowness (b^*)	23.0	12.7	10.7
Hue angle	62.2	97.0	93.3
Chroma	26.0	12.8	10.7

ASPF = alkaline-treated sweetpotato flour; DSF = defatted soy flour; SPC = soy protein concentrate.

Table 2
Treatment effects on color of cooked pasta

	L^*	a^*	b^*	Hue angle	Chroma
Levels of soy proteins	**	**	ns	**	ns
0 g/100 g Soy proteins	40.5 ^c	21.6 ^a	34.1	57.7 ^c	40.4
15 g/100 g Soy proteins	42.0 ^c	19.1 ^b	35.3	61.4 ^b	40.3
30 g/100 g Soy proteins	45.9 ^b	19.1 ^b	36.4	62.4 ^b	41.5
45 g/100 g Soy proteins	48.4 ^a	17.0 ^c	36.7	64.9 ^a	40.3
LSD	2.2	1.6	2.0	1.2	2.4
Types of protein ¹	ns	ns	ns	**	ns
DSF	44.4	19.7	34.9	60.5 ^b	40.2
SPC	44.0	18.7	36.3	62.6 ^a	41.0
LSD	1.6	1.1	1.4	0.8	1.7
Interaction	ns	*	ns	**	ns

* $P < 0.05$; ** $P < 0.01$; ns = no significant difference.

¹DSF = defatted soy flour; SPC = soy protein concentrate.

^{a-c}Means with the same letter in the same column within a treatment indicate no significant difference ($P < 0.05$).

However, the L^* value of ASPF (82.7) was lower than DSF (93.9) and SPC (92.7). The hue angle of ASPF was 62.2, indicating the orange color of flour while the hue angles of DSF and SPC were 97.0 and 93.3, respectively, indicated the cream color of soy proteins.

Fortification of DSF in pasta formulation significantly affected the color of cooked products. Addition of DSF and SPC (0, 15, 30, 45 g/100 g) significantly increased L^* value and hue angle and decreased a^* value of cooked pasta; however, DSF and SPC did not affect b^* value and chroma (Table 2). The hue angles ranged from 57.7 to 67.7 (Table 3) implying that pasta had an orange color. The yellow-orange color of sweetpotato flour was caused by the presence of carotenoid pigments, which affect the red-green

chromaticity (Collado, Mabesa, & Corke, 1997; Van Hal, 2000).

3.3. Cooking loss of pasta

Pasta made from 100 g/100 g ASPF had lowest cooking loss (9.9 g/100 g). Cooking loss of pasta significantly increased with the increased level of DSF and SPC (Table 4). Cooking loss increased to 11.2–15.8 g/100 g and 11.5–16.6 g/100 g as the levels of DSF and SPC increased to 15–45 g/100 g, respectively (Table 5). However, there was no significant difference of losses among the levels of DSF and SPC at 15 g/100 g and 30 g/100 g. Collins and Pangloli (1997) reported that addition of 10–15 g/100 g sweetpotato and soy flour in wheat noodles increased cooking loss of products. Cooking yield significantly increased as the levels of soy proteins increased; however, no significant difference of cooking yields among levels of DSF and SPC was observed (Table 4). Cooking yields of pasta supplemented with DSF and SPC at 15–45 g/100 g were 200.4–208.5 g/100 g and 202.0–212.8 g/100 g, respectively (Table 5).

3.4. Texture of cooked pasta

Levels of soy protein significantly decreased firmness, stickiness, and springiness (Table 4). Firmness of sweetpotato pasta significantly decreased from 1.8 to 1.0 N (Table 5) at the addition of DSF and SPC at 15 g/100 g level. Pasta made from 100 g/100 g ASPF had highest firmness (1.8 N). Addition of 15–45 g/100 g of DSF and SPC decreased the firmness to 1.0–0.4 and 1.1–0.4 N, respectively.

Stickiness of pasta significantly decreased as the levels of DSF and SPC increased. At 15 g/100 g DSF and SPC substitution, stickiness of pasta had no significant difference as compared to stickiness of pasta made from 100 g/100 g ASPF (Table 4).

Table 3
Color values of cooked pasta made from ASPF as affected by level of DSF and SPC substitution

Treatments	L^*	a^*	b^*	Hue angle	Chroma
Control	40.6 (1.4)	21.6 (2.2)	34.1 (2.0)	57.7 (4.0)	40.4 (3.0)
15 g/100 g DSF	41.9 (1.9)	18.7 (2.3)	35.0 (4.0)	61.6 (5.9)	39.8 (2.3)
30 g/100 g DSF	44.6 (1.8)	19.6 (2.9)	35.0 (2.7)	60.7 (5.4)	40.2 (1.2)
45 g/100 g DSF	48.9 (0.8)	18.9 (3.3)	35.6 (0.6)	62.1 (4.6)	40.4 (1.1)
15 g/100 g SPC	42.0 (3.1)	19.5 (2.2)	35.6 (5.4)	61.1 (4.6)	40.7 (3.6)
30 g/100 g SPC	47.2 (3.1)	18.5 (2.2)	38.4 (4.5)	64.0 (4.9)	42.8 (3.6)
45 g/100 g SPC	47.9 (2.5)	15.2 (2.6)	37.2 (2.7)	67.7 (4.9)	40.3 (1.7)

DSF = defatted soy flour; SPC = soy protein concentrate.
Numbers in parenthesis are standard deviation.

Table 4
Treatment effects on cooking characteristics of cooked pasta

	Cooking loss (g/100 g)	Cooking yield (g/100 g)	Firmness (N)	Stickiness (Ns)	Cohesiveness	Springiness (mm)
Levels of proteins	*	*	**	**	ns	*
0 g/100 g	9.9 ^d	198.5 ^d	1.8 ^a	7.8 ^a	0.59	1.18 ^a
15 g/100 g	11.4 ^c	201.2 ^{bc}	1.0 ^b	6.8 ^a	0.58	1.15 ^a
30 g/100 g	12.8 ^b	207.1 ^{ab}	0.7 ^c	3.7 ^b	0.57	1.16 ^a
45 g/100 g	16.2 ^a	210.7 ^a	0.4 ^d	3.7 ^b	0.55	1.07 ^b
LSD	1.1	8	0.2	1.3	0.03	0.07
Types of protein ¹	ns	ns	ns	ns	ns	ns
DSF	12.4	202	1	5.8	0.57	1.13
SPC	12.7	206.7	1	5.1	0.58	1.15
LSD	0.8	5.6	0.1	0.9	0.02	0.04
Interaction	ns	ns	ns	ns	ns	ns

* $P < 0.05$; ** $P < 0.01$; ns = no significant difference.

¹DSF = defatted soy flour; SPC = soy protein concentrate.

^{a-d}Means with the same letter in the same column within a treatment indicate no significant difference ($P < 0.05$).

Table 5
Cooking quality of cooked pasta made from ASPF as affected by level of DSF and SPC substitution

Treatments	Cooking loss (g/100 g)	Cooking yield (g/100 g)	Firmness (N)	Stickiness (N s)	Cohesiveness	Springiness (mm)
Control	9.9 (0.4)	198.5 (2.4)	1.8 (0.2)	7.8 (1.4)	0.59 (0.03)	1.18 (0.02)
15 g/100 g DSF	11.2 (0.5)	200.4 (3.3)	1.0 (0.1)	7.5 (0.5)	0.57 (0.03)	1.16 (0.02)
30 g/100 g DSF	12.6 (1.2)	200.7 (1.9)	0.8 (0.1)	4.1 (0.7)	0.56 (0.04)	1.15 (0.04)
45 g/100 g DSF	15.8 (1.1)	208.5 (5.6)	0.4 (0.0)	4.1 (0.8)	0.54 (0.04)	1.07 (0.06)
15 g/100 g SPC	11.5 (0.4)	202.0 (1.8)	1.1 (0.2)	6.2 (1.9)	0.58 (0.02)	1.14 (0.02)
30 g/100 g SPC	12.9 (1.3)	213.5 (3.5)	0.6 (0.2)	3.3 (0.8)	0.58 (0.02)	1.14 (0.05)
45 g/100 g SPC	16.6 (0.8)	212.9 (17.1)	0.4 (0.1)	3.3 (0.6)	0.57 (0.02)	1.09 (0.04)

DSF = defatted soy flour; SPC = soy protein concentrate.
Numbers in parenthesis are standard deviation.

No significant difference was observed on cohesiveness among pasta samples in all treatments (Table 5). No significant difference among springiness of pasta made from pasta fortified with DSF or SPC at all levels except at a level of 45 g/100 g (Table 4).

3.5. Protein and β -carotene content

Both types of soy proteins and levels of fortification significantly increased protein content of pasta (Table 6). Protein content of pasta fortified with 15, 30, and 45 g/100 g DSF increased up to 4.6, 8.8, and 13.2 times, respectively, whereas protein content of pasta fortified with 15, 30, and 45 g/100 g SPC increased up to 5.4, 10.4, and 15.9 times, respectively, as compared to pasta made from 100% ASPF (1.9 g/100 g). The ranges of protein content of dried pasta fortified with DSF and SPC at 15, 30 and 45 g/100 g were 8.9–25.5 g/100 g (db) and 10.4–30.7 g/100 g (db), respectively (Table 7).

The β -carotene content of pasta significantly decreased as the level of DSF and SPC increased (Table 6). Pasta made from 100 g/100 g ASPF contained the highest amount of β -carotene (751 RAE) (Table 7). At 15 g/100 g substitution of DSF or SPC, sweetpotato pasta also contained high β -carotene content, 658 RAE and 646 RAE, respectively, which accounted for 71–73 g/100 g for adult male and 92–94 g/100 g for adult female recommendation intake by DRI (900 RAE for adult male and 700 RE for adult female) (DRI, 2001). The β -carotene content decreased about 50–70 g/100 g as the levels of DSF and SPC increased to 30–45 g/100 g. This may be due to addition of soy proteins that decreased carotenoid pigment of ASPF.

Table 6
Treatment effects on protein and β -carotene content of cooked pasta

	Protein (g/100 g db)	β -carotene (mg/100 g dry weight)	Retinol activity equivalent
Levels of proteins	**	**	**
0 g/100 g	1.9 ^d	9.0 ^a	750 ^a
15 g/100 g	9.6 ^c	7.8 ^a	652 ^a
30 g/100 g	18.8 ^b	4.1 ^b	345 ^b
45 g/100 g	28.1 ^a	2.9 ^b	244 ^b
LSD	0.7	2.6	215
Types of protein ¹	**	ns	ns
DSF	13.3 ^b	6.1	510
SPC	15.9 ^a	5.8	485
LSD	0.5	1.8	152
Interaction	**	ns	ns

* $P < 0.05$; ** $P < 0.01$; ns = no significant difference.

¹DSF = defatted soy flour; SPC = soy protein concentrate.

^{a-d}Means with the same letter in the same column within a treatment indicate no significant difference ($P < 0.05$).

3.6. Correlation among cooking characteristics of sweetpotato pasta

Correlation among cooking quality characteristics were analysed (Table 8). Cooking loss was negatively correlated with firmness ($r = -0.84$, $P < 0.01$), stickiness ($r = -0.75$, $P < 0.01$), and springiness ($r = -0.44$, $P < 0.05$), but positively correlated with cooking yield ($r = 0.49$, $P < 0.05$). Thus, cooking loss increased as firmness, stickiness and springiness decreased. Kim and Wiesenborn (1996) reported that firmness of cooked potato starch

noodles was negatively correlated to cooking loss ($r = -0.52$) and cooked weight ($r = -0.82$) at $P < 0.01$, which agreed to our correlation.

Firmness was negatively correlated with cooking loss ($r = -0.84$, $P < 0.01$) and cooking yield ($r = -0.56$, $P < 0.01$), but positively correlated with stickiness ($r = 0.76$, $P < 0.01$). Stickiness was positively correlated

with springiness ($r = 0.74$, $P < 0.01$). Cohesiveness was positively correlated to springiness ($r = 0.74$, $P < 0.01$).

3.7. Cooking characteristics of commercial pasta

The color of commercial wheat and rice pasta were pale yellow and white color, respectively, while our pasta products were in the range of orange color (57.6–61.9 hue angle) indicating that the carotenoid pigment is still present in our products. Both commercial wheat and rice pasta had lower cooking loss than our experimental pasta (Table 9). The firmness of our experimental pasta products was similar to that of rice noodle, but lower than that of wheat noodle. However, the firmness of pasta made from 100 g/100 g ASPF was higher than that of rice noodle.

4. Conclusion

The results obtained indicated that ASPF could be the alternative ingredients for production of pasta with nutritious nutrients and yellow-orange natural color. Pasta made from 100 g/100 g ASPF had the lowest cooking loss, the highest firmness and β -carotene content among samples. Pasta fortified with 15 g/100 g DSF or 15 g/100 g SPC contained approximately five times higher protein content as compared to pasta made from 100 g/100 g ASPF. The products also contained β -carotene content higher than that recommended by RDA. These products also had cooking quality, stickiness, cohesiveness, and springiness similar to pasta made from 100 g/100 g ASPF.

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Table 7
Composition of dried sweetpotato pasta

Treatments ^a	Moisture content ^{ns} (g/100 g)	Protein (g/100 g db)	β -carotene (mg/100 g)	Retinol activity equivalent ^b
Control	11.4	1.9	9.0	751
15 g/100 g DSF	10.5	8.9	7.9	658
30 g/100 g DSF	11.5	16.9	4.4	372
45 g/100 g DSF	12.2	25.5	3.2	264
15 g/100 g SPC	11.1	10.4	7.6	646
30 g/100 g SPC	11.0	20.6	3.9	321
45 g/100 g SPC	11.4	30.7	2.7	224

ns = no significant difference.

^aDSF = defatted soy flour; SPC = soy protein concentrate.

^bRetinol activity equivalent (RAE): 1 μ g RAE = 1 μ g retinol = 12 μ g β -carotene.

Table 8
Correlation coefficient among cooking characteristics of cooked pasta

	Cooking loss	Cooking yield	Firmness	Stickiness	Cohesiveness
Cooking yield	0.49*				
Firmness	-0.84**	-0.56*			
Stickiness	-0.75**	-0.58**	0.76**		
Cohesiveness	-0.31	-0.08	0.41	0.02	
Springiness	-0.44*	-0.20	0.43	0.74**	0.74**

* $P < 0.05$; ** $P < 0.01$.

Table 9
Cooking characteristics of different types of pasta

Cooking characteristics	Wheat noodle	Rice noodle	Experimental pasta 1 ^a	Experimental pasta 2 ^b	Experimental pasta 3 ^c
Color values “L**”	75.4	74.7	40.6	41.9	42.0
Color values “a**”	2.2	-2.1	21.6	18.7	19.5
Color values “b**”	13.3	2.1	34.1	35.0	35.6
Hue angle	80.6	136.3	57.6	61.9	61.3
Chroma	13.5	3.0	40.4	39.7	40.6
Cooking time (min)	7.0	4.0	5.0	5.0	5.0
Cooking loss (g/100 g)	3.4	2.6	9.9	11.2	11.5
Cooking yield (g/100 g)	231.1	271.2	198.4	200.4	202.0
Firmness (N/mm) ^d	4.5	1.9	2.7	1.5	1.7

^aPasta made from 100 g/100 g ASPF with the dimension 2 mm diameter.

^bPasta made from ASPF fortified with 15 g/100 g DSF with the dimension 2 mm diameter.

^cPasta made from ASPF fortified with 15 g/100 g DSF with the dimension 2 mm diameter.

^dBased on three strands of noodle.

analysis of β -carotene from Drs. Ronald R. Eitenmiller and Lin Ye of the Department of Food Science and Technology, University of Georgia, Athens, GA, USA.

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