

Effects of Ground, Concentrated, and Powdered Beef on the Quality of Noodle Products

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Abstract

The aim of this study was to ascertain the effects of beef on the quality characteristics, such as color, texture profile, water absorption ratio, volume, turbidity, and sensory evaluation, of noodle products. Various types of beef were added to the flour at a mixture ratio of ground beef (BG) 10, 15, 20, 25%; concentrated beef (BC) 9, 11, 13, 15%; and powdered beef (BP) 1, 3, 5, 7%. Each treatment was analyzed and compared with a 100% flour noodle as a control. With increasing BG, BC, and BP ratios, the L and b values for color decreased, while the a value increased, from that in the control. The hardness of the noodles treated with BG increased with increasing mixture ratios, but hardness decreased in the BC and BP treatments with increasing mixture ratios ($p < 0.05$). The noodles with the largest beef composition in the mixtures of each treatment exhibited the highest turbidity scores, which was believed to be because the solid contents would be transferred to the soup during heating. In the sensory evaluation of cooked noodles, the BG 10%, BC 9%, and BP 1% treatments exhibited the best color. In an overall preference test, 20% of BG and 3% of BP could be added to the noodles. The best palatability was exhibited by the BG 10%, BC 13%, and BP 3% treatments.

Keywords: ground beef, concentrated beef, powdered beef, quality, noodle

Introduction

Noodles are a very common food product. Since wheat flour was first introduced into Korea in the 1950s, many kinds of noodle products have been developed (Lee *et al.*, 2000), and instant noodles account for a large proportion of the noodle market because they are easy and convenient to use (Lee and Kim, 2000).

Currently, various kinds of noodle products are being developed that meet the requirements of consumers who want healthier and better-tasting products. Consequently, the consumption of healthy noodle products, such as green tea, seaweed, cacti, gardenia fruits, etc. is increasing (Kim and Kim, 2009). However, these noodle products are based almost entirely on plant materials, and no noodle products that contain meat are on the market.

Rich, fatty animal parts, such as beef loins and ribs, are very popular in Korea because of their suitability for roasting. However, the low-fat-containing parts that are

not good for roasting, such as beef round, are oversupplied because they are less in demand. Therefore, many researchers are attempting to balance demand and supply by developing popular processed-meat products.

Noodle products containing ground beef, concentrated beef, and powdered beef could be beneficial in terms of good nutrition. This study was conducted to develop fresh noodle products that contain over 20% meat, and that retain a good binding capacity.

Materials and Methods

Preparation of materials

The meat materials used in this experiment were ground (BG), concentrated (BC), and powdered beef (BP) from beef round. These were mixed with flour, salt, and water to prepare various types of beef-added noodle products. The Hanwoo round was purchased at the local mart in Bundang and was ground (Hand Blender, MR5550MCA Braun, Spain) to make BG. The remaining BG was freeze-dried (Ilshin FD5512, Ilshin, Korea) after deep freezing (VIP Series, Sanyo, Japan) for 48 h. The freeze-dried beef powder was sieved through 20 meshes (Test sieve, 850 μ m; Korea) before being used for the noodles as BP. BC

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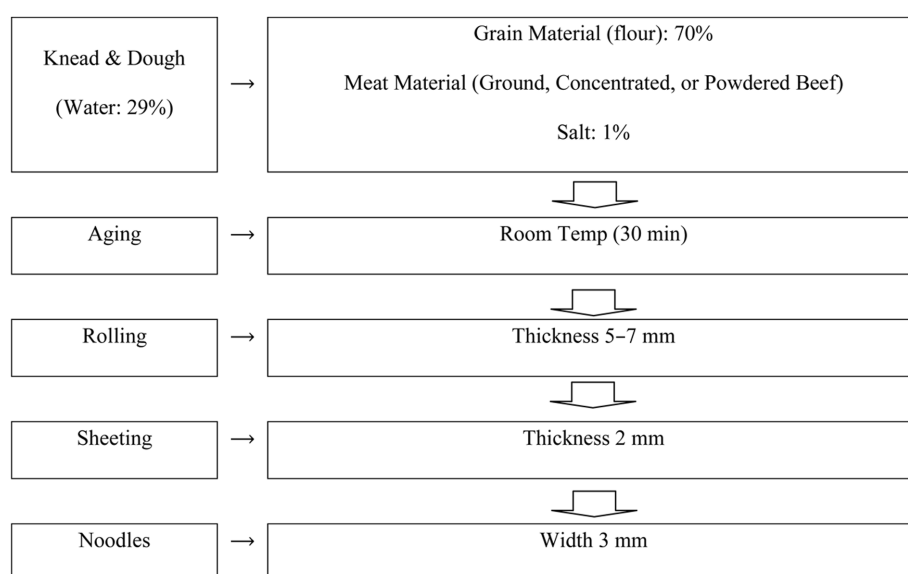


Fig. 1. Processing noodles made by mixing various types of beef.

was purchased from the N company. Wheat flour (Chal-milgaru, C company) and salt (Ggotsogeum, T company) were also bought at a local mart and used for noodle making.

Manufacturing noodles added with meat

The process of kneading dough mixed with flour, and various types of beef and noodle making, is shown in Fig. 1. As the various moisture and solid contents of the BG, BC, and BP mixture ratios of each treatment changed, depending on the mixture ratio, to make up the moisture balance in the noodle. The formulations of the mixtures with BG, BC, BP, and the other materials in the noodles are presented in Table 1. The mixtures were kneaded (KitchenAid, K5SS, USA) and aged for 30 min at room temperature. The kneaded dough was passed through a pasta roller (KitchenAid, K5SS 5957Adzw 707, USA) dozens of times until it had the same thickness (2 mm), and was then cut into the same width (3 mm) with a pasta cutter. Each noodle was cooked at 100°C for 3 min in a separate pot, and was washed with cold water for 30 s immediately after cooking.

Chemical analysis

The moisture, crude protein, crude fat, and crude ash contents of BG, BC, and BP were analyzed using AOAC (2000) methods.

Color

The color of the noodles was detected using a color dif-

Table 1. Formulation of noodle mixtures made with different mixing ratios of BG, BC, and BP

Types of beef	Formulation (%)			
	Beef addition	Flour	Water	Salt
Control	0	70	29	1
BG-10%	10	67	22	1
BG-15%	15	66	18	1
BG-20%	20	65	14	1
BG-25%	25	64	10	1
BC-9%	9	65	25	1
BC-11%	11	63	25	1
BC-13%	13	62	24	1
BC-15%	15	61	23	1
BP-1%	1	69	29	1
BP-3%	3	67	29	1
BP-5%	5	65	29	1
BP-7%	7	63	29	1

Control, noodles with no beef added; BG, Beef ground added; BC, Beef concentrate added; BP, Beef powder added.

ference meter (Chroma meter, CR-410, Minolta Co., Japan) at a calibration of L: 97.10, a: -0.17, and b: 2.08 on a standard white plate. Each sample was tested five times and average values of CIE L* (lightness), CIE a* (redness), and CIE b* (yellowness) were obtained.

Texture profile analysis (TPA)

The texture profile of the noodles before and after cooking was tested using a Texture analyzer (TA-XT2i; Stable Micro Systems Ltd., UK) with a 20-40 mm round probe at a pre-test speed of 0.5 mm/s, a test speed of 0.5 mm/s, a post-test speed of 0.5 mm/s, a strain of 50%, and

a 75% distance. During the experiment, the hardness, springiness, cohesiveness, gumminess, and chewiness of the noodles were analyzed using the force-distance curve acquired when the probe pressed the sample.

Water absorption ratio

The water absorption ratio of the noodles after cooking was tested by weighing them before and after cooking, and using the following equation:

$$([\text{Weight after cooking} - \text{Weight before cooking}] / \text{Weight before cooking}) \times 100$$

Volume

The volumes of the noodles were calculated using the volumetric differences of water. Cooked noodles were individually placed in 300 mL of water in a 500-mL mesh cylinder and the differences in scale were recorded.

Turbidity

The turbidity of cooked noodle soup with the various types of beef added was tested using a spectrophotometer (Mecasys, Optizen 2120UV, Korea) at 675 nm of Optical Density (OD). Cooked noodle soup was prepared under the same conditions of heating for 3 min each, cooled for 30 min at room temperature, and then made up to an equal volume of 500 mL with water.

Sensory evaluation

A sensory test was conducted by 15 trained panelists to evaluate cooked noodles with various types of beef added. Samples were tested by the panelists immediately after heating, to avoid changes in the sensory conditions caused by serving time differences. Appearance, color, flavor, taste, texture, and overall acceptability were evaluated using a 9-point scale (1=extremely undesirable, 9=extremely desirable).

Statistical analysis

An ANOVA was conducted using SAS/PC+ software. A significance test of the differences between the samples was performed using Duncan's multiple range test ($p <$

0.05).

Results and Discussion

Chemical Analysis

The chemical analysis results are presented in Table 2. BG had 74.87%, BC had 39.58%, and BP had 5.76% moisture content, indicating that the differences between the types of beef were large. It is possible that the variation in the moisture contents of BG, BC, and BP was because the mixing ratio of water and flour was changed in order to balance the moisture content in the dough and noodle. BP contained the highest proportions of crude protein and fat (80.10 and 6.94%, respectively), and those in BG were the lowest (21.05 and 2.07%, respectively).

Color

The colors of uncooked and cooked noodles with BG, BC, and BP added are shown in Table 3. With a higher ratio of BG in the uncooked and cooked noodles (from 10 to 25%), the color turned dark brown, which was obviously because of the color of the beef. The L and b values of uncooked noodles decreased, from 81.62 and 17.41 to 61.84 and 12.95, respectively ($p < 0.05$), as the BG ratio increased. In the case of the a value, it was -1.29 in the control but rapidly increased to 6.30 after the 25% BG treatment ($p < 0.05$).

Regarding the changes in the L and b values in the cooked noodles, they showed a similar tendency of decreasing as the BG content increased. However, the L and b values of uncooked noodles were higher than those of cooked noodles ($p < 0.05$).

With the addition of more BC, the L and a values of the uncooked and cooked noodles also decreased, even more so than those in the BG treatment, which indicated that BC was darker than BG. However, the a value increased from -1.08 to 2.43 in the uncooked control and from -0.74 to 3.79 in the cooked control ($p < 0.05$), which was a similar result to that obtained in the BG treatment.

In the BP treatment, the L value of the uncooked noodles decreased from 79.18 to 57.30, but the a value increased from -0.57 in the control to 7.57 in the 7% treat-

Table 2. Chemical analysis of ground, concentrated, and powdered beef

Types of beef	Proximate composition (%)			
	Moisture	Crude protein	Crude fat	Crude Ash
Ground beef	74.87±0.20	21.05±2.07	2.07±0.52	1.14±0.01
Concentrated beef	39.58±0.24	52.36±1.36	4.03±0.83	3.02±0.03
Powdered beef	5.76±0.04	80.10±1.99	6.94±0.30	4.52±0.03

Table 3. Color of uncooked and cooked noodles made with different mixing ratios of BG, BC, and BP

Treatment	Hunter's color value			
	L	a	b	
Uncooked cooked	Control	81.62±0.06 ^a	-1.29±0.01 ^e	17.41±0.04 ^a
	BG-10%	71.42±0.19 ^b	3.37±0.02 ^d	14.52±0.16 ^b
	BG-15%	67.12±0.22 ^c	4.77±0.01 ^c	13.92±0.04 ^c
	BG-20%	64.14±0.22 ^d	5.46±0.02 ^b	13.28±0.04 ^d
	BG-25%	61.84±0.21 ^e	6.3±0.01 ^a	12.95±0.07 ^e
Cooked noodle	Control	72.36±0.38 ^a	-0.88±0.01 ^e	16.10±0.06 ^a
	BG-10%	59.21±0.25 ^b	4.78±0.02 ^d	12.24±0.07 ^b
	BG-15%	53.44±0.78 ^c	5.71±0.01 ^c	10.19±0.20 ^c
	BG-20%	50.43±0.31 ^d	6.13±0.04 ^b	9.53±0.20 ^d
	BG-25%	46.93±0.30 ^e	6.56±0.04 ^a	8.08±0.10 ^e
Uncooked noodle	Control	82.23±0.17 ^a	-1.18±0.02 ^e	17.47±0.05 ^a
	BC-9%	75.97±0.09 ^b	1.35±0.01 ^d	15.34±0.07 ^b
	BC-11%	75.95±0.08 ^b	1.44±0.02 ^c	15.10±0.15 ^c
	BC-13%	73.28±0.34 ^c	2.06±0.05 ^b	14.79±0.03 ^d
	BC-15%	72.50±0.25 ^d	2.43±0.02 ^a	14.68±0.11 ^e
Cooked noodle	Control	73.35±0.26 ^a	-0.74±0.01 ^e	15.44±0.12 ^a
	BC-9%	62.38±1.22 ^b	2.41±0.01 ^d	14.19±0.25 ^b
	BC-11%	63.13±1.36 ^b	2.82±0.02 ^c	13.98±0.45 ^b
	BC-13%	61.99±0.29 ^b	3.33±0.03 ^b	13.23±0.4 ^c
	BC-15%	59.02±0.55 ^c	3.79±0.03 ^a	13.02±0.23 ^c
Uncooked noodle	Control	79.18±0.16 ^a	-0.57±0.01 ^e	16.68±0.03 ^d
	BP-1%	72.09±0.22 ^b	3.23±0.08 ^d	18.33±0.06 ^c
	BP-3%	64.14±0.14 ^c	5.94±0.02 ^c	19.82±0.07 ^a
	BP-5%	60.55±0.38 ^d	6.85±0.04 ^b	19.27±0.15 ^b
	BP-7%	57.30±0.28 ^c	7.57±0.02 ^a	19.15±0.17 ^b
Cooked noodle	Control	71.81±0.56 ^a	-0.43±0.02 ^e	15.31±0.28 ^a
	BP-1%	60.47±0.36 ^b	3.80±0.02 ^d	15.50±0.18 ^a
	BP-3%	50.37±0.44 ^c	6.63±0.01 ^c	14.16±0.23 ^b
	BP-5%	46.79±0.35 ^d	7.75±0.05 ^b	13.22±0.19 ^c
	BP-7%	40.68±0.7 ^e	8.37±0.04 ^a	10.69±0.32 ^d

Control, noodles with no beef added; BG, Beef ground added; BC, Beef concentrate added; BP, Beef powder added. Values are Means±SD (n=3).

Means with the same letter in a column are not significantly different ($p>0.05$).

ment group ($p<0.05$).

The L value of cooked noodles also decreased with increasing BP content, and the a value increased with the BP content, from -0.43 in the control to 8.37 in the 7% treatment ($p<0.05$).

Similar results have been obtained in previous studies that have investigated color changes in noodles with various additives such as shiitake mushrooms (*Lentinula edodes*) (Kim *et al.*, 2008), Sanghwang mushrooms (*Phellinus linteus*) (Kim *et al.*, 2005), king oyster mushrooms (*Pleurotus eryngii*) (Sung *et al.*, 2008), or kudzu powder (Lee *et al.*, 2000). By increasing the contents of additives such as chlorella extracts (Park and Cho, 2004), lotus leaf powder (Park *et al.*, 2010), *Ligularia Fischeri* and *Angelica Gigas Nakai* extracts (Chang *et al.*, 2008), bamboo leaf powder (Oh, 2004), or mulberry leaf powder (Kim, 2002)

in the noodle, L and a values decreased and b values increased. Recently, there have been reports that consumers prefer colored noodles to white ones, because they believe that colored additives might help to improve their health (Cho, 2010; Cho and Kim, 2009; Park *et al.*, 2010).

Texture profile

The results of the TPA of uncooked and cooked noodles made with various mixing ratios of BG, BC, and BP are presented in Table 4.

In the case of the uncooked noodle, the more BG that was added, the harder was the noodle, but the BC and BP treatments had the opposite effect, and the more the BC or BP that was added, the softer was the noodle. We believe that the BG particles that were not emulsified in the noodle affected the hardness result. In the case of the

Table 4. Texture profiles of uncooked and cooked noodles made with different mixing ratios of BG, BC, and BP

Treatment	Hardness(g)	Springiness	Cohesiveness	Gumminess	Chewiness	
Uncooked noodle	Control	2,844.3±104.1 ^c	0.80±0.07 ^a	0.50±0.03 ^a	1,454.6±153.9 ^b	1,226.6±61.7 ^a
	BG-10%	2,875.2±71.3 ^c	0.72±0.19 ^a	0.52±0.01 ^a	1,532.9±91.6 ^b	1,165.9±64.9 ^{ab}
	BG-15%	3,381.7±54.8 ^b	0.74±0.18 ^a	0.54±0.01 ^a	1,527.2±120.8 ^b	1,134.7±43.6 ^b
	BG-20%	3,327.7±63.4 ^b	0.76±0.08 ^a	0.51±0.03 ^a	1,804.6±57.1 ^a	1,129.0±34.0 ^b
	BG-25%	3,534.7±75.8 ^a	0.86±0.12 ^a	0.54±0.02 ^a	1,897.0±116.0 ^a	1,114.8±78.7 ^b
Cooked noodle	Control	1,513.5±71.2 ^c	1.49±0.61 ^a	0.70±0.02 ^a	1,049.8±87.9 ^c	1,182.2±53.6 ^b
	BG-10%	1,762.0±67.2 ^b	1.27±0.12 ^{ab}	0.71±0.02 ^a	1,258.9±37.1 ^b	1,166.4±55.6 ^b
	BG-15%	1,851.0±105.5 ^b	1.21±0.49 ^{ab}	0.71±0.01 ^a	1,309.7±62.2 ^{ab}	1,181.2±99.1 ^b
	BG-20%	1,965.8±84.1 ^a	0.91±0.08 ^b	0.69±0.03 ^a	1,344.0±133.5 ^{ab}	1,249.5±48.7 ^{ab}
	BG-25%	2,017.7±49.2 ^a	0.89±0.07 ^b	0.71±0.03 ^a	1,415.9±46.0 ^a	1,329.5±69.7 ^a
Uncooked noodle	Control	3,548.9±368.1 ^a	0.72±0.07 ^b	0.53±0.04 ^a	1,898.5±325.4 ^a	1,295.9±62.8 ^a
	BC-9%	2,168.6±116.6 ^b	0.97±0.00 ^a	0.51±0.02 ^{ab}	1,098.8±76.8 ^b	1,073.3±52.5 ^b
	BC-11%	2,114.3±149.6 ^b	0.97±0.01 ^a	0.50±0.03 ^{ab}	1,091.8±142.2 ^b	989.0±64.7 ^b
	BC-13%	2,076.4±139.1 ^b	0.97±0.00 ^a	0.51±0.02 ^{ab}	1,057.9±77.0 ^b	1,022.4±75.5 ^b
	BC-15%	1,887.7±113.9 ^b	0.97±0.04 ^a	0.47±0.02 ^b	893.4±70.6 ^b	820.9±89.0 ^c
Cooked noodle	Control	1,959.5±111.3 ^a	0.92±0.01 ^a	0.76±0.02 ^a	1,494.7±85.8 ^a	1,377.5±73.1 ^a
	BC-9%	1,518.6±91.0 ^b	0.93±0.01 ^a	0.72±0.03 ^b	1,172.3±59.1 ^b	1,089.1±58.9 ^b
	BC-11%	1,495.4±131.2 ^b	0.93±0.00 ^a	0.71±0.02 ^b	1,115.3±39.7 ^{bc}	1,018.3±92.1 ^{bc}
	BC-13%	1,4730.3±70.3 ^b	0.93±0.01 ^a	0.71±0.02 ^b	1,087.0±57.4 ^c	958.8±76.6 ^c
	BC-15%	1,397.9±108.3 ^b	0.92±0.02 ^a	0.69±0.02 ^b	963.2±43.2 ^d	854.1±69.3 ^d
Uncooked noodle	Control	2,897.6±75.6 ^a	0.54±0.04 ^b	0.47±0.02 ^b	1,349.3±21.2 ^a	700.9±25.5 ^a
	BP-1%	2,525.2±97.3 ^b	0.71±0.23 ^{ab}	0.49±0.04 ^{ab}	1,230.2±53.7 ^b	677.3±79.4 ^{ab}
	BP-3%	1,769.9±0.1 ^c	0.83±0.16 ^a	0.49±0.03 ^{ab}	848.1±31.0 ^c	618.5±45.1 ^{bc}
	BP-5%	1,514.7±44.3 ^d	0.87±0.13 ^a	0.50±0.05 ^{ab}	727.1±68.3 ^d	563.3±53.6 ^{cd}
	BP-7%	1,190.7±46.2 ^e	0.89±0.11 ^a	0.53±0.06 ^a	605.7±42.0 ^e	532.4±11.2 ^d
Cooked noodle	Control	1,648.1±25.6 ^a	0.91±0.07 ^a	0.71±0.01 ^a	1,204.7±29.0 ^a	1,126.7±62.3 ^a
	BP-1%	1,508.9±54.1 ^b	0.93±0.06 ^a	0.70±0.01 ^a	1,058.2±76.9 ^b	976.5±51.3 ^b
	BP-3%	1,465.7±94.0 ^b	0.94±0.06 ^a	0.64±0.02 ^b	897.1±67.5 ^c	908.9±26.0 ^b
	BP-5%	1,036.5±83.9 ^c	0.94±0.07 ^a	0.63±0.03 ^b	657.9±41.0 ^d	593.4±68.0 ^c
	BP-7%	1,015.8±35.8 ^c	0.93±0.06 ^a	0.65±0.03 ^b	721.5±43.4 ^d	580.3±82.3 ^c

Control, noodles with no beef added; BG, Beef ground added; BC, Beef concentrate added; BP, Beef powder added.

Values are Means±SD (n=3).

Means with same letter in a column are not significantly different ($p>0.05$).

cooked noodle, BG, BC, and BP resulted in the same pattern of hardness as previously observed in the uncooked noodle, which increased with increasing amounts of BG, but decreased with increasing BC or BP. Uncooked noodles were harder than cooked noodles because cooked noodles contain water, which affects their texture.

In the springiness and chewiness tests of the BG treatments in the cooked noodle, there were no significant differences except for between the 20% addition treatment and the control. This result suggests that the BG 10% and BG 15% treatments were within a reasonable range in order to maintain their texture capacity in a BG treatment ($p<0.05$).

In the TPA of the BC treatment, although there were significant differences between the control and each treatment, except for the cohesiveness of the uncooked noodle, there were no differences between treatments except

for the 15% addition of BC, regarding its chewiness. In the TPA test of cooked noodles, there was no significant difference between the BC treatments but all of them had lower values than those of the control, except for springiness ($p>0.05$). Therefore, adding 9% and 11% of BC to uncooked and cooked noodles, respectively, were the best conditions in the BC treatments.

In the TPA test of the BP treatments with uncooked noodles, hardness, gumminess, and chewiness decreased as BP increased, and springiness and cohesiveness also increased. In the cooked noodle, the results were similar to those of the uncooked noodle, that is the hardness, gumminess, and chewiness decreased, but springiness did not change ($p>0.05$). Therefore, adding 3% and 5% BP to uncooked and cooked noodles, respectively, is good for noodle texture.

These results are similar to results obtained in previous

Table 5. Water absorption ratio, volume, and soup turbidity of cooked noodles made with different mixing ratios of BG, BC, and BP

Treatment	Water absorption (%)	Volume (mL)	Turbidity of Soup (O.D.)
Control	56.93±0.1 ^a	75±0.2 ^a	0.26±0.00 ^b
BG-10%	45.32±0.2 ^b	65±0.1 ^b	0.24±0.01 ^c
BG-15%	45.40±0.2 ^b	65±0.1 ^b	0.25±0.00 ^c
BG-20%	45.01±0.1 ^b	65±0.2 ^b	0.27±0.00 ^{ab}
BG-25%	44.25±0.3 ^c	65±0.1 ^b	0.28±0.01 ^a
Control	75.52±0.4 ^a	80±0.2 ^a	0.21±0.00 ^d
BC-9%	74.26±0.3 ^b	80±0.1 ^a	0.24±0.00 ^c
BC-11%	70.79±0.2 ^c	75±0.1 ^b	0.25±0.00 ^b
BC-13%	70.72±0.3 ^c	75±0.2 ^b	0.29±0.00 ^a
BC-15%	62.66±0.3 ^d	70±0.1 ^c	0.29±0.00 ^a
Control	83.38±0.4 ^a	90±0.1 ^a	0.25±0.01 ^e
BP-1%	67.96±0.3 ^b	70±0.2 ^b	0.27±0.01 ^d
BP-3%	59.81±0.2 ^c	72±0.1 ^b	0.29±0.01 ^c
BP-5%	59.57±0.3 ^c	69±0.2 ^b	0.31±0.00 ^b
BP-7%	48.46±0.2 ^d	65±0.2 ^c	0.37±0.00 ^a

Control, noodles with no beef added; BG, Beef ground added; BC, Beef concentrate added; BP, Beef powder added.

Values are Means±SD (n=3).

Means with the same letter in a column are not significantly different ($p>0.05$).

studies that have investigated the effects of additives, such as *Dioscorea japonica* flour (Park and Cho, 2006), cactus powder (Chong and Park, 2003), onion powder (Kim and Shim, 2006), and lotus leaf powder (Park *et al.*, 2010) on noodle texture, and have found that noodle hardness increases if the volume of additives is too high.

Cooking properties

The results regarding cooking properties, such as the water absorption ratio, volume, and soup turbidity of noodles made with various mixing ratios of BG, BC, and BP are presented in Table 5.

The water absorption ratios of the BG, BC, and BP cooked noodles significantly decreased compared to the control, while the mixing ratio increased, regardless of the type of meat. In each test of 25% of BG, 15% of BC, and 7% of BP, these treatments exhibited the lowest value. This may have been caused by the moisture content of each additive affecting water absorption in the noodle, and that BP had a lower capacity for water absorption than did the other additives ($p<0.05$).

There were no significant differences with the control in the volumes of cooked noodles with BG added, but there was a significant difference between the BG 10% and BG 25% treatments ($p<0.05$). In the BC treatment, the control and the BC 9% treatment were also signifi-

cantly different ($p<0.05$), but were lower than in the BC 11% treatment. In the BP treatment, the control exhibited the highest value (90 mL), but decreased gradually to 65% in BP 7%. These results are similar to those obtained by a study that reported that there is a positive relationship between weight and volume in the cooked noodle (Kim *et al.*, 1996).

The turbidity test of cooked noodle soup was conducted, according to the various mixing ratios of BG, BC, and BP, to ascertain the effect of transferring solid content from noodle to soup. With a higher content of BG, BC, or BP, the higher the turbidity value was. For each treatment, the turbidity values were from 0.24 OD to 0.28 OD in BG, from 0.24 OD to 0.29 OD in BC, and from 0.27 OD to 0.37 OD in BP ($p<0.05$). These results are similar to those obtained by studies that have reported that the more additives there are in a noodle, the more solid content is lost while cooking, and the greater the turbidity (Hwang and Jang, 2001; Kim, 1998; Lee *et al.*, 1999; Lee and Kim, 2000). All of these results were caused by the weakness of the noodle binding capacity, because additives, such as meat that replaces flour, do not have sufficient strength when heated.

Sensory evaluation

The results of the sensory evaluation of the noodles are presented in Table 6. The evaluation result of the sensory test decreased by increasing BG from 10% to 25%. In this experiment, the 10% BG treatment obtained the best results among the BG treatments, and for some results, such as appearance, color, test, and overall acceptability, even exhibited higher scores than those of the control, even when there were no significant differences ($p>0.05$). In the sensory test of noodles that added various ratios of BC from 9% to 15%, all the treatments had higher scores than those of the control, except for appearance and color in the BC 13% and 15% treatments.

In the texture test, BC 13% had the highest score with 7.3, and BC 9% had the second highest score of 6.8. BC 11% had the best score (6.8) for overall acceptability, but there was no significant difference ($p>0.05$). The above results suggest that the BC-added noodle has the potential to be a qualified noodle, which includes meat.

In the sensory test of noodles with BP 1% to 7%, all of the treatments yielded higher scores for every test item than those of the control, except for appearance and color in the BP 7% treatment. It is believed that the panel recognized the taste of beef in the noodles and evaluated them to be better than the normal-flavored noodles of the

Table 6. Sensory evaluation of cooked noodles made with different mixing ratios of BG, BC, and BP

Treatment	Appearance	Color	Flavor	Taste	Texture	Overall acceptability
Control	6.7±0.7 ^{ab}	6.8±0.7 ^a	6.8±0.8 ^a	7.1±0.9 ^a	7.2±0.7 ^a	7.0±1.0 ^a
BG-10%	7.0±0.5 ^a	7.2±0.7 ^a	6.6±0.5 ^a	7.3±0.7 ^a	7.2±1.1 ^a	7.2±0.8 ^a
BG-15%	6.4±0.9 ^{ab}	6.9±1.1 ^a	6.4±0.7 ^a	7.2±0.7 ^a	6.9±0.9 ^a	7.0±1.0 ^a
BG-20%	6.4±1.1 ^{ab}	6.4±0.9 ^{ab}	6.1±0.8 ^{ab}	6.3±0.7 ^b	6.7±1.0 ^a	6.3±0.7 ^a
BG-25%	6.0±1.2 ^b	5.8±1.1 ^b	5.3±1.2 ^b	5.7±1.0 ^b	6.3±1.2 ^a	5.4±1.0 ^b
Control	6.4±0.7 ^a	6.3±0.7 ^{ab}	5.9±0.8 ^a	6.0±0.7 ^a	6.6±1.1 ^a	6.2±0.7 ^a
BC-9%	6.7±1.0 ^a	6.6±1.0 ^a	6.4±1.0 ^a	6.2±1.3 ^a	6.8±1.3 ^a	6.7±0.9 ^a
BC-11%	6.8±1.1 ^a	6.3±1.3 ^{ab}	6.4±1.1 ^a	6.8±1.1 ^a	6.6±1.4 ^a	6.8±1.1 ^a
BC-13%	5.9±1.4 ^{ab}	5.9±1.4 ^{ab}	6.8±1.0 ^a	6.8±1.4 ^a	7.3±0.7 ^a	6.7±0.9 ^a
BC-15%	5.1±1.5 ^b	5.1±1.5 ^b	6.3±1.5 ^a	6.4±1.3 ^a	6.7±1.0 ^a	6.2±1.4 ^a
Control	6.3±1.0 ^{ab}	6.3±1.2 ^{ab}	5.8±1.0 ^b	5.6±1.1 ^b	6.1±1.6 ^a	5.9±1.2 ^b
BP-1%	7.3±0.9 ^a	7.3±0.9 ^a	6.4±0.9 ^{ab}	6.3±1.0 ^{ab}	6.3±1.3 ^a	6.5±0.9 ^{ab}
BP-3%	6.9±1.5 ^a	7.1±1.1 ^a	6.8±0.7 ^{ab}	6.9±1.4 ^a	7.3±0.5 ^a	7.4±0.7 ^a
BP-5%	6.4±0.9 ^{ab}	6.4±1.3 ^{ab}	7.1±0.8 ^a	7.1±0.8 ^a	7.1±0.6 ^a	7.3±0.9 ^a
BP-7%	5.3±1.3 ^b	5.3±1.5 ^b	6.6±1.1 ^{ab}	6.9±0.8 ^a	6.8±1.0 ^a	6.8±1.0 ^{ab}

Control, noodles with no beef added; BG, Beef ground added; BC, Beef concentrate added; BP, Beef powder added.

Hedonic scale: 1 (extremely bad) to 9 (extremely good).

Values are Means±SD (n=3).

^{a-b}Means with the same letter in a column are not significantly different ($p>0.05$).

control. The taste and overall acceptability of BP 3% was significantly different to that in the control ($p<0.05$). In addition, the scores for the other tests, such as appearance, color, flavor, and texture, were higher for BP 3% than for the control, even when there was no significant difference. Therefore, BG 10%, BC 11%, and BP 3% had the best results in the sensory evaluation test.

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