

Effects of Sea Tangle (*Lamina japonica*) Powder on Quality Characteristics of Breakfast Sausages

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Abstract

Breakfast sausages containing 1, 2, 3, and 4% sea tangle powder (*Lamina japonica*) were prepared. No differences were found in moisture, protein, and fat contents among the control and treatments. However, the ash content increased with increasing amounts of sea tangle powder ($p < 0.05$). The pH levels in the treated samples were lower than the control in both the meat batters and the breakfast sausages ($p < 0.05$). The L^* and a^* values of the meat batters and breakfast sausages were decreased by the addition of the sea tangle powder, and the control had the highest b^* value ($p < 0.05$). The added sea tangle powder improved cooking loss and improved emulsion stability. The T4 sample (containing 4% sea tangle powder) was shown to have the lowest cooking loss and water loss ($p < 0.05$). The hardness, gumminess, and chewiness of the treatments increased compared to the control due to the presence of dietary fibers in the sea tangle. In the sensory evaluations, the 1% sea tangle powder treatment received a lower color score, but received significantly higher scores for flavor, tenderness, and juiciness ($p < 0.05$). Collectively, the breakfast sausage containing 1% sea tangle powder was determined to have the highest overall acceptability. Altogether, the best results, in terms of physicochemical and sensory properties, were obtained for the breakfast sausage containing 1% sea tangle powder.

Keywords: breakfast sausage, dietary fiber, sea tangle, seaweed

Introduction

Sea tangle (*Lamina japonica*) is a type of brown algae that grows in Korean waters. In Korea, sea tangle along with sea mustard (*Undaria pinnatifida*) are commonly used in Korean soups and Korean stews to enhance flavor. Moreover, the flavor and taste compounds in sea tangle have been used as the artificial flavor enhancer, monosodium L-glutamate (MSG). Sea tangle contains alginate, which is a kind of dietary fiber, with a ratio of manuronic acid to guluronic acid of 6:4 (Lee *et al.*, 1994). It also contains laminarin, fucoidan, vitamin B₂, glutamic acid, and is rich in minerals such as Mg, Ca, K, and I (Kim *et al.*, 2005). Alginate is a structural material in brown algae cell walls and cannot be digested by human digestive enzymes. According to previous studies, sea tangle has various kinds of biological activities. For

example, it has shown antitumor and anticoagulant activities by fucoidan, which is an acid polysaccharide (Haroun-Bouhedja *et al.*, 2000), as well as antimutagenic, antimicrobial (Oh *et al.*, 1998), and antioxidant activities (Cho *et al.*, 2006) qualities. For these reasons, it has recently been used in the form of pills and extracts, and has also been added to foods as a functional health ingredient.

Over the past few years, several studies have examined such meat products with respect to low-fat (Choi *et al.*, 2009; Chin and Ban, 2008), low-salt (Kim *et al.*, 2008a; Lee *et al.*, 2006), and functionality (Kang *et al.*, 2008; Kim *et al.*, 2008b; Lee *et al.*, 2008). In particular, Chun *et al.* (1999), Hwang *et al.* (1998), and López-López *et al.* (2009) reported that sea algae improved the quality characteristics of hamburger patties, low-fat frankfurters, and meat patties, respectively.

Breakfast sausage is made from fresh or frozen pork, beef, meat by-products, and occasionally mechanically deboned meat, and also contains fat, salt, ice or water, and other ingredients (Pearson and Gillett, 1999). Cho (2005) reported that the use of natural sources and vegetables in breakfast sausage may enhance acceptability due

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to the added convenience and nutritional value. Cho (2005) and Lee *et al.* (2008) applied kimchi powder, a traditional Korean food, but the utilization of natural Korean sea tangle in breakfast sausages has not been studied for its effects on quality characteristics.

Therefore, the objective of this study was to enhance the quality characteristics of breakfast sausages by adding sea tangle, a traditional food material, and to offer basic data for further study and development of sea tangle with respect to antioxidant activities, functionality within meat products, and utilization in low-fat meat products.

Materials and Methods

Preparing sea tangle (*Lamina japonica*) powder

A commercial sample of dried sea tangle was purchased from a local market. The dried sea tangle was ground in a blender (KA-2610, Jworld Tech, Ansan, Korea) for 1 min and passed through a 20 mesh sieve. The powder had been vacuum-packed and stored at -20°C until added to the treatments.

Formulation and processing of breakfast sausages

Fresh pork hams (at 48 h postmortem), weighing 6.8-7.2 kg each, and pork back fat were obtained from a local meat market. The meat was trimmed of visible fat and connective tissue. Meat and back fat were passed through a grinder with an 8 mm plate (PM-100, Mainca, Spain).

Breakfast sausages were produced (in pilot plant, Konkuk University, Seoul) and the formulations are given in Table 1. The quantity of meat controlled as sea tangle powder level. Five batches (each 2 kg) were prepared for each treatment. For each batch of breakfast sausage, meat, fat, ice, and other ingredients were emulsified by using a silent cutter (Nr-963009, Scharfen, Witten, Germany). After emulsification, each batters, the part for batter analysis was packed with PE/Nylon film bags with sealing (FJ-500XL, FUJee Tech, Korea), stored at 4°C until experimented. The other matters were stuffed into collagen casings (#240, NIPPI Inc., Tokyo, Japan; approximate 25 mm diameter) by using a stuffer (IS-8, Sirman, Marsango, Italy). The breakfast sausages were heated at 75±1°C for 30 min in a water bath (VS-1901W, Vision Scientific Co., Ltd., Buchun, Korea), after heated, the cooked sausages were then cooled at room temperature for 30 min and stored at 4°C until analysis.

Proximate composition

The compositional properties of samples were deter-

Table 1. Formulation of the breakfast sausages

Ingredients	Formulation (% in batch)				
	Control	T1	T2	T3	T4
Pork meat	50	49	48	47	46
Back fat	25	25	25	25	25
Ice	25	25	25	25	25
Sea tangle powder ¹⁾	0	1	2	3	4
Total	100	100	100	100	100
Salt	1.5	1.5	1.5	1.5	1.5
Phosphate ²⁾	0.15	0.15	0.15	0.15	0.15
Sugar	0.5	0.5	0.5	0.5	0.5
MSG ³⁾	0.07	0.07	0.07	0.07	0.07
Onion powder	0.05	0.05	0.05	0.05	0.05
Garlic powder	0.05	0.05	0.05	0.05	0.05

¹⁾Sea tangle powder : milled *Lamina japonica* powder.

²⁾Phosphate : sodium tripolyphosphate .

³⁾MSG : monosodium L-glutamate.

mined by using a standard AOAC (1995) and were performed on samples. The moisture content was determined by weight loss after 12 h of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Bucheon, South Korea). The fat content was determined by Soxhlet method with a solvent extraction system (Soxtec[®] Avanti 2050 Auto System, Foss Tecator AB, Höganäs, Sweden) and protein content was determined by Kjeldahl method with an automatic Kjeldahl nitrogen analyzer (Kjeltec[®] 2300 Analyzer Unit, Foss Analytical AB, Höganäs, Sweden). The ash content was determined according to AOAC method 923. 03.

pH

The pH sample was determined with a pH meter (Model 340, Mettler-Toledo GmbH, Schwerzenbach, Switzerland). The pH values of breakfast sausage were measured by blending a 5 g sample with 20 mL distilled water for 60 s in a homogenizer (Ultra-Turrax T25, Janke & Kunkel, Staufen, Germany).

Instrumental color evaluations

The instrumental color analysis of breakfast sausage were conducted. The meat batter weighed (80 g) into Petri dish and cooked at 75±1°C for 30 min. After cooling, the cooked breakfast sausages were evaluated on the surface. Color measurements were taken with colorimeter (Chroma meter CR-210, Minolta, Japan; illuminate C, calibrated with white standard plate L=97.83, a=-0.43, b=+1.98), consisted of an 8 mm diameter measuring area and a 50 mm diameter illumination area. Color values (CIE L*, CIE a*, and CIE b*) were measured on the sur-

face of samples and results were taken in triplicate for each sample.

Cooking loss

The meat batter weighed (80 g) stuffed into collagen casing and after heat processing at $75\pm 1^\circ\text{C}$ for 30 min. After cooling 30 min, cooked breakfast sausages were weighed and a percentage of cooking loss was calculated from the weights.

Cooking loss (%)

$$= \frac{\text{weight of sausage (before cooking - after cooking)}}{\text{weight of sausage before cooking}} \times 100$$

Emulsion stability

The meat batters were analyzed for emulsion stability using the method of Bloukas and Honikel (1992) with the following modifications. At middle of a 15 mesh sieve (50 mm diameter), pre-weighed graduated glass tube (Pyrex Chojalab Co., Seoul, South Korea, Volume: 15 mL, Graduated units: 0.2 mL) were filled with batter. The glass tubes were closed and heated for 30 min in boiling water bath to a core temperature of $75\pm 1^\circ\text{C}$. After cooling to approximately 4°C to facilitate the fat and water layers separation. The fluid water and fat, which separated well in the bottom of graduated glass tube, were measured in mL and calculated as percentage of the original weight of batter (Choi *et al.*, 2009).

$$\text{Fat loss (mL/g)} = \frac{\text{the fat layer (mL)}}{\text{weight of raw meat batter (g)}} \times 100$$

$$\text{Water loss (mL/g)} = \frac{\text{the Water layer (mL)}}{\text{weight of raw meat batter (g)}} \times 100$$

Texture profile analysis (TPA)

The profile analysis was performed in duplicate on each sausage. Samples were cooked as previously described. The cooked breakfast sausages were cooled at room temperature for 1 h to determine texture properties. The tex-

tural properties of each sausage were measured by a spherical probe (5 diameter), set attached to a Texture Analyzer (TA-XT2i, Stable Micro System Ltd., Surrey, UK). The test conditions were as follow : stroke, 20 g; test speed, 2.0 mm/s; distance, 10.0 mm. Data were collected and analyzed from the hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) values.

Sensory evaluations

The breakfast sausages were evaluated for color, flavor, juiciness, tenderness, and overall acceptability. The cooked samples as previously described were cooled to the room temperature at $25\pm 1^\circ\text{C}$ and cut and served to the panelists in random order. The sensory evaluations were performed by the panelists under fluorescence lighting. Panelists were instructed to cleanse their palates between samples using water. The color, flavor, and overall acceptability (1 =extremely undesirable, 10=extremely desirable), tenderness (1=extremely tough, 10=extremely tender), juiciness (1=extremely dry, 10=extremely juicy) of the cooked samples were evaluated using a 10-point descriptive scale. The panel consisted of 10 members from the department of food sciences and biotechnology of animal resources at Konkuk University in Korea.

Statistical analysis

An analysis of variance were performed on all the variables measured using the General Linear Model (GLM) procedure of the SAS statistical package (SAS Institute, Inc., 1999). Duncan's multiple range test ($p < 0.05$) was used to determine differences among the treatment means.

Results and Discussion

Proximate composition

The proximate compositions of the breakfast sausages containing sea tangle powder are shown in Table 2. The sea tangle powder was analyzed for contents of moisture

Table 2. Proximate analysis (%) of the breakfast sausages containing sea tangle powder

Traits (%)	Control	Treatments ¹⁾			
		T1	T2	T3	T4
Moisture	59.70±0.60 ²⁾	59.75±1.69	60.13±1.57	59.76±0.64	59.51±0.29
Protein	10.53±1.13	11.07±0.80	11.18±0.59	11.14±0.51	11.34±0.58
Fat	26.29±1.78	25.99±1.38	24.31±2.39	24.07±0.57	23.95±2.04
Ash	2.13±0.15 ^d	2.35±0.25 ^{cd}	2.49±0.27 ^{bc}	2.74±0.17 ^{ab}	2.89±0.27 ^a

¹⁾Treatments are shown in Table 1.

²⁾All values are mean±SD.

^{a-d}Means in the same row with different letters are significantly different ($p < 0.05$).

(11.5%), protein (7.8%), fat (1.2%), and ash (31.3%). The moisture contents of all samples ranged from 59.51-60.13% ($p>0.05$). Chun *et al.* (1999) obtained similar results in cooked hamburger patties with added *Sargassum thunbergii*, a variety of seaweed. No differences were found in protein contents among the control and treatments ($p>0.05$). When the meat content was replaced with the same percentage of sea tangle powder, the resulting protein contents of the treatments were higher than the control. Fat contents were not significantly different among the all treatments. Cofrades *et al.* (2008) also reported no significant differences among treatments. However, in the present study, ash contents increased with increasing amounts of sea tangle powder ($p<0.05$). This result was due to the high ash content of the sea tangle powder, including Mg, Ca, K, and I (Kim *et al.*, 2005). López-López *et al.* (2009) obtained similar results in frankfurters, for the same reason.

pH and instrumental color evaluations of meat batters and breakfast sausages

The pH value of the sea tangle powder was 5.88, and the values of the meat batters ranged from 5.97 to 6.07 (Table 3). The highest pH was obtained in the control, and the pH values of the treatments decreased with increasing sea tangle powder ($p<0.05$). After cooking, the pH value of T4 (containing 4% sea tangle powder) was higher than that of the control ($p<0.05$). Similar results were reported by Cofrades *et al.* (2008) who studied additions of diverse types of edible seaweeds such as Sea Spaghetti (*Himanthalia elongata*), Wakame (*Undaria pinnatifida*), and Nori (*Porphyra umbilicalis*).

In terms of instrumental color, sea tangle offers rich pigments such as carotenoids, xanthophyll, and chlorophyll, and therefore had an effect on the color of the

breakfast sausages. The lightness (CIE L*) of the meat batters and breakfast sausages decreased with increasing sea tangle powder ($p<0.05$), and these significant reductions in lightness were due to the lower lightness of the sea tangle powder. Chun *et al.* (1999) and Hwang *et al.* (1998) reported similar results, in which treatments groups had lower lightness than a control due to the added algae. Redness (CIE a*) decreased significantly ($p<0.05$) with increasing sea tangle powder content due to the low redness of the sea tangle powder; however, in the breakfast sausages containing up to 2% sea tangle powder, the result was not significant ($p>0.05$), for both the meat batters and the breakfast sausages. Yellowness (CIE b*) of all treatments values were higher ($p<0.05$) in the sea tangle powder treatment groups compared to the controls irrespective of cooking. The sea tangle powder had a yellowness value of 13.76 ± 0.35 , which would likely be the result of its carotenoid and xanthophyll pigments. Cofrades *et al.* (2008) obtained similar results in a study of seaweeds (Wakame, Sea spaghetti) added to a meat system. All results showed that the addition of sea tangle powder to the breakfast sausages caused decreases in lightness and redness and increased yellowness. Many studies have reported that the addition of a brown algae, such as sea tangle, decreases lightness in various foods (Cho *et al.*, 2006; Chun *et al.*, 1999). López-López *et al.* (2009) obtained similar results to our color parameters (lightness, redness, yellowness).

Cooking loss and emulsion stability of meat batters

The cooking loss and emulsion stability of the sea tangle powder-added breakfast sausages are shown in Table 4. The results indicate that cooking loss was significantly decreased in the treatments ($p<0.05$) when compared to the control. This was probably due to the dietary fibers in

Table 3. The pH and instrumental color values of the meat batters and breakfast sausages containing sea tangle powder

Type traits		Control	Treatments ¹⁾			
			T1	T2	T3	T4
Un-cooked batter	pH	6.07±0.02 ^a	6.04±0.05 ^{ab}	6.01±0.05 ^{bc}	5.97±0.07 ^c	5.97±0.06 ^c
	CIE L*	76.05±2.84 ^a	71.82±3.56 ^b	69.59±1.23 ^c	66.13±1.52 ^d	62.55±1.49 ^e
	CIE a*	3.38±0.15 ^a	0.97±0.60 ^b	0.13±0.70 ^c	-0.55±0.50 ^d	-0.75±0.51 ^d
	CIE b*	11.94±1.31 ^b	14.39±2.75 ^{ab}	16.38±3.76 ^a	17.57±3.18 ^a	17.18±4.43 ^a
Cooked sausage	pH	6.31±0.14 ^a	6.27±0.10 ^{ab}	6.24±0.08 ^{ab}	6.22±0.09 ^{ab}	6.20±0.09 ^b
	CIE L*	73.51±2.02 ^a	68.00±1.76 ^b	64.56±1.94 ^c	61.61±1.40 ^d	58.05±1.69 ^e
	CIE a*	5.72±0.52 ^a	3.05±1.14 ^b	1.86±1.30 ^c	0.88±0.83 ^d	0.44±1.05 ^d
	CIE b*	9.87±0.38 ^d	12.82±1.59 ^c	14.43±1.72 ^b	15.78±2.42 ^{ab}	16.40±2.11 ^a

¹⁾Treatments are shown in Table 1.

²⁾All values are mean±SD.

^{a-e}Means in the same row with different letters are significantly different ($p<0.05$).

Table 4. Cooking loss and emulsion stability of meat batters containing sea tangle powder

Traits	Control	Treatments ¹⁾			
		T1	T2	T3	T4
Cooking loss (%)	11.26±1.39 ^{a2)}	9.16±0.41 ^b	8.67±1.60 ^{bc}	7.60±0.40 ^c	6.74±0.19 ^c
Emulsion stability					
Water loss (%)	7.24±1.14 ^a	5.83±0.74 ^{ab}	4.06±1.71 ^{bc}	3.66±0.43 ^{bc}	2.67±0.66 ^c
Fat loss (%)	1.83±0.17 ^a	1.78±0.74 ^{ab}	1.28±0.36 ^{ab}	1.08±0.32 ^b	1.12±0.44 ^{ab}

¹⁾Treatments are shown in Table 1.

²⁾All values are mean±SD.

^{a-c}Means in the same row with different letters are significantly different ($p<0.05$).

the sea tangle, such as alginate and laminarin, which have high water holding capacity and binding capacity (Hwang *et al.*, 1998). Similar results were obtained by Chun *et al.* (1999) and López-López *et al.* (2009) in hamburger patties and low fat frankfurters, respectively. Also, in various studies examining emulsified type meat products containing dietary fiber, additions of chitosan (Park *et al.*, 2005), rice bran (Choi *et al.*, 2008; Huang *et al.*, 2005), and wheat fiber (Choi *et al.*, 2007) decreased cooking loss in the final products.

Emulsion stability is an index that estimates the physical properties of a final meat product. Meat batter that has high emulsion stability does not extrude fat and water during cooking (Surh *et al.*, 2006). The added sea tangle powder had significant effects on the emulsion stability of the breakfast sausages ($p<0.05$). Water loss decreased with increasing sea tangle powder, and the highest value was obtained in the control. For fat loss, all treatments had lower values than the control. According to Wong and Cheung (2000), the dietary fiber and protein in seaweeds improved the physicochemical properties of meat products by affecting the matrix structure of the meat gel/emulsion system. The results of the present study were similar to the former. Also, insoluble dietary fiber has fat absorption capacity, and consequently fat loss was lower in the treatments than the control. Cofrades *et al.* (2008) reported similar results in low-salt gel/emulsion meat systems.

Texture properties

Table 5 shows the texture property comparisons of the breakfast sausages containing sea tangle powder. The hardness values of the treatments, excluding the treatment containing 1% sea tangle powder, were higher than that of the control. For springiness, the breakfast sausage containing 4% sea tangle powder had the highest value compared to the other samples ($p<0.05$). Cofrades *et al.* (2008) and Fernández-Martín *et al.* (2009) obtained similar results of increasing hardness and decreasing springiness by additions of sea tangle powder and sea spaghetti seaweed. Cohesiveness was unaffected according to the different formulations of sea tangle powder ($p>0.05$). On the other hand, the addition of sea tangle powder increased gumminess and chewiness values, and the breakfast sausage containing 4% sea tangle powder had the highest values ($p<0.05$). Fernández-Martín *et al.* (2009) reported similar results. In various foods such as bread (Kwon *et al.*, 2003), cookies (Cho *et al.*, 2006), the addition of sea tangle powder increases hardness. This result is similar to reports in which the addition of dietary fiber to meat product increased hardness (Choi *et al.*, 2008; Yilmaz and Daglioilu, 2003; Yilmaz, 2004, 2005). There are several factors that can influence the texture of breakfast sausage. In particular, the addition of dietary fiber to meat products influences their textural properties (Thebaudin *et al.*, 1997).

Table 5. Comparisons on texture properties of the breakfast sausages containing sea tangle powder

Traits	Control	Treatments ¹⁾			
		T1	T2	T3	T4
Hardness (kg)	0.33±0.03 ^{c2)}	0.32±0.04 ^c	0.36±0.03 ^{bc}	0.39±0.06 ^{ab}	0.42±0.05 ^a
Springiness	0.92±0.03 ^{bc}	0.96±0.03 ^a	0.94±0.03 ^{ab}	0.91±0.05 ^{bc}	0.90±0.02 ^c
Cohesiveness	0.47±0.02	0.47±0.04	0.48±0.02	0.47±0.02	0.46±0.01
Gumminess (kg)	0.16±0.02 ^c	0.15±0.01 ^c	0.17±0.01 ^{bc}	0.19±0.03 ^{ab}	0.20±0.03 ^a
Chewiness (kg)	0.14±0.01 ^b	0.14±0.01 ^b	0.16±0.01 ^{ab}	0.17±0.02 ^a	0.18±0.02 ^a

¹⁾Treatments are shown in Table 1.

²⁾All values are mean±SD.

^{a-c}Means in the same row with different letters are significantly different ($p<0.05$).

Table 6. Comparisons on sensory properties of the breakfast sausages containing sea tangle powder

Traits	Control	Treatments ¹⁾			
		T1	T2	T3	T4
Color	8.75±0.71 ^{a2)}	8.00±1.07 ^{ab}	7.63±1.06 ^b	7.00±0.76 ^b	7.13±0.99 ^b
Flavor	7.63±0.52 ^b	8.63±0.52 ^a	8.13±0.64 ^{ab}	7.75±0.71 ^b	7.75±0.71 ^b
Tenderness	7.88±0.64 ^a	7.83±0.64 ^a	7.75±0.71 ^a	7.38±0.74 ^{ab}	6.75±1.04 ^b
Juiciness	8.00±0.53 ^{ab}	8.38±0.52 ^a	8.13±0.64 ^a	7.88±0.83 ^{ab}	7.25±1.04 ^b
Overall acceptability	8.00±0.53 ^{ab}	8.63±0.92 ^a	8.13±0.99 ^{ab}	7.50±0.76 ^{bc}	7.00±0.76 ^c

¹⁾Treatments are shown in Table 1.

²⁾All values are mean±SD.

^{a-c}Means in the same row with different letters are significantly different ($p < 0.05$).

Sensory properties

The sensory property comparisons of the breakfast sausages containing sea tangle powder are shown in Table 6. The addition of sea tangle powder decreased color scores, and all the treatments received lower scores than the control. This result was a direct relationship to the percentage of sea tangle powder added. In many studies examining additions of brown algae, visual color has been a key problem. Chun *et al.* (1999) and Cho *et al.* (2006) reported lower color scores in hamburger patties and cookies containing brown algae powder, respectively. However, regardless of high sea tangle content, Cho and Hong (2006) obtained high color scores in *Sulgidduk*. Though there are several factors influencing these differences, the most important factor is the type of food in which the algae was applied. Tenderness was not significantly different among the control and breakfast sausages containing 1 and 2% sea tangle powder. The sausages generally had a bright visual color; nonetheless those containing sea tangle powder had lower brightness than the traditional breakfast sausages. For flavor and juiciness, the breakfast sausage containing 1% sea tangle powder received the highest scores. The flavor sensory property was probably due to the savory flavor and taste of the sea tangle. In terms of juiciness, the panelists sensed a soft texture due to the dietary fiber in the sea tangle and its high water holding capacity. García *et al.* (2002) reported that additions of peach, apple, and orange fiber resulted in higher texture scores compared to a control in low fat (6%) fermented sausages. The breakfast sausage containing 1% sea tangle powder, which had high scores for flavor, tenderness, and juiciness, but not for color, was evaluated as excellent in terms of overall acceptability. In connection with these results, Kwon *et al.* (2003) reported that in consumers who value well-being, the color of the final product is not of great importance. Hwang *et al.* (1998) obtained similar results.

Therefore, the breakfast sausage containing 1% sea tan-

gle powder will be accepted by well-being consumers due to improved physico-chemical properties and sensory properties.

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