SEA TANGLE POWDER AS A POSSIBLE NATURAL REPLACEMENT OF PHOSPHATE

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Abstract – The present study examined whether the sea tangle powder (STP) could replace phosphate in emulsion-type meat product. Meat batters (negative control, NC; positive control, 0.2% of sodium pyrophosphaste, PC; 1, 2, and 3% STP with no phosphate) and emulsion-type sausages (NC, PC, 2, and 4% STP) were prepared. pH of meat batter and water holding capacity of sausage containing the STP were higher than those of NC. Water content of the sausage containing 2% STP was higher than that of PC. Sausages contained STP showed higher gumminess than NC in texture profile analysis. Therefore, there is a possibility to use STP as a natural material for phosphate replacer in emulsion-type sausage but further study is needed to improve textural property.

Key Words –*Laminaria japonica*, Meat batter, Emulsion-type sausage

I. INTRODUCTION

Recently, consumers demand healthier products like low-salt, low-fat, and reduced synthetic additives [1]. With the consumers' demand, there were various efforts to develop substitutes for some specific additives in the meat industry. The phosphate is also one of the additives to be tried to replace in the several studies [2, 3].

The phosphate increases the ionic strength of myofibrillar proteins and makes the extraction of myofibrillar proteins more efficiently. Because of this action, the phosphate could enhance the water holding capacity (WHC) and facilitate to form a strong gel by the gelation of myofibrillar protein. Therefore, it has used to improve the quality related with water and meat binding capacity of products in the meat industry [4].

Sea tangle (*Laminaria japonica*), kind of brown algae, contains several functional materials like laminarin, fucoidan, glutamic acid as well as minerals including Mg, Ca, K, and I. In addition, several studies reported antioxidant, antimutagenic, and antimicrobial activities of sea tangle [5]. Most of all, alginate in sea tangle which is dietary fiber has the characteristics such as WHC, viscosity, and binding ability [6]. These characteristics of sea tangle are expected to replace phosphate in meat and meat products.

In the present study, pH, water content, WHC, and texture profile analysis were performed to investigate the possibility to replace the phosphate with the sea tangle powder (STP).

II. MATERIALS AND METHODS

Sample preparation

Pork hind leg meat, back fat, and dried STP were obtained from a commercial market (Seoul, Korea).

Table 1 Formulation of the meat batter (g)

Ingredients	NC*	PC*	STP (%)		
			1	2	3
Pork meat	45	45	45	45	45
Back fat	15	15	15	15	15
Ice water	15	15	15	15	15
Sodium chloride	0.9	0.9	0.9	0.9	0.9
Sodium pyrophosphate	-	0.15	-	-	-
Sea tangle powder	-	-	0.75	1.5	2.25

*NC, negative control; PC, positive control; STP, sea tangle powder.

Meat batter processing

Meat was ground using a meat grinder with 6 mm plate. The ground meat was mixed with back fat, iced water, and additives in a mincer depending on the formula of five treatments, as shown in Table 1.

pH

Each meat batter (1 g) was homogenized with 9 mL of distilled water using a homogenizer (T10 basic, Ika Works, Germany). The homogenate was centrifuged (Union 32R, Hanil Co., Ltd., Korea) and filtered (Whatman No. 4, Whatman PLC., UK). The pH value of each filtrate was measured using a pH meter (SevenGo, Mettler-Toledo International Inc. Switzerland).

Manufacture of emulsion-type sausage

Ground meat was mixed with back fat, iced water, and additives in a silent cutter depending on the formula of four treatments (Table 2) (negative control; NC, positive control; PC, 2 and 4% of STP). The percentage of STP and formulation was determined by the results of previous meat batter experiment. After emulsification, each batter was stuffed in the collagen casing (2.5 cm of diameter). The sausages were cooked in a water-bath at 80°C for 30 min until internal temperature of the sausage reached to 75°C. Then, the cooked sausage was vacuum-packaged with a low-density polyethylene/nylon bags. The packaged sausage was second pasteurized in 85°C hot water for 2 min then cooled.

Table 2 Formulation of the emulsion-type sausage (g)

Ingredients	NC*	PC*	STP (%)	
			2	4
Pork meat	2400	2400	2400	2400
Back fat	800	800	800	800
Ice water	800	800	800	800
Sodium chloride	48	48	48	48
Sodium pyrophosphate	-	8	-	-
Sea tangle powder	-	-	80	160
Egg white	60	60	60	60
Sugar	20	20	20	20
Spice mix	40	40	40	40
L-Ascorbic acid	2	2	2	2
Sodium nitrite	0.28	0.28	0.28	0.28

*NC, negative control; PC, positive control; STP, sea tangle powder.

Water content

Moisture content was determined by drying 3 g of samples placed in falcon tube for 16 h at 105°C.

Water holding capacity (WHC)

Cooked sausage samples (25 × 15 mm) were placed on a filter paper and compressed at a test speed of 2 mm/s and trigger force of 13 kg for 2 min. WHC was calculated as:

A: The weight of sample before compression

B: The weight of sample after compression

Exudated water (%) = (A - B) / A × 100

WHC (%) = (water content - exudated water) / water content × 100

Texture profile analysis

The centers of the cooked sausage samples were compressed twice to 60% of their original height using a texture analyzer (TA-XT Plus, Stable Micro Systems Ltd., Surrey, UK) attached with a compression plate (70 mm in diameter) at a test speed of 2 mm/s and a trigger force of 0.1 kg. The texture analysis was performed using the Exponent Lite Texture Analysis software (Stable Micro System Ltd.), and the values of hardness, springiness, cohesiveness, gumminess, and chewiness were recorded. Three replicate samples were used for each treatment.

Statistical analyses

The experimental data were subjected to one-way analysis of variance (ANOVA) for a completely randomized design using the procedure of General Linear Model, and significant differences among mean values were determined by using the Tukey's multiple comparison test in SAS software (SAS Institute Inc., Cary, NC, USA) at a significance level of $P< 0.05$.

III. RESULTS AND DISCUSSION

Meat batter study

The pH value of meat batter containing STP was significantly higher than that of NC (Table 3). Positive control showed the higher pH and the meat batters with 2% and 3% STP had higher pH than that with 1% STP. Negative control without phosphate and STP showed the lowest pH.

Emulsion-type sausage

Sausage containing 2% STP without addition of phosphate presented higher water content compared to PC (P<0.05). On the other hand, PC showed the highest WHC (Table 4). Similar to pH data, WHC of NC was significantly lower than the treatments containing STP.

Table 3 pH of the meat batters containing sea tangle powder

NC*	PC*	STP (%) 1	STP (%) 2	STP (%) 3	SEM 1)
5.77^{d}	6.14^{a}	5.82^{c}	5.88^{b}	5.88^{b}	0.016

*NC, negative control; PC, positive control; STP, sea tangle powder.
1)Standard error of the means (n=15).
a-dValues with different letters within the same row differ significantly (P <0.05).

PC was higher than NC and other treatments containing STP in texture profile analysis except for springiness and adhesiveness (P<0.05) (Table 5). In springiness, there was no significant difference among NC, PC, and STP treatments. Hardness, adhesiveness, gumminess, chewiness, and cohesiveness were the lowest in NC but was not always the case that sausages contained STP were higher values than that of NC in all texture parameters.

The pH of pyrophosphate is known as about 11. Thus phosphate increases the pH of meat and improves WHC [7]. In addition, the increased pH generates strong gel as well as high emulsion stability [4]. PC in the present study had the highest pH value, presented higher WHC, and stronger texture when compared with other treatments.

Dried marine algae are known to have great WHC since it absorbs water about 20 times of their dry matter volume [8]. Thus, the water content of the samples with STP was higher than PC or at least not different from PC. Metal chelating capacity of phosphate has also effect on high WHC [9]. However, STP contains various minerals including calcium and magnesium ions [10], which may be one of the reasons of lower WHC of the sausages with STP than PC and that with 2% STP was higher than 4% STP.

IV. CONCLUSION

The results of the water content and water holding capacity showed possibility in replacement of phosphate with the sea tangle powder. However, there was no clear effect on texture of emulsion-type sausage which may be studied further.

Table 4 Water content and water holding capacity of the emulsion sausage containing sea tangle powder

Traits	NC*	PC*	STP (%) 2	STP (%) 4	SEM 1)
Water content	56.02^{ab}	55.69^{b}	57.91^{a}	57.31^{ab}	0.450
Water holding capacity	70.35^{d}	84.53^{a}	77.72^{b}	73.89^{c}	0.538

*NC, negative control; PC, positive control; STP, sea tangle powder.
1)Standard error of the means (n=12).
a-dValues with different letters with in the same row differ significantly (P <0.05).

Table 5 Texture profile analysis of the emulsion sausage containing sea tangle powder

Traits	NC*	PC*	STP (%) 2	STP (%) 4	SEM 1)
Hardness	4.18^{c}	6.89^{a}	4.71^{bc}	5.44^{b}	0.242
Adhesiveness	0.00^{a}	-3.78^{b}	0.00^{a}	0.02^{a}	0.947
Springiness	0.78	0.76	0.77	0.76	0.030
Gumminess	0.90^{c}	2.42^{a}	1.31^{b}	1.44^{b}	0.094
Chewiness	0.70^{c}	1.84^{a}	1.00^{bc}	1.09^{b}	0.095
Cohesiveness	0.22^{c}	0.35^{a}	0.28^{b}	0.27^{bc}	0.016

*NC, negative control; PC, positive control; STP, sea tangle powder.
1)Standard error of the means (n=12).
a-dValues with different letters within the same row differ significantly (P <0.05).

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