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Substitution of synthetic nitrite and phosphate using plasma treated winter mushroom in canned ground ham

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Introduction

Nitrite is an essential additive for cured meat products. The natural nitrite source is manufactured by converting the nitrate to nitrite through nitrate-reducing bacteria. This method has a limitation because nitrate must be contained in the natural source.

Plasma is an ionized gas including cations, anions, electron, and free radicals. Recently, the possibility of using atmospheric pressure cold plasma as a new curing method has been suggested because nitrite can be generated by reactions of plasma with water molecules. In the previous study, the extract of the natural plant contained nitrite after the treatment of atmospheric pressure cold plasma. Therefore, natural nitrite sources can be manufactured regardless of its nitrate content.

Phosphate stabilizes the emulsion of meat batter and improves the water holding capacity through the increasing pH in the manufacture of meat products. However, it is a synthetic additive. Thus, it has become necessary to replace with natural products. Winter mushroom have rich in nutrients and antioxidants. It has a high pH and dietary fiber that has functional properties such as improving the water and oil holding capacity and emulsification in food products. Previous studies have shown that winter mushroom powder can effectively replace phosphate in meat products. For this reason, we hypothesized that the use of plasma treated winter mushroom could replace not only sodium nitrite but also phosphate in the meat product.

Therefore, the aim of this study was to evaluate the effect of plasma treated winter mushroom powder as an alternative to nitrite and phosphate in canned ground ham.

Methods

The plasma generated from cylindrical dielectric-barrier discharge was infused into food mixer containing ground winter mushroom. Plasma was infused until the pH 6 of ground winter mushroom, and it was lyophilized to make the powder. The meat batters composed of ground pork, pork back fat, water, salt, ascorbic acid, nitrite, and phosphate were prepared. The treatments were classified into four groups according to nitrite sources and the addition of phosphate; no nitrite and phosphate (NC), sodium nitrite and phosphate (PC), celery powder and phosphate (Celery), 1% of plasma treated winter mushroom powder and no phosphate (PWMP). The nitrite content of all treatment was controlled 48 ppm without PC. The pH of meat batter, the proportion of jelly and melted fat exuded, lipid and protein oxidation, residual nitrite, and nitrosyl hemochrome of canned ground ham manufactured with three times (three batches) at independent day were measured. The data from this study were statistically analyzed using a general linear model under a randomized complete block design (batch as a block). The results were expressed as least-square mean and standard error of the least-square mean, and specific comparisons were performed by Tukey's multiple-range test when the main effect was significant ($p<0.05$).

Results

The pH of meat batter was the highest in PC and the lowest in NC ($p<0.05$, Table 1). The pH of PWMP was lower than PC and Celery. The previous study showed that the addition of 1% winter mushroom powder to pork sausage increased the pH of meat batter to a level similar to the addition of phosphate. In this study, the addition of PWMP didn't sufficiently increase the pH because the pH of winter mushroom was reduced through plasma treatment. The proportion of jelly and melted fat exuded from ground ham was highest in NC ($p<0.05$, Table 1). Despite the absence of phosphate in PWMP, the exudation of jelly and melted fat was less than NC ($p<0.05$). This is because not only PWMP was higher in pH than NC, but also the dietary fiber of the winter mushroom increased water and fat retention in the ground ham.

The malondialdehyde and carbonyl content were highest in NC and no significant difference among PC, Celery, and PWMP ($p<0.05$, Table 2). The inhibition of lipid and protein oxidation was observed in PWMP without the addition of phosphate. This is because of antioxidant compounds contained in winter mushroom. Winter mushroom contains high levels of antioxidants such as phenolic compounds and ergothioneine. In previous studies, the addition of winter mushroom in meat products inhibited lipid and protein oxidation.

Residual nitrite content was highest in PC, followed by Celery and PWMP ($p < 0.05$, Table 3). Nitrosyl hemochrome was no significant difference in PC, Celery, and PWMP, but it tended to highest in Celery and PWMP. This result may be because the antioxidants of celery powder and PWMP reduced nitrite to nitric oxide. Nitric oxide reacted with myoglobin to generate nitrosyl hemochrome after heating.

Conclusion

The addition of plasma treated winter mushroom powder to canned ground

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ham showed the reduction of water and fat exudation although it had no equivalent effect with phosphate. Plasma treated winter mushroom powder generated nitrosyl hemochrome in canned ground ham effectively. In addition, it inhibited lipid and protein oxidation. Therefore, plasma treated winter mushroom powder can serve as a substitute for nitrite and phosphate in meat products.

Table 1 pH of the meat batter, proportion of jelly and melted fat exuded from ground ham (%)

Treatment	pH	Exuded jelly and melted fat
NC	5.81[d]	22.58[a]
PC	6.32[a]	8.46[c]
Celery	6.20[b]	6.49[c]
PWMP	6.03[c]	14.24[b]
SEM[1]	0.003	0.884

[1]Standard error of the least square mean (n=12)

[a-d]Different letters in the same column indicate significant differences between means ($p < 0.05$)

Table 2 Malondialdehyde (mg/kg) and carbonyl content (nmol/mg of protein) of ground ham

Treatment	Malondialdehyde content	Carbonyl content
NC	2.02[a]	1.43[a]
PC	0.39[b]	1.00[b]
Celery	0.49[b]	0.93[b]
PWMP	0.49[b]	0.94[b]
SEM[1]	0.041	0.068

[1]Standard error of the least square mean (n=12)

[a-d]Different letters in the same column indicate significant differences between means ($p < 0.05$)

Table 3 Residual nitrite content (mg/kg) and nitrosyl hemochrome (%) of ground ham

Treatment	Residual nitrite	Nitrosyl hemochrome
NC	0.003[d]	4.71[b]
PC	4.30[a]	22.58[a]
Celery	2.52[b]	26.56[a]
PWMP	1.94[c]	26.76[a]
SEM[1]	0.095	1.249

[1]Standard error of the least square mean (n=12)

[a-d]Different letters in the same column indicate significant differences between means ($p < 0.05$)

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