Evaluation of storage condition and phosphate addition on the physicochemical properties and textural characteristics of model lamb sausages

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Abstract— **This study was performed to evaluate the physicochemical properties and textural characteristics of model lamb sausages with various storage and phosphate combinations. After lamb loins were stored for 8 weeks at -1.5°C and continuously stored with either refrigerated or frozen conditions for 1 week. The refrigeration and frozen combinations resulted in higher pH, but reduced hunter a (redness) and b (yellowness) values of the loins. These lamb meats were mixed with salt (1.5%) and either with or without sodium tripolyphosphate (STPP 0.4%). After homogenized for 2~3 min, the meat batters were packed in the 50 mL-tubes and cooked to an internal temperature of 72°C. Since no interactions between storage condition and STPP addition were observed (P>0.05), data were pooled and separated out by storage condition and STPP addition. The refrigerated and frozen combinations resulted in lighter and redder in color, and less cooking loss and expressible moisture (P<0.05). However, STPP addition reduced hunter redness, cooking loss (%) and expressible moisture, regardless of storage conditions. Furthermore, improved textural characteristics, such as hardness (gf), cohesiveness, gumminess and chewiness were observed with the addition of 0.4% STPP. These results indicated that 1-week freezing storage right after refrigeration (-1.5°C) for 8 weeks reduced color stability, but improved water-holding capacity. The addition of STPP reduced the redness, but improved water-holding capacity and textural characteristics, regardless of storage condition.**

Keywords—**storage condition, phosphate addition, physicochemical properties**

I. INTRODUCTION

New Zealand is the largest lamb producers in the world. Thus, the high quality lamb would be required to export overseas countries. For conventional frozen products for export, New Zealand lamb carcass was electrically stimulated and aged for 10 hr at 6°C and frozen within 48 hr of slaughter by following the Accelerated Conditioning and Ageing process. However, unfrozen chilled lamb meats have been produced for the better quality, resulting in the higher price than the frozen counterpart [1]. During long–time transportation, the chilling condition is critical for the lamb quality. Kim et al. [2] reported that the aging prior to freezing provided equivalent tenderness and colour stability, and better lipid oxidation stability compared to the aged-only loins under high oxygen modified atmosphere. Thus, the aging-then-freezing process might provide positive effects on processed meat quality. This study was designed to evaluate the processing properties of lamb loin aged at -1.5°C for 8 week, and either frozen or continuously chilled for 1 week as affected by salt and phosphate alone or in combination.

III. MATERIALS AND METHODS

A. Preparation of model lamb sausage

Aged lamb meats (two loins from each animal) from either 9 week aged at -1.5°C (fresh) or 8-week aged/ 1-week frozen (fresh/frozen) were ground and mixed with salt and sodium tripolyphosphate alone in combination in the mixer for 3 min as shown in Table 1. Then, approximately 40 g of meat batter were stuffed 50 mL centrifuge tube (4 tubes of each treat)

Table 1. Formulation of lamb model sausage

Ingredients (g)	Fresh		Fresh/Frozen	
	NaCl	NaCl+STPP	NaCl	NaCl+STPP
Ground lamb	350	350	350	350
Water	142.43	142.43	142.43	142.43
Salt	7.5	7.5	7.5	7.5
STPP	0	2	0	2
Sodium nitrite	0.075	0.075	0.075	0.075
Total	500	502	500	502

and cooked at 75°C for 30 min until the internal temperature reached to 72°C. The cooked meat was cooled and stored at the refrigerator (3°C) until analyzed.

B. pH and Hunter color measurement

After the pH electrode was calibrated with standardized buffers (pH 4 and 7), pH values measured using a calibrated pH probe (Testo 205 pH meter, Lenzkirch, Germany). The Hunter L (lightness), a (redness) and b (yellowness) values were measured three times on the model sausage using a Hunter Lab Miniscan XE Plus Colour Meter (Hunter Associates Laboratory, Inc. Reston, VA, USA).

C. Cooking loss and Expressible moisture

After cooking 75°C for 30 min and cooled overnight, and the amount of water from the model sausages was recorded to calculate the cooking loss and expressed as the percentage of the original raw meat batter.

To measure the expressible moisture contents, an approximately 1.5 g of sausage samples was weighed and wrapped with filter paper (Whatmann #3), and then centrifuged at 3,000 rpm for 15 min according to the modified method of Jauregui et al. [3]. Expressible moisture contents were calculated as below:

Expressible moisture (EM, %) = (weight of expressed water in filter paper / weight of sample) ×100

D. Textural hardness

Textural hardness was performed using a Texturometer (TA-XT2, Stable Micro System, Haslemere, England) according to the texture profile analysis (TPA) method of Bourne [4]. The sausage samples (12.5 mm in diameter x 1.2 cm length) was compressed twice to 75% of their original height with a 50 kg load cell at a cross speed of 300 mm/min. Textural hardness was expressed as hardness (gf) of the model sausage samples.

E. Statistical analysis

The experiment was replicated twice, and the data were analysed by two-way analysis of variance (ANOVA) using SPSS [5]. Least squares means for each trait were separated (F test, $P < 0.05$) by using least significant differences.

III. RESULTS AND DISCUSSION

After 9-week chilled or 8-week chilled/1-week frozen lamb loins was evaluated for pH and Hunter color values. As shown in Table 2, the 9-week chilled lamb loins had higher Hunter a and b values, but lower pH and Hunter L values than 8-week fresh and 1-week frozen ones. The higher pH of fresh/frozen lamb loin might have higher functional attributes compared to the 9-week fresh ones [6]. Zhang et al. [6] also reported that high pH meat had lower L*, a* and b* values than normal pH meat, which was partially agreed with our results. These results indicated that the storage condition affected meat quality.

Table 2. Pooled mean of pH and Hunter color values of lamb loin as affected by different storage condition

	Storage condition	
	Fresh	Fresh/Frozen
pH	5.77B[a]	5.91A
Hunter L	37.5B	35.6A
Hunter a	14.6 A	10.8B
Hunter b	17.4 A	14.7B

a: mean of duplicates
A, B mean with same letter in a same row are not different (P>0.05)

Since no interaction between storage condition and ingredient (salt * phosphate) was observed, date were pooled and separated by the storage condition and ingredient (Table 3). In the main effect, the storage condition affected the Hunter L and a values, cooking loss and expressible moisture (WHC), but the ingredient combinations (salt alone or salt * STPP) significantly affected the Hunter b, cooking loss and textural hardness (P<0.001) and expressible moisture (WHC) (P<0.05). Thus, the storage conditions and ingredient affected the physicochemical and textural characteristics of the lamb sausage.

Table 3. Summary of interactions and main effects of meat and model sausage as affected by storage condition or ingredients

	Interactions	Main effect	
		Storage	Ingredient
pH	-	-	-
Hunter L	-	*	-
Hunter a	-	*	-
Hunter b	-	-	***
Cooking loss	-	*	***
WHC[1]	-	*	*
Hardness (gf)	-	-	***

Differences are significant at $p<0.05$ (*); $p<0.01$(**) and $p<0.001$(***):
-: no significant
WHC[1]: water-holding capacity (expressible moisture %)

As shown in Table 4, the storage condition affected physicochemical properties of model lamb sausages. The model lamb sausages manufactured with the 9-week chilled lamb loins had higher hunter a, cooking loss and expressible moisture, but lower Hunter L values than those with the 8-week chilled and 1-week frozen lamb loins ($p<0.05$). Thus, the 8-week chilled and 1-week frozen lamb sausage had higher water-holding capacity than those with 9-week chilled ones. This result was partially due to the loss of water from the meat during thawing. However, no differences in pH, Hunter b and textural hardness were observed. The higher pH of the sausages with 8-week chilled/1-week frozen loins was partially due to the higher pH of the raw meat and therefore, the reduced salt and phosphate in formulation would be possible in the manufacture of processed meats [6].

Table 4. Pooled mean of pH and physicochemical properties of lamb model sausages as affected by different storage condition

	Storage condition	
	Fresh	Fresh/Frozen
pH	6.25A[a]	6.32A
Hunter L	63.3 B	66.5A
Hunter a	9.06 A	6.91B
Hunter b	10.1 A	10.0A
Cooking loss (%)	3.31A	1.76B
Expressible moisture (%)	28.3A	24.9B
Textural hardness (gf)	3842A	3725A

A, B mean with same letter in a same row are not different ($P>0.05$); a: mean of duplicates

The effects of different ingredient combinations (salt alone or in combined with STPP) on pH, Hunter colour values, cooking loss (%), expressible moisture and textural hardness were observed (Table 5). The salt and STPP combination had higher Hunter L, but lower Hunter a (redness), cooking loss, expressible moisture and textural hardness. Thus, the addition of STPP increased water-holding capacity and textural hardness. Therefore, the combination of salt and STPP would be recommended to have better texture and water-holding capacity to manufacture processed meats. Chin et al. [7] produced low-fat meat products with konjac flour, carageenan and soy protein isolates to reduce the in-going amount of the salt with hydrocolloids.

Table 5. Pooled mean of pH and physicochemical properties of lamb model sausages as affected by ingredient combination

	Ingredient(s)	
	NaCl	NaCl+STPP
pH	6.23A[a]	6.34A
Hunter L	64.5 B	65.2A
Hunter a	9.80 A	6.16B
Hunter b	10.1 A	10.1A
Cooking loss (%)	4.65A	0.42B
Expressible moisture (%)	28.3A	24.8B
Textural hardness (gf)	2647B	4920A

A, B mean with same letter in a same row are not different ($P>0.05$): a: mean of duplicates.

IV. CONCLUSIONS

The lamb meat characteristics were affected by the storage conditions (fresh or fresh/ frozen). The model sausages with the 9-week aged lamb loins had higher water holding capacity than those of 8-week fresh/1-week frozen one ($P<0.05$). The salt and STPP combination resulted in improving processing properties (better water-holding capacity and textural characteristics) of the lamb model sausages, as compared to the salt addition alone in model lamb sausages.

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