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Characterization of Restructured Meat Products Manufactured with PSE Pork Hams as Compared to Those with Normal Pork Counterparts

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정상육과 PSE 돈육으로 제조된 재구성 육제품의 품질 특성

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Abstract

The objectives of this study were to develop restructured meat products(RMPs) using a transglutaminase(TGase) and to improve the textural characteristics of RMPs manufactured with pale, soft, exudative(PSE) pork hams. The pH values of RMPs with PSE and normal pork were 5.94 and 6.07, respectively, and their water activity value was approximately 0.981. The RMPs had 70~72% moisture, 4~5% fat, 19~20% protein, and approximately 3% ash contents. No differences in pH, water activity, chemical composition, and hunter color values were observed between RMPs manufactured with normal and PSE pork($p>0.05$). However, RMPs containing PSE pork hams had higher drip loss(%)($p<0.05$) than those with normal pork hams after 10 days of refrigerated storage. Although no differences were observed in the texture profile analysis(TPA) hardness and sensory evaluation, RMPs with PSE pork hams tended to have more pores and lower binding capacity those with normal pork. This result indicated that additional substrates or longer tumbling time(>4 hr) for the manufacture of RMPs containing PSE pork were required for the products to have similar palatability to those with normal pork.

Key words : restructured meat products, transglutaminase, textural characteristics, PSE pork hams

Introduction

Transglutaminase(TGase) is an enzyme that catalyzes the polymerization and cross-linking of proteins, peptides, and some other primary amines. It catalyze non-thermal reaction between glutamine and lysine residues of proteins, where the enzymes catalyzed the formation of(ξ (γ-Glutamyl) lysine bond(Kumazawa et al., 1993; Payne, 2000; Sakamoto et al., 1995). The enzyme has been widely used for the improvement of binding capacity to stabilize meat texture before cooking(Kuraishi et al., 1997; Motoki and Seguro, 1998; Muguruma et al., 1999). When the restructured meats were mixed with TGase and sodium caseinate, and held at 5℃ for 2 hr for the enzyme reaction, the desirable binding capacity was produced. The reaction of microbial TGase was affected by the substrates, pH, and time and temperature combinations (Sakamoto, et al., 1994).

The functional and rheological properties of low-quality meat sources, such as pale, soft, exudative(PSE), may be improved with the use of TGase as a binder in the meat system. In addition, there is a potential possibility for the use of TGase to substitute some portion of the salt in order to

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reduce the salt content in low-fat meat products. Thus, the objectives of this study were to develop high quality and low-fat restructured meat products(RMPs) using TGase and to improve the binding capacity of PSE pork with TGase and soy protein isolate as a substrate.

Materials and Methods

Selection of pork meats and processing of re-structured meat products

Pork hams were selected based on their pH values at 45 min after slaughter, with normal pork having a pH value of higher than 6.0 and PSE pork with pH values ranged from 5.5 to 5.7. The selected pork hams were trimmed off visible and external fats, and connective tissues. Then, these were cut into 2~2.5 cm^3 cubes in a cutter(Model 84/2, Treif, Germany) and placed in a vacuum tumbler(Type 180/14, Frig-O-Vac System, Germany) for 4 hr to mix uniformly with cure ingredients including 0.3% TGase(Activa TG-EB, Ajinomoto Co., Ltd, Japan) to extract salt soluble proteins. Approximately 20% of brine solution was mixed with the meat block. The brine formulation is listed in Table 1. Then, the mixtures were stuffed into fibrous casing(Nalro Faser-Huellen, 90 mm Wiesbaden, Germany), left to stand for 2 hr for the enzyme reaction, and then cooked to an internal temperature of 71.7℃ in a smoke chamber(MC3, Maurer, Germany) according to the cooking procedures for typical RMPs(Table 2).

Table 1. Brine formulation for the manufacture of restructured meat products

Items	Percentage(%)	Amounts(g)
Water	72	3600
Salt	8	400
Sodium nitrite	0.075	3.75
Erkopur(sugar)	9	450
Suchrose	4	200
Soy protein isolate (EX-33)	4	200
Sodium tripolyphosphate	1.8	90
Sodium erythorbate	0.2	10
Activa-TG-EB	1	50

Product analyses and evaluation

pH, water activity, and proximate analysis

RMPs were mixed with 90 mL of double distilled water and pH values were measured using a pH meter (Type 340, Mettler Toledo, Switzerland). Water activity values(Aw) were measured with a Novasina hygrometer. Moisture, fat, protein, and ash percentages(%) of the RMPs were determined by using the dry-oven method, soxhlet fat extraction, nitrogen/protein determinator(FP-528, Leco, USA), and muffle furnace, respectively, followed by AOAC(1995).

Cooking yield and drip loss

Cooking yield(CY, %) for RMPs was measured by weighing and calculating individual chubs before cooking and re-weighing after cooking at 75℃ for 30 min. Drip loss(%) was measured by calculating the released moisture(%) over the total sliced RMPs after 10 days of refrigerated storage.

Table 2. Smoking condition for the manufacture of restructured meat products

Steps	Time(min)	Temp.(℃)	% RH	Smoking
Reddening	30	50	100	off
Drying	30	50	0	off
Smoking	30	55	0	on
Heating 1	30	68	40	off
Heating 2	30	77	45	off
Heating 3	30	82	60	off
Heating 4	30	87	100	off

Until product reaches internal temperature of 71℃.
Cold shower for 20 min until the IT < 40℃.

Color values

Hunter color values(L, a and b) were determined using the Color Meter(45/0 Color Quest, USA). Samples were measured at five different locations across the cut surface and expressed as L(lightness), a(redness), and b(yellowness).

Textural hardness

Textural hardness values were evaluated by using an Instron textural analyzer(Model 1140, Germany) for RMP samples as described by Klettner(1989). The samples were prepared to give cores with 10 mm height and 12.3 mm diameter, and compressed to 80% of their original height at a speed of 100 mm/min in order to measure the firmness.

Microbiological analysis

Microbial determinations were made of the total plate counts (Merck, Standard I-nutrient agar, Germany) for total bacteria and violet red bile agar(Merck VRB, Germany) for *Enterobacteriaceae*. A 10-g sample was blended with 90 mL of sterilized dd-water, diluted several times, and incubated at 37℃ for 48 hr. Results were expressed with $\log_{10}$ No of colony forming unit(CFU) per gram of RMPs.

Sensory evaluation

The sensory evaluation was conducted by a seven-member trained and experienced sensory panel from the sensory testing facilities of the Federal Center for Meat Research (Kulmbach, Germany). The sample preparation and panel training followed the method by Meilgaard et al.(1987). Sensory attributes such as flavor, texture, and juiciness were evaluated using an 8-point descriptive scale(1=extremely weak; 8=extremely strong). Restructured meat samples were sliced at 2 mm height and held at room temperature prior to evaluation.

Statistical analysis

Data were analyzed by analysis of variance(ANOVA) using the general linear model(GLM) procedures of SAS(1989).

Results and Discussion

Mean values for pH, water activity(Aw), and chemical composition are listed in Table 3. The pH of RMPs manufactured with PSE and normal pork hams were 5.94 and 6.07, respectively. As compared to raw meats, the pH difference between the two products was minimal and the increases in pH of the products were partially due to the addition of salt and sodium tripolyphosphate(STPP) as an ingredient for binding and improving water holding capacity. This result was consistent with that of a previous study(Chin and Chung, 2003) which reported that the pH value of RMPs was approximately 6.00. However, this pH value was lower than the result of another study(Tsao et al., 2002). No differences in Aw values(0.980~0.981) were found between RMPs with normal and PSE pork. RMPs with normal pork had 71.39% moisture, 3.90% fat, 19.39% protein, and 3% ash contents, whereas, those with PSE pork had 70.5% moisture, 4.54% fat, 19.45% protein, and 2.99% ash contents(Table 3). No differences in chemical composition of RMPs with both meat sources were observed, and results on proximate composition in RMPs of a previous study(Chin and Chung, 2003) were consistent with those of this current study.

Cooking yield(CY, %), textural hardness, and color values are listed in Table 4. No differences in CY were observed(92.05 vs. 91.66) in RMPs with PSE and normal pork(Table 4). These CY values were comparable with those of previous studies(Rhee et al., 1995; Tsao et al., 2002). Rhee et al.(1995) reported that ionic strengths of 0.385 and 0.462 were the optimum condition in precooked roasts, wherein a combination of sodium chloride, sodium tripolyphosphate, and

Table 3. pH, water activity(Aw) and chemical compositions of restructured hams manufactured with transglutaminase (Activa-TG-EB)

Treatments	pH	Aw	Chemical composition			
			Moisture	Fat	Protein	Ash
Normal	6.07[a]	0.981[a]	71.39[a]	3.90[a]	19.39[a]	3.00[a]
PSE	5.94[a]	0.981[a]	70.49[a]	4.54[a]	19.45[b]	2.99[a]

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

tetrasodium pyrophosphate was added. In addition, textural hardness values of RMPs with normal pork were not significantly different from those with PSE pork. These results were partially due to the synergistic effect of the addition of STPP and TGase with a substrate(soy protein isolate) for improving water holding capacity and textural characteristics. Kurashi et al.(1997) reported that salt was the critical factor for improving binding strength, however, casein(~ 1%) was a good substrate for TGase in RMPs, resulting in sufficient binding strength as a replacement of salt. In this study, soy protein isolate(SPI) was used as a substrate for TGase, and was believed to work well in this RMP system. Tsao et al.(2002) reported that the favorable conditions for the binding of restructured pork chunks were 5% soy protein containing 0.2% $NaHSO_3$ and 20 units MTGase/g, and a setting condition of 60 min at 40℃. They also suggested that soy protein and MTGase as binders could be used to manufacture restructured pork chunks when the salt(%) was reduced. Mean color values of RMPs are shown in Table 3, and no differences in color values were observed($p>0.05$) between the RMPs of the two meat sources. Although the PSE pork tended to be lighter than the normal pork, color values of RMPs were not significantly affected by the meat sources.

The excessive loss of proteinaceous fluids during processing and storage, called drip, is the most important factor in evaluating meat products. Drip contains water soluble proteins and increases with an increase in the degree of denaturation of some or all of sarcoplasmic proteins(Savage et al., 1990). In this study, drip loss(%) of RMPs with normal pork was higher than that with PSE pork at a significance level of $p<0.05$(Fig. 1). This result was partially due to the low-quality meat protein in PSE pork. Kauffman et al.(1994) reported that PSE pork had more water released than dark, firm, and dry(DFD) pork. Thus, water release in RMPs with PSE pork during refrigerated storage might be unavoidable,

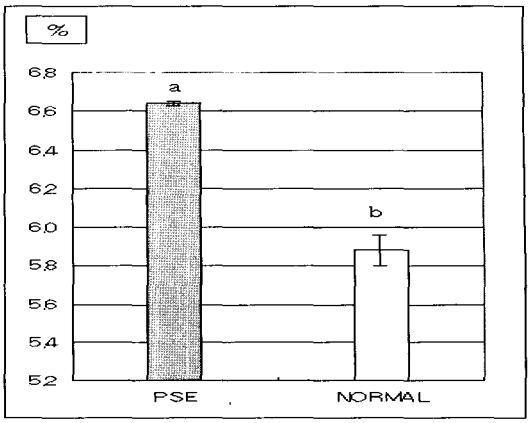

Fig. 1. Drip loss(%) of restructured meat products manufactured with PSE and normal pork hams.

even though TGase and other ingredients were added to these products.

Results on the microbial counts in RMPs are shown in Table 5. No microorganisms($<10^2$ CFU/g) were detected in these meat products, probably due to the fact that the products containing both meat sources were fully cooked, and that the slaughterhouse had good sanitary conditions. The composition of the seven-member trained and experienced sensory panel that tested the products and the sensory results is shown in Table 5. An interesting result of the sensory evaluation was that the RMPs were unusually sweet and not salty, as compared to the German style products, due to the addition of sugars in the formulation. As compared to RMPs with normal pork, RMPs with PSE pork tended to have higher scores in the sensory evaluation. However, no significant differences between the two products were observed. RMPs containing normal pork were more acceptable in terms of flavor and taste than those with PSE pork because the latter tended to have more voids in the surface and had lesser binding ability. These results suggest that the addition of substrates or more tumbling time(>4 hr) for the manufacture of RMPs containing abnormal PSE pork are required to have

Table 4. Physico-chemical and textural characteristics of restructured hams manufactured with transglutaminase (Activa-TG-EB)

Treatments	Cooking yields (%)	Textural hardness	Color values		
			L*	a*	b*
Normal	91.6[a]	101[a]	62.66[a]	17.86[a]	11.99[a]
PSE	92.1[a]	98[a]	63.12[a]	18.07[a]	12.44[a]

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

Table 5. Microbiological counts and sensory evaluation of restructured hams manufactured with transglutaminase (Activa-TG-EB)

Parameters / Treatments	Total[a] (CFU/g)	Entero[a] (CFU/g)	Sensory evaluation[b]					
			Smo	Bea	Sal	Txt	Jui	Overall
Normal	$<10^2$	$<10^2$	4.00[a]	2.33[a]	3.50[a]	4.50[a]	4.33[a]	3.83[a]
PSE	$<10^2$	$<10^2$	4.50[a]	2.00[a]	4.33[a]	5.67[a]	4.67[a]	4.3 [a]

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

[a] Total=Total bacteria, Entero=*Enterobacteriaceae*.

[b] Sensory evaluation: Smo=Smoking flavor, Bea=Beany flavor, Sal=salty flavor, Txt=texture, Jui=Juiciness.

similar palatability to those with normal pork. However, the overall sensory results indicated that PSE pork could be used for the manufacture of RMPs, and textural and sensory attributes could be improved with the addition of TGase and soy protein isolate as a binder.

Conclusion

Restructured meat products(RMPs) were developed using transglutaminase(TGase) and PSE pork, and their physico-chemical, textural, and sensory properties were evaluated. RMPs manufactured with normal pork had lower drip loss during 10 days of refrigerated storage. No differences in pH, water activity, proximate composition, and physico-chemical and textural hardness values were observed, indicating that RMPs could be developed with PSE pork when TGase and substrates were used in these products. Results of sensory evaluation showed that RMPs manufactured with PSE pork hams tended to have more pores and less binding capacity in the products, as compared to those with normal pork. Further study will be performed to develop RMPs with PSE pork using additional substrates or more tumbling time(>4 hr) to achieve palatability similar to those with normal pork.

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