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GEL PROPERTIES OF SURIMI-LIKE MATERIALS FROM CARDIAC AND SKELETAL MUSCLES OF PORCINE

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Introduction

Interest in utilizing edible meat by-products as value-added products has increased in recent years. The use of beef heart muscle as an ingredient in restructured meat products has been limited by low protein functionality and less desirable flavor compared with skeletal muscle. Also, it was suggested that heart muscle had a problem because of higher fat, heme pigment and collagen content in processing surimi-like material (SLM) (Park et al., 1996). Contrary, McKeith et al. (1988) demonstrated that SLM prepared from beef hearts had improved textural properties when compared with fish surimi. Kenney et al. (1992) also showed that incorporation of washed beef cardiac muscle into restructured beef enhanced sensory and instrumental texture traits. Considerable work investigating the role of various proteins in thermal gelation of muscle foods has indicated that myosin and actomyosin are superior to sarcoplasmic proteins. Cardiac muscle, which is composed mainly of red fibers having two isoforms of myosin, is considered to be relatively poor in functional properties, possibly as a consequence of the low solubility of its myofibrillar proteins and its high connective tissue content. However, there is a little information on gel properties of SLM derived from cardiac and skeletal muscle of porcine. An understanding of the characteristics of porcine muscles will assist in determining recommendations for how to handle the SLM from pork muscles for manufacture of surimi products.

Objectives

The objectives of this study were to investigate the characteristics of cardiac and skeletal muscles and to evaluate the gel properties of SLM from porcine muscles.

Methodology

Fresh pig heart (PH), and psoas major muscle (PM) and semimembranosus muscle (SM) of porcine were obtained at Meat Plant of Gyeongsang National University in Korea. After removal of caps, vessels and external fat tissue, the lean muscle was diced into approximately 2 cm cubes, and ground through a 4.7 mm diameter orifice with a mincer to manufacture SLM. The SLM manufacture procedure was modified to method of Kang et al. (2004). The all minced muscles were chopped in a homogenizer with ten volumes (v/w) of cold 25 mM phosphate buffer (NaH2PO4/Na2HPO4), pH 7.0. The

resulting slurry was filtered through a 1 mm-mesh metal screen to remove connective tissues. The filtrate was centrifuged and the supernatant containing fat and water-soluble proteins was discarded. The sediment was mixed with 25 mM phosphate buffer, the volume of which was equal to that of the supernatant discarded in the previous step, homogenized again and filtered through a 500 mm-mesh metal screen and centrifuged (15 min/2,220 × g). A final wash was done in five volumes (v/w based on original weight of mince) of iced water. The washing procedure was repeated by third times. The resulting residue was centrifuged at 2,220 × g for 15 min at 4 and the supernatant discarded. Finally, sediment (SLM) concentration was adjusted 5% protein by adding solution containing 3% NaCl, 0.5% tripolyphosphate (TPP) and 4% sorbitol. The adjusted SLM were mixed with 3% NaCl, 0.5% TPP and 4% sorbitol. Gel of cooked SLM was prepared by heating 15 mL of SLM in capped 1.5 cm diameter tubes for 20 min in a water bath at a constant 75 . After heating, tubes were cooled (15 min) to room temperature in an ice bath. Gel characteristics were determined by proximate composition, color, cooking loss, water-holding capacity, pH, firmness and SDS-PAGE.

Results & Discussion

SLM from SM had significantly ($p<0.05$) higher moisture content and lower crude protein content compared with PH and PM (Table1). Crude fat was removed almost (<0.02%) by water-washing procedure. This was expected since the repeated water washing, the centrifugation and the lower density of the fat result the fat to float off and be removed. Although pH of PH was higher than those of PM and SM, there were no significant differences in pH among SLMs from all muscles (Fig. 1). No difference in pH among SLMs might be due to addition of 3% NaCl, 0.5% TPP and 4% sorbitol. Also, there was no significant difference in pH of cooked SLM gels from all muscles.

There was significant difference in color measurements of cooked SLM (Table 2). The cooked SLM of PH was darker than those of PM and SM. Gel of PH had significantly ($p<0.05$) lower L* and hue values, and higher b* and chroma values compared to gels of PM and SM. Results suggested that some of sarcoplasmic proteins including heme pigments and enzymes in PH would not be excluded enough by water-washing procedure, resulted in remaining in SLM. SDS-PAGE clearly showed many of sarcoplasmic protein bands in myofibrillar protein fractions of PH sample (Fig. 3). Also it was speculated that the sarcoplasmic proteins remained in SLM would affect on not only color measurements but also functionality of cooked SLM gel.

The cooked SLM of PH had poor water-holding capacity (WHC) resulting in higher cooking loss (Table 3). WHC of cooked SLM is mainly a function of protein-protein interaction results in an open matrix allowing a higher proportion of total water to be immobilized than in meat proteins with strong protein interactions. It was suggested that cardiac muscle of porcine had strong protein interactions compared with skeletal muscles. Addition of salt and phosphate into SLM dissociates actomyosin, reducing interactions of meat proteins and opening the protein matrix in gel of cooked SLM. Although protein content in SLM of PH was higher than that of SM, however, moisture content in SLM was less in PH (Table 1) because of its poor WHC (Table 3). The poor WHC probably affected on gel-forming ability of cooked SLM of PH. Gel of PH had significantly ($p<0.05$) lower gel strength and hardness compared with gels of PM and SM (Fig. 2).

These results suggested that proteins of cardiac muscle was not dissociated enough with salt and phosphate, resulted in higher cooking loss compared with both skeletal muscles of PM and SM.

Myofibrillar proteins play the most critical role during meat processing as they are responsible for cohesive structure and the firm texture of meat products (Xiong, 1997). PH sample showed significantly different SDS-PAGE gel pattern of myofibrillar and sarcoplasmic proteins compared to SM and PM samples (Fig. 3). Especially, in myofibrillar protein fractions, the bands of myosin and TM/TN (tropomyosin/troponin) had reduced staining intensity in PH sample, and some of unidentified bands that were not in PM and SM samples, were observed in PH samples. SDS-PAGE indicated that the most notable difference between cardiac and skeletal muscles was the intensity of myosin and TM/TN bands. This result implied that compositions of muscle protein in SLM had effects on gel properties of cooked SLM.

Conclusions

SLM from cardiac muscle of porcine had a poor WHC resulted in much cooking loss compared with those from skeletal muscles. Also SLM of cardiac muscle made a dark gel of cooked SLM because of sarcoplasmic enzymes and heme pigments remained in SLM. Proteins of cardiac muscle did not produce a good gel for surimi because they had strong interaction each other resulted in reducing gel matrix for water, and had less myosin and TM/TN compared with skeletal muscle.

References

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Tables and Figures

Table 1. Proximate composition of surimi-like materials from pig heart (PH), *psoas major* muscle (PM) and *semimembranosus* muscle (SM) of porcine

Treatments	Moisture %	Crude protein %	Crude fat %
PH	73.66±1.75^{B}	28.71±1.79^{A}	<0.02
PM	72.75±1.65^{B}	29.52±1.58^{A}	<0.01
SM	77.05±0.80^{A}	25.03±0.84^{B}	<0.01

^{A,B}Means±S.D with different superscripts within a variable differ ($p<0.05$).

Table 2. Color measurements of surimi-like materials from pig heart (PH), *psoas major* muscle (PM) and *semimembranosus* muscle (SM) of porcine

Treatments	CIE values			Chroma	Hue
	L*	a*	b*		
PH	59.43±1.80^{B}	-1.06±0.16^{A}	11.03±0.92^{A}	11.08±0.91^{A}	95.53±1.22^{C}
PM	73.68±0.92^{A}	-3.70±0.06^{B}	3.13±0.18^{B}	4.84±0.13^{B}	139.89±1.64^{B}
SM	72.52±1.41^{A}	-3.80±0.07^{B}	-2.56±0.20^{C}	4.58±0.11^{B}	213.96±2.26^{A}

$^{A-C}$Means±S.D with different superscripts within a variable differ ($p<0.05$).

Table 3. Cooking loss and water-holding capacity (WHC) of surimi-like materials from pig heart (PH), *psoas major* muscle (PM) and *semimembranosus* muscle (SM) of porcine

Treatments	Cooking loss %	WHC %
PH	20.52±0.46^{A}	67.63±2.34^{C}
PM	17.33±1.05^{B}	84.82±3.11^{A}
SM	19.97±0.72^{A}	74.30±3.46^{B}

$^{A-C}$Means±S.D with different superscripts within a variable differ ($p<0.05$).

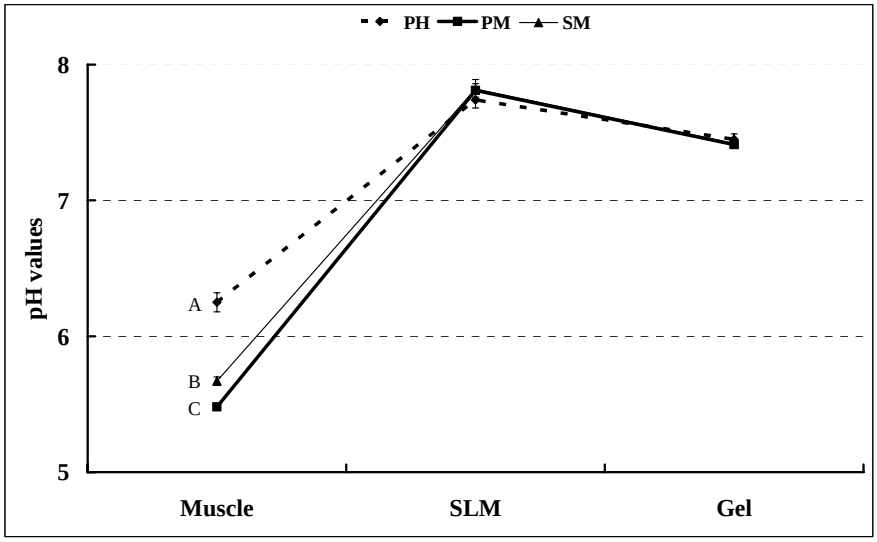

Figure 1. Changes in pH during processing of surimi-like materials from pig heart (PH), *psoas major* muscle (PM) and *semimembranosus* muscle (SM) of porcine. $^{A-C}$Means±S.D with different superscripts differ (p<0.05).

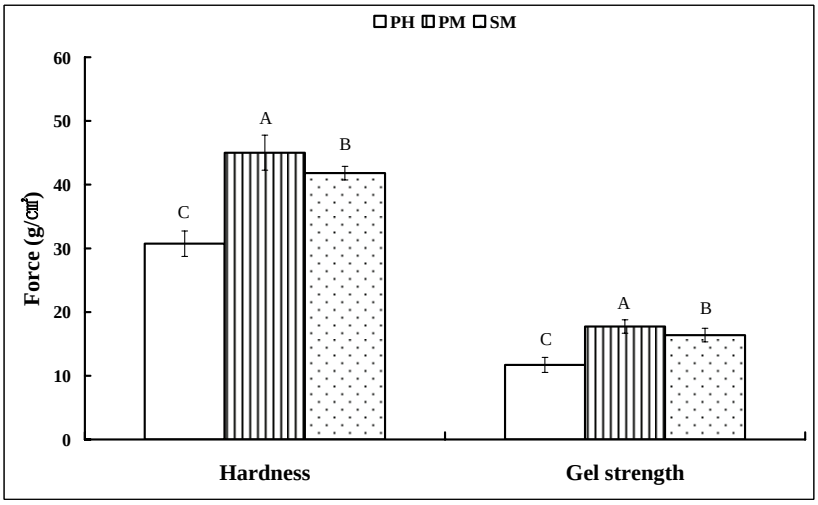

Figure 2. Hardness and gel strength of cooked surimi-like materials from pig heart (PH), *psoas major* muscle (PM) and *semimembranosus* muscle (SM) of porcine. $^{A-C}$Means±S.D with different superscripts within a variable differ (p<0.05).

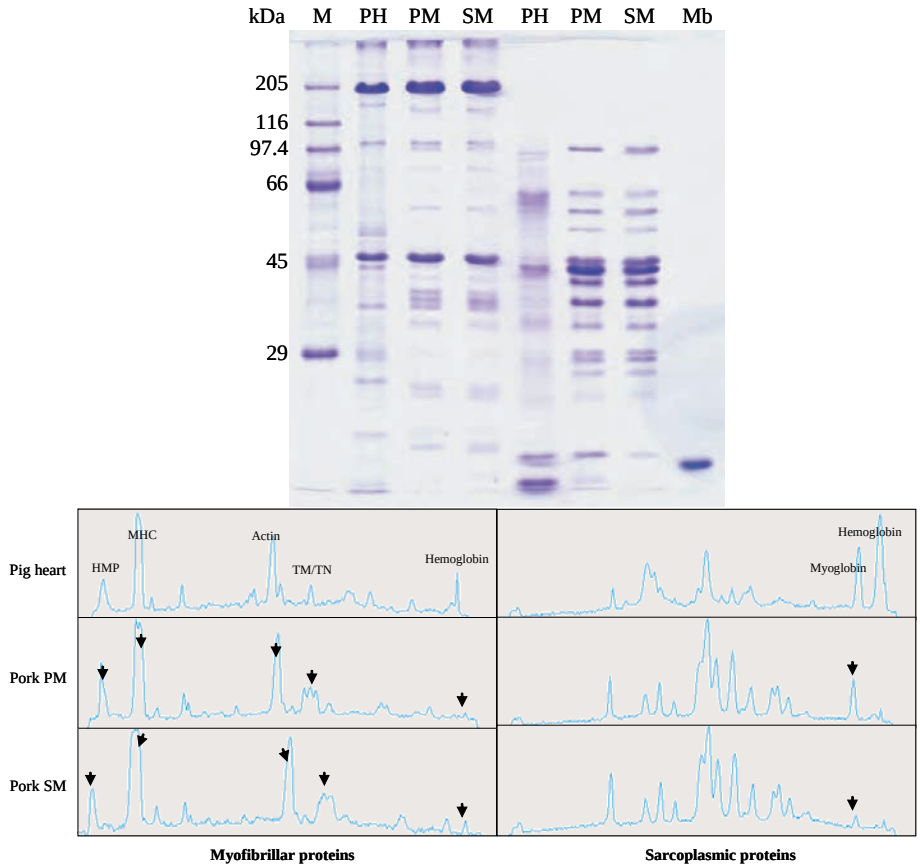

Figure 3. SDS-PAGE patterns (upper) and band intensity (lower) of myofibrillar and sarcoplasmic protein from pig heart (PH), psoas major muscle (PM) and semimembranosus muscle (SM) of porcine. The myofibrillar (lanes 2-4) and sarcoplasmic (lanes 5-7) protein fractions (upper), which were defined as the sediment and supernatant after the first water-washing and centrifugation of the water-washed pork from heart, PM and SM of porcine. M and Mb denote protein molecular mass standards and horse myoglobin, respectively. TM/TN P is tropomyosin/troponin.