EFFECT OF HIGH-PRESSURE TREATMENT ON THE TEXTURAL IMPROVEMENT OF NATURAL HOG CASING

T. Nishiumi[1*], Y. J. Kim[1,2], A. Suzuki[3], H. Yoon[4], and R. Sakata[5]

[1] Division of Life and Food Science, Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan

[2] High Pressure Project Team, Niigata Industrial Creation Organization, Niigata 950-0078, Japan

[3] Faculty of Medical Science for Health, Teikyo Heisei University, Tokyo 170-8445, Japan

[4] New Asia Trading Co. Ltd., Osaka 541-0055, Japan

[5] School of Veterinary Medicine, Azabu University, Sagamihara 229-8501, Japan

[*]Corresponding author (phone: +81-25-262-6663; fax: +81-25-262-6663; e-mail: riesan@agr.niigata-u.ac.jp)

Abstract—**Natural sausage casing is preferred for the manufacture of sausage but varies in quality, particularly with respect to strength and elasticity. In the present study, we attempted to soften the casing through application of high pressure and then to investigate the tenderizing mechanism of casing collagen using high pressure comparing to that using organic acids. High-pressure treatment brought about significant tenderizing of Chinese hog casing under optimum conditions of 200 MPa, 10 min and 20ºC, while 0.2 M lactic and citric acids both proved to be effective tenderizers. Thermal stability of the casing collagen determined by solubility and DSC analyses had no changes with high pressure but a significant decrease by organic acids. There were no changes in the density of bands of collagen α- and β-chains during high pressure on SDS-PAGE, which suggested that the collagen molecules might not be degraded by high-pressure treatment. On the collagen-derived peptide analysis, organic acid treatment raised hydroxyproline contents in both fractions including soluble, molecular and assembled collagens and including collagen-derived peptides, while these contents had no changes with high pressure. SEM revealed the structural weakening, especially the separation the collagen fiber bundles into collagen fibers with high pressure and, on the other hand, the fragmentation of collagen fibers owing to acidic denaturation by organic acids. The present results suggest that high-pressure treatment enables tenderization of natural sausage casing and may physically weaken the collagen fibers by different mechanisms than in organic acid treatment.**

Index Terms—**collagen, high pressure, mechanical strength, natural sausage casing**

I. INTRODUCTION

In the meat industry, natural casing is preferred for the manufacture of sausage owing to its desirable texture. Such casing, however, varies in quality, particularly with respect to strength and elasticity because of its animal origin. An appropriate method is being sought to tenderize this casing in consideration of the low price for its mass production.

Natural casing is principally obtained from small intestines of sources such as hogs, sheep, goats, cows and horses. The intestinal wall is composed of four basic layers including tunica serosa, tunica muscularis, tunica submucosa, and tunica mucosa. For hog and sheep casings, this submucosa is the remaining layer of the intestine after cleaning process and forms the natural sausage casing. The natural casing is therefore connective tissue which is mainly composed of numerous sheet-like layers of collagen fibers in a criss-cross arragement. A previous study indicated that the thermal and structural stabilities of collagen fibers could be determined based on the mechanical strength of natural casings (Nishiumi, Sato, Suzuki, & Sakata, 2001).

Several treatments aiming to tenderize natural casings have been investigated, e.g. lactic acid and pepsin (Sakata, Segawa. Morita, & Nagata, 1998), various additives (Bekker, Houben, Koolmees, Bindrich, & Sprehe, 1999), high pressure (Nishiumi et al., 2005), and trisodium phosphate (Nakae, Oshida, Nishiumi, Yoon, & Sakata, 2008). In the present study, we attempted to soften natural hog casing through application of high pressure and then to investigate the tenderizing mechanism of the casing collagen using high pressure comparing to that using organic acids.

II. MATERIALS AND METHODS

Treatment of high pressure or organic acid

Analysis was conducted on hog casing (32-34 mm in diameter) from China after being washed and desalted in running water. Desalted casing was packed in a polyethylene bag, sealed with distilled water and pressurized using an isostatic press (Nikkiso KK, Japan) under optimum conditions of 200 MPa, 10 min and 20ºC. For organic acid application, desalted casing was immersed in 0.2 M lactic or citric acid solution at 20ºC for 10 min and then washed in running water for 30 min.

Mechanical strength measurement

Mechanical strength of the casing prior to and following high pressure or acid treatment was measured using a Rheometer (Fudoh NMR-2002J, Japan). The peak breaking point of casing strength was found using a cylindrical plunger 3-mm in diameter inserted into the casing.

Analyses of thermal stability of collagen

Both heat solubility of collagen and differential scanning calorimetry (DSC) of the casings were measured to confirm thermal stability of casing collagen. Analysis of the heat solubility of collagen was performed according to Ichinoseki, Nishiumi, & Suzuki (2006). Thermal denaturation of collagen fibers was analyzed using a differential scanning calorimeter (Micro DSC VII, Setaram, France) with increasing rate of 1.0ºC/min.

Biochemical analyses of collagen

SDS-PAGE and collagen-derived peptides were analyzed in order to confirm the degradation of collagen molecules or fibrils by high-pressure treatment. Both analyses were carried out according to the method of Ichinoseki, Nishiumi, & Suzuki (2006).

Scanning electron microscopy (SEM)

Structure and arrangement of collagen fibers on the surface of casing before and after treatment were observed with a scanning electron microscope (JSM5310LV, JEOL, Japan). All SEM specimens were prepared according to the cell-maceration method (Ohtani, Ushiki, Taguchi, & Kikuta, 1988).

III. RESULTS AND DISCUSSION

Chinese hog casing could be significantly tenderized by both treatments of high pressure and organic acid. Organic acid brought out a severe tenderization even in tender casing by nature, while high pressure could reduce the scatter of the breaking strength of natural casing. High-pressure treatment is more effective for improving the mechanical strength of natural sausage casing and therefore effectively rendered uniformly tender casing.

Effect of high pressure or organic acid on heat solubility of collagen was shown in Fig. 1. The ratio of soluble collagen by heating did not increase with high-pressure treatment but did increase significantly ($P<0.01$) with organic acid treatment. Thermal stability of collagen demonstrated by both thermal denaturation tempertature and enthalpy using a DSC had also no changes with high pressure but a significant decrease with organic acid treatment (Fig. 2). A significant decline of the thermal stability by acid treatment may reflect an acid denaturation of collagens comprising the hog casing, while high-pressure treatment may tenderize the casing via a different mechanism.

There were no changes in the density of bands of collagen α- and β-chains during high pressure on SDS-PAGE, which suggests that the collagen molecules may not be degraded by high-pressure treatment. On the collagen-derived peptide analysis, organic acid treatment raised hydroxyproline contents in both fractions including soluble, molecular and assembled collagens and including collagen-derived peptides, while these contents had no changes with high pressure (Fig. 3). These results suggest that organic acid may result in denaturation of casing collagens but high pressure may not.

SEM of collagen fibers on the surface of natural hog casing prior to and following high pressure or acid treatment were shown in Fig. 4. The casing prior to the treatment was composed of numerous thick collagen fiber bundles in a criss-cross arragement (Fig. 4A). SEM revealed the structural weakening, especially the separation the collagen fiber bundles into collagen fibers, with high pressure (Fig. 4B), which was similar to the report observed in the structural weakening of intramuscular connective tissue (Ichinoseki, Nishiumi, & Suzuki, 2006). On the other hand, the fragmentation of collagen fibers or fibrils due to acidic denaturation was observed with organic acid treatment (Fig. 4C).

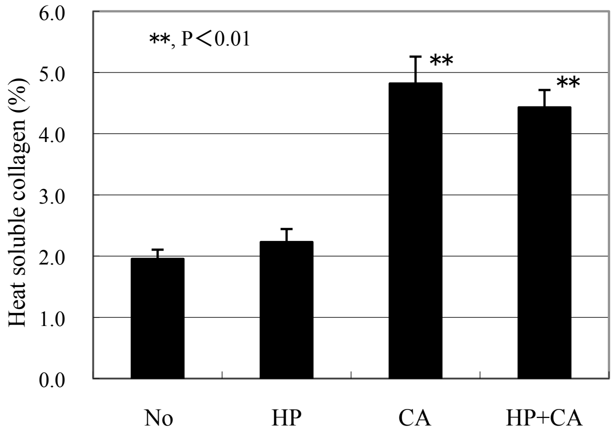

Fig. 1. Effect of high pressure or organic acid treatment on heat solubility of casing collagen. No, no treatment; HP, high pressure; CA, citric acid; HP+CA, high pressure and citric acid in conjunction.

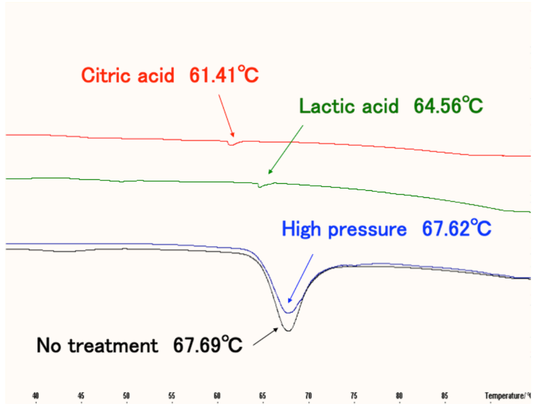

Fig. 2. Effect of high pressure or organic acid treatment on thermal behaviour casing collagen by DSC.

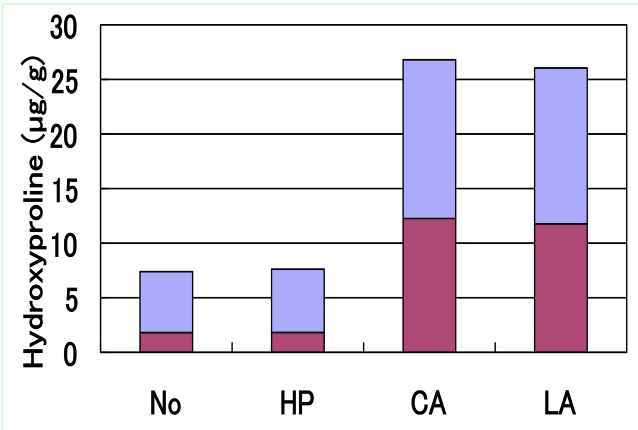

Fig. 3. Effect of high pressure or organic acid treatment on solubilized collagen content. No, no treatment; HP, high pressure; CA, citric acid; LA, lactic acid.

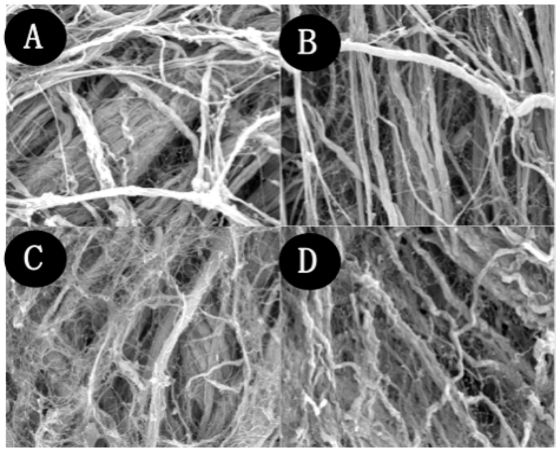

Fig. 4. SEM of collagen fibers on the surface of natural hog casing. A, no treatment; B, high pressure; C, citric acid; D, high pressure and citric acid in conjunction.

IV. CONCLUSION

The present results suggest that high-pressure treatment enables an effective tenderization of natural hog casing and may physically weaken the collagen fibers and fibrils by different mechanisms from that in organic acid treatment.

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