**P-04-14**

# Influence of freeze-thawing on muscle fiber structure and meat quality of bovine *longissimus lumborum* muscle
(#417)

Sumin Song[1], Chi-Hoon Ahn[1], Mingeun Song[1], Gap-Don Kim[1, 2]

[1] Seoul National University, Institute of Green-Bio Science & Technology, Pyeongchang, South Korea; [2] Seoul National University, Graduate School of International Agricultural Technology, Pyeongchang, South Korea

## Introduction
Freezing is a commonly used method for meat preservation (Srinivasan et al., 1997). However, freezing induces physical and biochemical changes in meat and consequently is accompanied by deterioration in the meat quality, such as discoloration, protein and lipid oxidation, and detrimental changes of texture (Sebranek, 1982; Leygonie et al., 2012; Kim et al., 2013a). Recently, some studies demonstrated that microstructure damages, including Z-line fracture, I band weakening, and enlargement of gaps between muscle fibers could be caused due to the formation of ice crystals by freezing or repeated freeze-thawing (Zhang et al., 2017; Setyabrata & Kim, 2019). However, damages associated with muscle fiber types have not been studied. Therefore, the purpose of this study is to investigate the impact of freeze-thawing on damages related to different types of muscle fibers as well as on the quality of beef.

## Methods
Twenty *longissimus lumborum* muscles were obtained from the left side of Hanwoo (Korean native cattle) carcasses at 24 h postmortem from a commercial slaughterhouse. Two chops (approximately 10-cm thickness) were cut from the center of each muscle and randomly allocated to two groups: fresh, stored at 1℃ for 5 days; freeze-thawed (FT), frozen at -20℃ for 3 days followed by thawing at 1℃ for 2 days. Meat quality traits, such as Commission Internationale de l'Eclairage (CIE, 1978) L*a*b*, pH, cooking loss (%), purge or thawing loss (%), Warner-Bratzler shear force (N; WBSF), moisture content (%), and crude fat content (%), were analyzed according to a previous study (Kim et al., 2013b). For typing of muscle fibers, two monoclonal antibodies, such as SC-71 and 6H1 (DSHB, Iowa City, IA, USA), and secondary antibodies conjugated with fluorescence dyes (Alexa Fluor® 405 and 488, Abcam, Cambridge, UK) were used (Fig. 1). Statistical analysis was performed using the SAS 9.4 program (2016). Effects of freeze-thawing on the quality of beef and muscle fiber structure were tested using a paired t-test model and in general linear model, respectively. $P < 0.05$ was accepted as statistically significant.

## Results
Many cavities were found in both the vertical and horizontal sections of FT muscle (Fig. 1), demonstrating that the fibers of FT muscle were essentially damaged. However, muscle fibers of fresh muscle were not damaged by freezing. It was observed that 53.42±4.10% of the muscle fibers were damaged by FT (Fig. 2A). Moreover, 75.68% of IIX fibers were damaged, the highest among the muscle fiber types ($P < 0.05$). In contrast, fiber type I had the lowest numbers of damaged fibers (25.45%; $P < 0.05$). Furthermore, the percentage of areas of the cavities formed showed a similar trend to that of the damaged fibers (Fig. 2B). The cavity area of fiber type IIX was 8.90% and was significantly higher ($P < 0.05$) than those of types I (2.23%) and IIA (4.56%). Meat quality of the freeze-thawed beef loin was significantly different ($P < 0.05$) in traits of water-holding capacity and tenderness than that of control (Table 1). Purge (thawing) loss ($P < 0.01$), and cooking loss ($P < 0.05$), and WBSF ($P < 0.01$) were higher in FT muscle than those in fresh muscles. However, the other traits of meat quality, such as pH, meat color, moisture and fat contents were not significantly different between FT and fresh muscles ($P > 0.05$).

**Table 1. Comparison of meat quality between fresh and freeze-thawed beef loin**

| Measurements | | Fresh | | Freeze-thawed | | P-value |
|---|---|---|---|---|---|---|
| Moisture (%) | | 58.85 | ±0.86 | 61.33 | ±3.07 | 0.2490 |
| Fat content (%) | | 18.16 | ±1.41 | 17.95 | ±2.85 | 0.9157 |
| pH | | 5.48 | ±0.02 | 5.47 | ±0.04 | 0.4816 |
| Meat color | CIE L* | 38.70 | ±1.50 | 36.97 | ±3.26 | 0.4512 |
| CIE a* | 20.70 | ±1.19 | 20.83 | ±0.70 | 0.8722 | |
| CIE b* | 11.03 | ±0.95 | 11.11 | ±0.58 | 0.8990 | |
| Purge loss (%) | | 0.50 | ±0.07 | 1.27 | ±0.20 | 0.0031 |
| Cooking loss (%) | | 21.54 | ±1.26 | 26.55 | ±2.04 | 0.0224 |
| WBSF[1)] (N) | | 59.95 | ±2.76 | 71.38 | ±2.98 | 0.0082 |

Data are means±SE.
[1)] Warner-Bratzler shear force.

## Conclusion
Deterioration of beef loin qualities due to freezing, such as water-holding capacity and tenderness by freezing is closely related to the damage of muscle fiber structure. Among the muscle fiber types, IIX was the most susceptible to freezing, whereas type I was more stable to freezing than types IIA and IIX. In conclusion, muscle fiber composition is an important characteristic of beef that is influenced by the deterioration of its quality due to freeze-thawing.

Notes

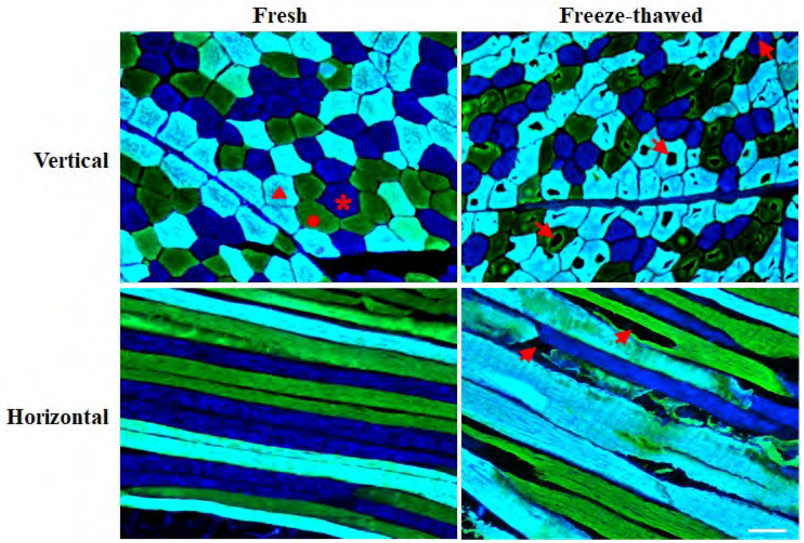


**Fig. 1**
**Representative stained sections cut vertically and horizontally from fresh and freeze-thawed bovine *Longissimus lumborum* muscles, respectively.** Muscle fiber types: I, blue (*); IIA, green (●); IIX, bright blue (▲). Arrows indicate cavities formed by freezing. Bar = 100 μm.

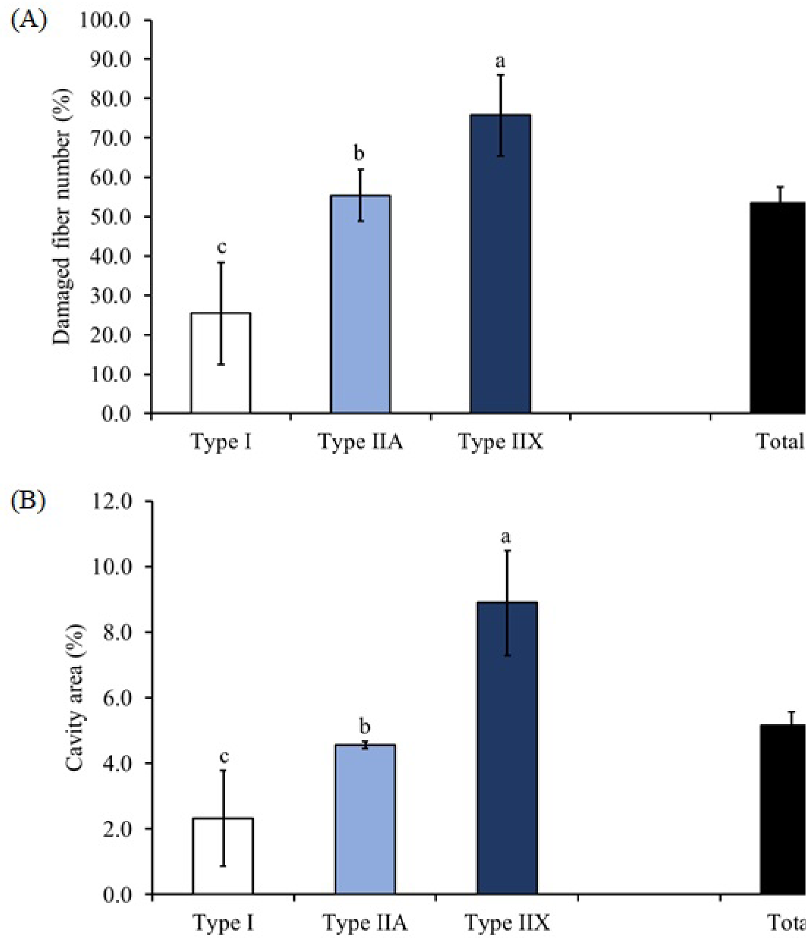


**Fig. 2**
**Damaged muscle fiber number (A) and cavity area (B) caused by freeze-thawing in bovine *Longissimus lumborum* muscle.** Data are means±SE. Different letters (a-c) on the bar indicate significant differences between muscle fiber types ($P < 0.05$).

Notes