EFFECT OF VERY FAST FREEZING BEFORE RIGOR MORTIS ON TENDERNESS OF BEEF *LONGISSIMUS LUMBORUM*

H. Wang[1,2], J. Li[1,2], X. Luo[1,2], X. Yang[1,2], L. Tong[3], D L. Hopkins[4], Y. Zhang[1,2*]

[1]College of Food Science and Engineering, Shandong Agricultural University, Tai'an, China

[2]Shandong Provincial Key Laboratory of Quality Safety Monitoring for Animal Products and Veterinary Drug Innovation, Tai'an, China

[3]Tongliao Station of China Agriculture Research System (beef), Tongliao, China

[4]Canberra ACT, 2903, Australia

*Corresponding author email: ymzhang@sdau.edu.cn

I. INTRODUCTION

Fast chilling before rigor mortis enhances production efficiency, reduces weight loss and microbial contamination, and extends meat shelf life by rapidly lowering temperature [1]. However, it increases the risk of cold shortening [2]. A recent study found that freezing bovine M.*Longissimus lumborum* (LL) to -3°C before rigor mortis, followed by storage at -1°C for 24 h, prevented toughness from cold or thaw shortening [3]. Yet, whether deeper freezing before rigor mortis cause thaw shortening or not, is unknown. This study investigates the effect of very fast freezing (VFF) for pre-rigor bovine muscle, to different core temperatures (-3°C, -7°C, -10°C) on beef tenderness.

II. MATERIALS AND METHODS

The carcasses from 4 crossbred cattle (Luxi yellow cattle × Simmental, 18–24 months) were selected. Each LL was taken from the left carcass and cut into five 5-cm thick steaks. These steaks from each LL were randomly assigned to 3 VFF groups (-30°C until the core temperature decreased to -3°C (VFF–I), -7°C (VFF–II) and -10°C (VFF–III)), one very fast chilling group (-30°C to bring the temperature down to 0°C within 5 h postmortem) and one control group (4°C, conventional chilling in the cold storage). The steaks were chilled to target core temperatures using a -30°C propylene glycol solution (55% v/v), then held at 0~4°C until 24 h postmortem. All steaks were cut into two 2.5 cm-thick steaks, vacuum-packed and aging at 0~4°C for 14 d. The shear force was determined at 1 and 14 d of storage. The core temperatures during the chilling process were continuously monitored. The sarcomere length was evaluated at 48 h postmortem. The data for pH and shear force were analyzed by a two-way ANOVA using the MIXED procedure of SAS (Version 9.2, SAS Institute, Cary, USA), with treatment, postmortem time and their interaction as fixed factors for pH, treatment, aging time and their interaction as fixed factors for shear force, and carcass as a random factor.

III. RESULTS AND DISCUSSION

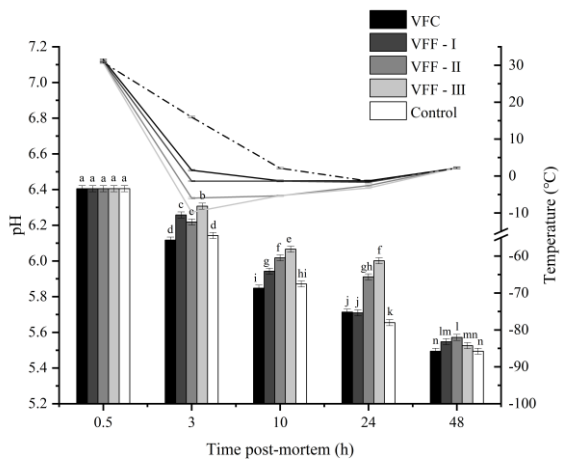


Fig. 1. Effect of very fast freezing treatments on core temperature and pH value decline of beef *longissimus lumborum*. Note: Means ± standard errors are shown. Different letters (a–n) indicate significant differences ($P < 0.05$).

As shown in Fig.1, all fast-chilling groups dropped to a different core temperature within 3 h postmortem. And fast chilling slowed down the decline in pH after slaughter, the lower the chilling core temperature, the more obvious the delay effect.

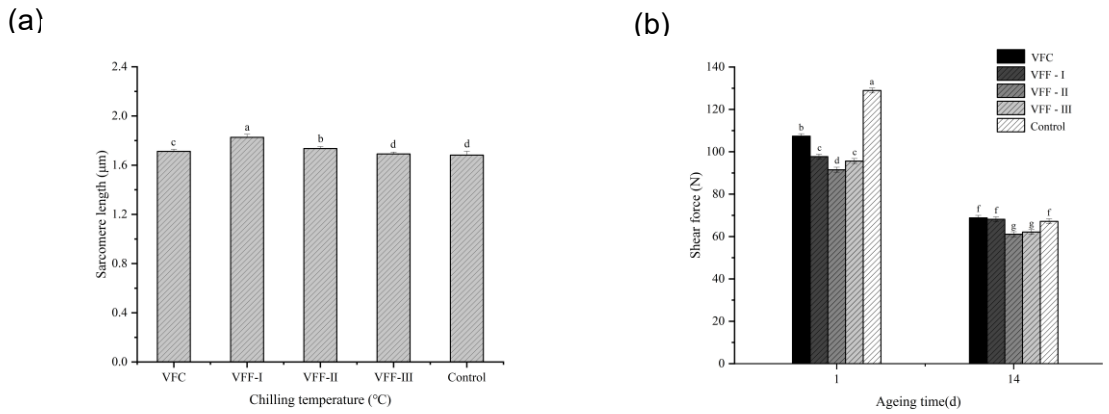


Fig. 2. Effect of very fast freezing treatments on sarcomere lengths (a) and shear force value (b) of beef *longissimus lumborum*. Note: Means ± standard errors are shown. Different letters (a-g) indicate significant differences ($P < 0.05$).

As shown in Fig. 2a, the VFF-I had the longest sarcomere length. The sarcomere length of the VFF-II and VFF-III was shorter. The sarcomere length was shortened to varying degrees in all groups, but all were greater than 1.5 μm and did not reach the extent of cold shortening [4], and the VFF group was not lower than the control group, indicating that there was no thaw shorting. As shown in Fig. 2b, the shear force of the VFF were lower than those of VFC and control group at 1 d of aging ($P < 0.05$), VFF-II and VFF-III were still lower than those of the control group and VFC ($P < 0.05$). The difference in sarcomere length cannot fully explain the difference in shear force, and the disruption of muscle fibers by ice crystals should be further considered [3].

IV. CONCLUSION

This study suggested that pre-rigor beef muscles can be deeply frozen, and this will not cause obvious shortening with proper freezing and thawing procedures (VFF treatment). The VFF treatment affected the rate of decline in pH and improved the tenderness of beef, but this tenderness difference cannot be fully explained by the difference in sarcomere length alone, which may be more related to the destruction of muscle structure by ice crystals formed at low temperature.

ACKNOWLEDGEMENTS

This work was supported by Excellent youth fund projects of Shandong province (ZR2022YQ27), the earmarked fund for China Agriculture Research System (beef-CARS-37), Young Experts of Taishan Scholar Program (tsqn202312149).

REFERENCES

Papers:

1. Watt, D. B., & Herring, H. K. (1974). Rapid chilling of beef carcasses utilizing ammonia and cryogenic systems: Effects on shrink and tenderness. Journal of animal science, 38(5), 928-934.
2. Brown, T., & James, S. J. (1992). Process design data for prok chilling. International journal of refrigeration, 15(5), 281-289.
3. Chen, X., Luo, X., Zhu, L., Liang, R., Dong, P., Yang, X., Niu, L., Hopkins, D.L., Gao, S., Mao, Y., & Zhang, Y. (2022). The underlying mechanisms of the effect of superchilling on the tenderness of beef *Longissimus lumborum*. Meat science, 194, 108976.
4. McGeehin, B., Sheridan, J. J., & Butler, F. (1999). Further investigations on the ultra-rapid chilling of lamb carcasses. Journal of Muscle Foods, 10(1), 1-16.