RESEARCH ON UNDERLYING MECHANISMS OF BEEF TENDERNESS DIFFERENCES FOR BEEF WITH DIFFERENT ULTIMATE pH

J. Li[1], L. Zhu[1], Y. Mao[1], D.L. Hopkins[2], L. Tong[3] and Y. Zhang[1*]

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

[2]Canberra ACT, 2903, Australia

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

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

I. INTRODUCTION

There were significant differences in the tenderness of beef as well as the tenderizing rate during aging among ultimate pH (pHu) groups [1]. Phosphorylation of protein is thought to affect and even determine meat quality by influencing protein stability, enzyme activity, and muscle contraction. In this study, the differences in shear force and abundant phosphopeptides of beef from three pHu groups were compared, in order to provide new ideas and directions for clarifying the mechanism responsible for the development of beef tenderness.

II. MATERIALS AND METHODS

From a commercial abattoir, 30 carcases from Simmental crossbred cattle (18 to 24 months) were chosen at random. At 24 h post-mortem, the pH was determined on the *Longissmus lumborum* (LL) between the 12 and 13th ribs on the left side of each carcass to a depth of 3 cm with a portable pH meter (Senven2Go-S2, Mettler-Toledo, Switzerland). The loins were categorized into normal pHu ($5.4 \leq pHu < 5.8$), intermediate pHu ($5.8 \leq pHu < 6.2$) and high pHu groups ($pHu \geq 6.2$) according to the LL pHu. And around 50 g of LL sample was taken from the left side of each carcase and promptly frozen in liquid nitrogen for phosphorylated proteome analysis. After 48 h post-mortem, each LL was cut into 10 steaks (2.54 cm thick), vacuum-packaged and randomly assigned to 5 storage time points (0, 3, 7, 14 and 21 d). The Warner-Bratzler shear force (WBSF) was measured at each storage time point according to the method of Hou *et al.* [2] with some slight modifications. The data for WBSF were analysed by a two-way ANOVA, with pHu and postmortem time as fixed factors and carcase as a random factor. Partial least squares discrimination analysis (PLS-DA) was used to assess the results of differently phosphorylated peptides associated with pHu and WBSF (0 d) in the different pHu groups, and variable importance projection (VIP) values were obtained.

III. RESULTS AND DISCUSSION

There was a pHu groups and aging time interaction effect on the WBSF of the beef ($P < 0.05$). The WBSF values of the intermediate pHu group were always significantly higher than the other two pHu groups ($P < 0.05$), and the high pHu group showed the lowest WBSF (Fig. 1). This suggests that the intermediate pHu group had the worst tenderness and the rate of tenderization for intermediate pHu beef was significantly lower than that of normal pHu beef. Previous studies also found a strong correlation between beef tenderness and pHu, such that beef with high pHu values had the lowest shear force values and beef with intermediate pHu had the slowest decline in shear force in the three pHu groups during post-mortem ageing [3].

A total of 17 differentially abundant phosphopeptides (DAPs) were detected in all three pHu groups. The results demonstrated that the phosphorylated peptides with different pHu differed significantly according to the pH and WBSF (Fig. 2a). The A0A3Q1M1I7-Ser206 was located at the upper left of Fig. 2a, indicating that it was the key phosphorylated peptide affecting pH value, but its corresponding protein name and function have not been clearly described. Most of the phosphorylated peptides with higher VIP values were located at the upper right of Fig. 2a, and they were positively correlated with

WBSF (0 d).DAPs with higher VIP values (VIP > 1) correspond to stromal interaction molecule 1, signal recognition particle receptor subunit alpha, nebulin-related anchoring protein, striated muscle enriched protein kinase, glycogen synthase and two unknown proteins, respectively (Fig. 2b).
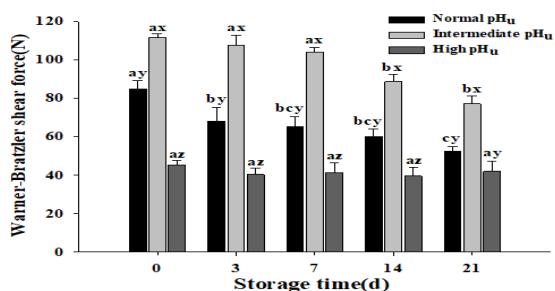

Fig. 1. Interaction effect of aging time × pHu group on the WBSF of beef steaks. Data points that do not share a common superscript (a-c) indicate significant differences between aging time points for the same pHu group. Data points that do not share a common superscript (x-z) indicate significant differences between pHu groups at the same time point ($P < 0.05$)
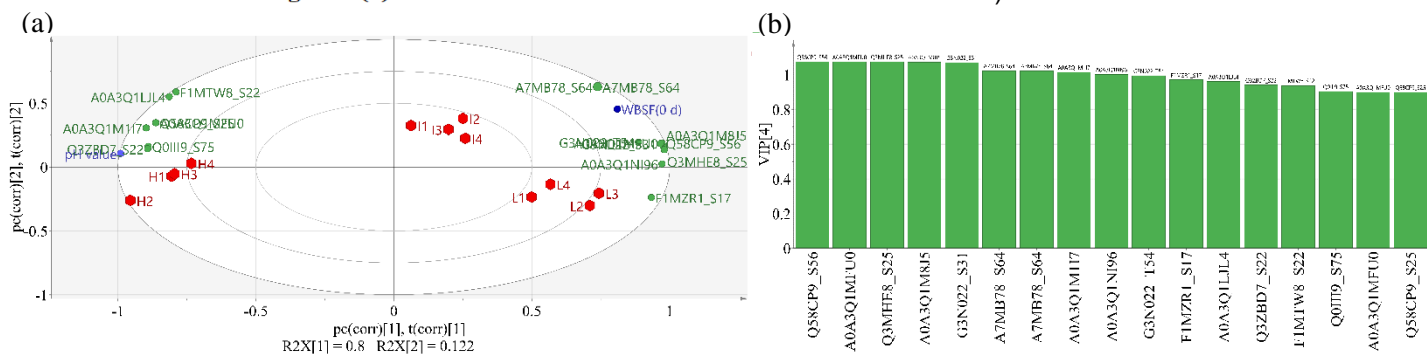

Fig. 2. The biplot (a) and VIP plot (b) of differentially phosphorylated peptides associated with pHu and WBSF (0 d) in different pHu groups. (a) The blue circles are the ultimate pH and WBSF (0 d) of beef in different pHu groups, the green circles are the differentially phosphorylated peptides, and the red circles are the samples of different pHu groups. L: normal pHu group; I: intermediate pHu group; H: high pHu group

IV.   CONCLUSION

The tenderness of beef with different pHu and the tenderizing rate of meat during aging are different. High pHu beef had the best tenderness, while intermediate pHu beef had the worst tenderness and would need a longer aging time. In the three pHu contrast groups, 7 phosphorylated proteins were associated with pHu formation or WBSF (0 d). The A0A3Q1M1I7-Ser206 was the key phosphopeptide affecting pH value and most of the phosphopeptides with higher VIP values were positively correlated with WBSF (0 d). In conclusion, phosphorylation of proteins is an important factor affecting the tenderness of beef, and future studies will confirm the role of phosphoproteins in more detail.

ACKNOWLEDGEMENTS

REFERENCES

1. Lomiwes D., Farouk M. M., Wiklund E. and Young O. A. (2014). Small heat shock proteins and their role in meat tenderness: A review. Meat Science, 96(1): 26-40.
2. Hou X., Liang R. R., Mao Y. W., Zhang Y. M., Niu L. B., Wang R. H., Liu C. L. and Liu Y.Q. (2014). Effect of suspension method and aging time on meat quality of Chinese fattened cattle M. Longissimus dorsi. Meat Science, 96(1): 640-645.
3. Pulford D. J., Dobbie P., Vazquez S. F., Fraser-Smith E., Frost D. A. and Morris C. A. (2009). Variation in bull beef quality due to ultimate muscle pH is correlated to endopeptidase and small heat shock protein levels. Meat Science, 83(1): 1-9.