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CHANGES OF HEAT ON SOLUBLE PROTEIN AND COOKING LOSS IN PORCINE SKELETAL MUSCLE

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I. INTRODUCTION

Heat treatment is a critical step in meat processing that directly affects muscle protein solubility and cooking loss, ultimately shaping the texture, juiciness, and overall quality of pork products (Zielbauer et al., 2016). Thermal processing induces protein denaturation, aggregation, and moisture loss, all of which influence the final product's sensory attributes and consumer acceptability (Promeyrat et al., 2010; Xia et al., 2019). In the meat export industry, ensuring that pork products reach the required heating temperatures is essential for both food safety and regulatory compliance. Undercooked or improperly heated products pose microbiological risks, while overcooking can degrade product quality (Crutchfield et al., 1997). To address these challenges, a rapid and reliable screening method is crucial for verifying proper heat treatment in pork products. Traditional approaches, such as microbial testing and end-point temperature monitoring, are often time-consuming and impractical for large-scale quality control. This study investigates the relationship between heating temperature, protein solubility, and cooking loss in porcine skeletal muscle while exploring potential rapid screening methods to ensure compliance with export-quality standards for cooked pork products.

II. MATERIALS AND METHODS

LYD (Landrace × Yorkshire × Duroc) crossbred pigs pig ham (*Semimembranosus*, N = 10) muscles were collected 12 hours postmortem from a meat processor. Visible fat was trimmed, and each muscle was cut into cubes (4 cm × 4 cm × 4 cm). The samples were individually vacuum-packaged and cooked in a water bath at 65°C, 70°C, or 80°C for 40 minutes. Cooking loss was measured for each treatment. The fluid loss, containing heat-induced soluble proteins, was collected and centrifuged at 1,300 × g for 30 minutes at room temperature. The supernatant volume and protein concentration were then measured. Protein composition was analyzed via SDS-PAGE (Li et al., 2023). Statistical analysis was performed using the Mixed Model procedure in SAS 9.3, with significance set at $P < 0.05$.

III. RESULTS AND DISCUSSION

It has been reported that muscle sarcoplasmic proteins aggregate between 40°C and 60°C (Liu et al., 2016). At temperatures above 65°C, actin begins to denature, followed by the progressive denaturation of collagen proteins, indicating that heat-induced protein denaturation leads to structural changes in meat and affects cooking yield (Tornberg, 2005;). The results of SDS-PAGE analysis showed a notable decrease in lactate dehydrogenase (~35 kDa) bands at 70°C, which disappeared completely at 80°C. Additionally, protein bands between 45 kDa and 60 kDa, including pyruvate kinase and phosphoglucose isomerase, decreased at 70°C and disappeared at 80°C. Similarly, bands between 35 kDa and 45 kDa, corresponding to troponin-T and tropomyosin, showed a reduction at 70°C and disappeared at 80°C. Lower molecular weight bands (<25 kDa) were present at 65°C but disappeared at 70°C and 80°C in the SDS-PAGE profiles. These findings suggest that heating temperature has a pronounced effect on the protein composition of cooked porcine skeletal muscle and may increase the extent of protein degradation in cooked pork fluid. At 70 °C or 80 °C, the higher cooking losses ($P < 0.05$) had occurred when compared with 65 °C of heating temperature.

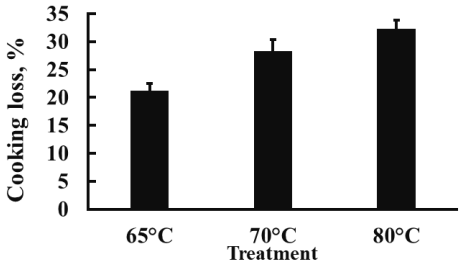


Figure 1. Cooking loss of LYD pig ham cooked at 65°C, 70°C, or 80°C for 40 minutes. Each point represents the mean of 10 observations. Error bars indicate the standard error (SE).

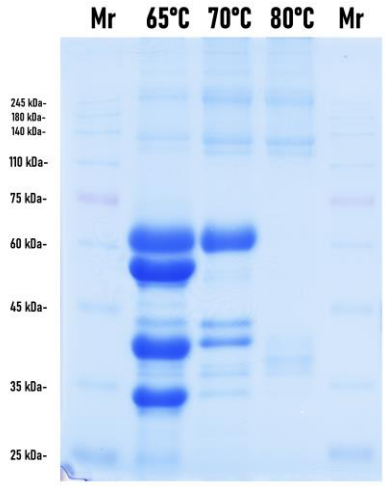


Figure 1. Coomassie-stained 10% SDS-PAGE gels showing protein degradation in porcine skeletal muscle fluid cooked at 65°C, 70°C, and 80°C. Mr = Excel-Band 3-Color Broad Range Protein Marker (SMOBIO, Hsinchu, Taiwan).

IV. CONCLUSION

Heat treatment significantly influences the solubility of muscle proteins and cooking loss, which are key factors affecting the texture, juiciness, and overall quality of pork products. This study demonstrates that increasing the heating temperature leads to progressive protein denaturation, as evidenced by the disappearance of specific protein bands in SDS-PAGE analysis. Cooking at 70°C and 80°C resulted in greater protein degradation and higher cooking loss compared to 65°C ($P < 0.05$), indicating that thermal processing plays a critical role in determining the final product characteristics. Given the importance of proper heat treatment in ensuring both food safety and quality in the meat export industry, a rapid and reliable screening method is essential for verifying compliance with heating standards. Future research should focus on developing efficient detection techniques to enhance large-scale quality control in cooked pork products.

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REFERENCES

1. Li, H., Chou, R. G. R. and Chang, Y. S. 2023. Postmortem calpain changes in longissimus muscle from Lanyu native and Kaohsiung crossbred black pigs. Animal Science Journal 94, e13868.
2. Liu, J., Arner, A., Puolanne, E. and Ertbjerg, P. 2016. On the water-holding of myofibrils: Effect of sarcoplasmic protein denaturation. Meat Science, 119, 32-40.
3. Christensen, M., Purslow, P. P., & Larsen, L. M. (2000). The effect of cooking temperature on mechanical properties of whole meat, single muscle fibres and perimysial connective tissue. Meat science, 55(3), 301-307.
4. Purslow, P. P. (2018). Contribution of collagen and connective tissue to cooked meat toughness; some paradigms reviewed. *Meat science*, *144*, 127-134.
5. Tornberg, E. V. A. 2005. Effects of heat on meat proteins–Implications on structure and quality of meat products. Meat Science, 70, 493-508.
6. Yu, T. Y., Morton, J. D., Clerens, S. and Dyer, J. M. 2017. Cooking-induced protein modifications in meat. Comprehensive Reviews in Food Science and Food Safety 16, 141-159.
7. Zielbauer, B. I., Franz, J., Viezens, B., & Vilgis, T. A. (2016). Physical aspects of meat cooking: Time dependent thermal protein denaturation and water loss. Food biophysics, 11, 34-42.
8. Promeyrat, A., Gatellier, P., Lebret, B., Kajak-Siemaszko, K., Aubry, L., & Santé-Lhoutellier, V. (2010). Evaluation of protein aggregation in cooked meat. Food Chemistry, 121(2), 412-417.
9. Crutchfield, S. R., Buzby, J. C., Roberts, T., Ollinger, M., & Lin, C. T. J. (1997). Economic assessment of food safety regulations: The new approach to meat and poultry inspection.
10. Xia, M., Chen, Y., Guo, J., Huang, H., Wang, L., Wu, W., ... & Sun, W. (2019). Water distribution and textual properties of heat-induced pork myofibrillar protein gel as affected by sarcoplasmic protein. Lwt, 103, 308-315.