71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

EFFECT OF TWO-STAGE LOW-TEMPERATURE TEMPERING PROCESS ASSISTED BY ELETROSTATIC FIELD APPLICATION ON PHYSICOCHEMICAL AND STRUCTURAL PROPERTIES OF MYOFIBRILLAR PROTEIN IN FROZEN *LONGISSIMUS DORSI* OF TAN MUTTON

Yuanlv Zhang[1], Yang Li[1], Jiajun Guo[1], Yuqin Feng[1], Qiwen Xie[1], Mei Guo[1], Junjie Yin[1], Guishan Liu[1*]

[1] Ningxia University, Yinchuan, China.

*Corresponding author email: liugs@nxu.edu.cn

I. INTRODUCTION

Freezing is pivotal for preserving Tan mutton quality, yet conventional thawing methods accelerate myofibrillar protein (MP) oxidation and structural denaturation, compromising its functional integrity. Recent innovations in thawing prioritize efficiency and protein conservation, though challenges like uneven heating (microwave)[1], structural damage (high-pressure)[2], and lipid oxidation (low-temperature fluctuations) persist[3]. Electrostatic fields (EF) offer non-thermal advantages, enhancing heat transfer uniformity and minimizing energy consumption[4], but their synergistic potential with controlled thermal strategies remains underexplored. This study hypothesizes that integrating two-stage low-temperature tempering (TLT) with EF stabilizes MP physicochemical and structural attributes by mitigating oxidative damage and aggregation. By evaluating MP oxidation, denaturation, and conformational changes, we aim to establish optimized tempering protocols to enhance frozen Tan mutton quality for industrial processing. The findings seek to advance sustainable thawing technologies while addressing protein preservation challenges in meat science.

II. MATERIALS AND METHODS

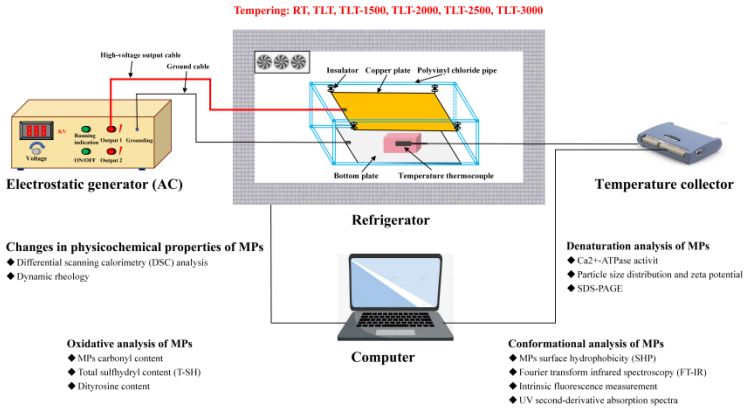


Figure 1.Schematic diagram of combined tempering of two-stage low temperature and electrostatic field.

III. RESULTS AND DISCUSSION

(1) Physicochemical changes of MPs

Table 1 – T_{max} and ΔH values obtained by different tempering treatments for *Longissimus dorsi* of Tan mutton.

Tempering	Peak 1		Peak 2		Peak 3	
	T_{max1} (℃)	ΔH_1 (J·g^{-1})	T_{max2} (℃)	ΔH_2 (J·g^{-1})	T_{max3} (℃)	ΔH_3 (J·g^{-1})
FM	56.17 ± 0.493^{b}	0.42 ± 0.002^{c}	63.37 ± 0.513^{a}	0.43 ± 0.044^{a}	78.23 ± 0.208^{a}	0.79 ± 0.099^{a}
RT	54.50 ± 0.656^{bc}	0.12 ± 0.013^{e}	62.50 ± 0.200^{b}	0.26 ± 0.030^{b}	77.37 ± 0.503^{b}	0.52 ± 0.042^{b}
TLT	54.80 ± 0.458^{bc}	0.15 ± 0.008^{e}	62.43 ± 0.814^{b}	0.16 ± 0.011^{c}	76.93 ± 0.306^{b}	0.56 ± 0.049^{b}
TLT-1500	54.80 ± 0.360^{bc}	0.32 ± 0.012^{c}	63.10 ± 0.346^{a}	0.28 ± 0.026^{b}	77.70 ± 0.100^{ab}	0.59 ± 0.067^{b}
TLT-2000	55.63 ± 0.551^{ab}	0.26 ± 0.004^{d}	62.50 ± 0.458^{b}	0.16 ± 0.012^{c}	77.80 ± 0.208^{ab}	0.66 ± 0.021^{ab}
TLT-2500	55.97 ± 0.208^{a}	0.37 ± 0.014^{b}	62.93 ± 0.709^{ab}	0.40 ± 0.037^{a}	77.70 ± 0.300^{ab}	0.76 ± 0.053^{a}
TLT-3000	53.63 ± 0.603^{c}	0.15 ± 0.003^{e}	62.17 ± 0.288^{b}	0.16 ± 0.004^{c}	77.53 ± 0.351^{ab}	0.59 ± 0.021^{b}

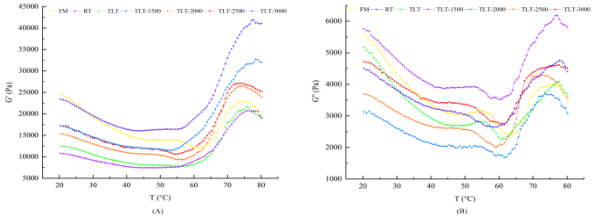


Figure 1. Changes in G’ (A) and G" (B) of Tan mutton samples under six different tempering conditions.

(2) MPs denaturation

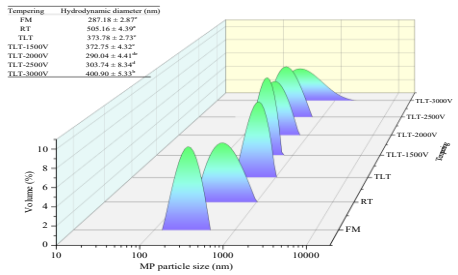
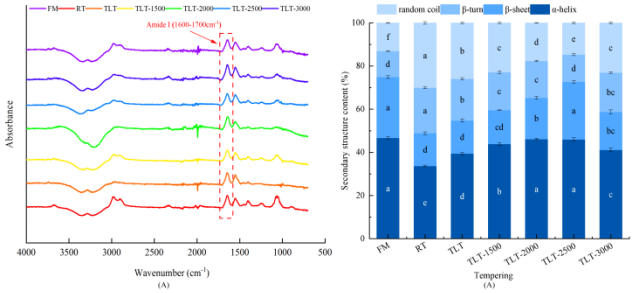


Figure 2. Influence of different tempering methods on particle size and hydrodynamic diameter of MP in *Longissimus dorsi* of Tan mutton.
Figure 3. Influence of different tempering methods on the SDS-PAGE patterns of MP in *Longissimus dorsi* of Tan mutton.

(3) Changes in MPs conformation



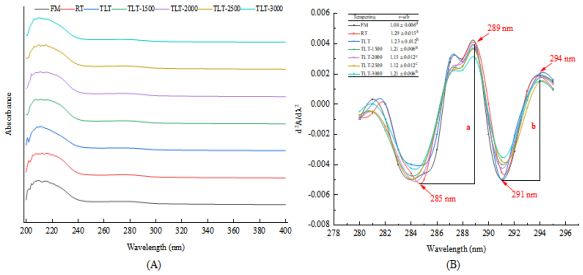


Figure 4. The FT-IR (A) and different proportions of secondary structure (B) of MP in *Longissimus dorsi* of Tan mutton under different tempering treatments.
Figure 5. UV absorption spectra (A) and second-derivative spectroscopy (B) of MP in *Longissimus dorsi* of Tan mutton under different tempering treatments.

IV. CONCLUSION

TLT-2000/2500 has been identified as a beneficial method for preserving the quality of MPs in frozen Tan mutton. Results from DSC and dynamic rheology revealed that the thermal stability and structural changes of MPs in TLT-2000/2500 were not significantly different from FM. The T-SH and Ca^{2+}-ATPase activity of MPs in TLT-2000/2500 were comparable to those in FM, while the carbonyl and dityrosine contents in TLT-2000/2500 were lower compared to those in RT, TLT, TLT-1500, and TLT-3000. Additionally, the results of particle size, zeta potential, and SDS-PAGE indicated a reduction in the degree of aggregation and degradation in MPs treated with TLT-2000/2500. Meanwhile, assessments of SHP, intrinsic fluorescence, FT-IR, and UV second-derivative absorption spectra demonstrated that the primary, secondary, and tertiary structures of MPs treated with TLT-2000/2500 closely resembled those of FM.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding support of the Natural Science Foundation of Ningxia Hui Autonomous Region in 2022 (Grant No. 2022AAC03019), the leading Talent Project of Science and Technology Innovation in Ningxia Hui Autonomous Region in 2020 (Grant No. 2020GKLRLX05), the Development and Standardization of Key Technologies for Processing and Storage of Prepared Dishes of Tan Mutton (Grant No. 2023BCF01041), the Science and Technology Planning Project of Yinchuan, Ningxia Province in 2022 (Grant No. 2022ZDNY05).

REFERENCES

[1] Peng, Z., Zhu, M., Zhang, J., Zhao, S., He, H., Kang, Z., & Xu, B. (2021). Physicochemical and structural changes in myofibrillar proteins from porcine *longissimus dorsi* subjected to microwave combined with air convection thawing treatment. *Food Chemistry*, 343, Article 128412. https://doi.org/10.1016/j.foodchem.2020.128412
[2] Jia, F., Jing, Y., Dai, R., Li, X., & Xu, B. (2020). High-pressure thawing of pork: Water holding capacity, protein denaturation and ultrastructure. *Food Bioscience*, 38, Article 100688. https://doi.org/10.1016/j.fbio.2020.100688
[3] Zhu, M. M., Zhang, J., Peng, Z. Y., Kang, Z. L., Ma, H. J., Zhao, S. M., & Xu, B. C. (2021). Fluctuated low temperature combined with high-humidity thawing to retain the physicochemical properties and structure of myofibrillar proteins from porcine *longissimus dorsi* [Article]. LWT- Food Science and Technology, 142(10). https://doi.org/10.1016/j.lwt.2021.111001
[4] Zhang, Y. L., Liu, G. S., Xie, Q. W., Wang, Y. Y., Yu, J., & Ma, X. J. (2023). A comprehensive review of the principles, key factors, application, and assessment of thawing technologies for muscle foods. *Comprehensive Reviews in Food Science and Food Safety*, *22*(1), 107 – 134. https://doi.org/10.1111/1541-4337.13064