Effect of ultrasound-assisted tumbling on the structure and rheological properties of myofibrillar proteins

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Objectives: As a modern curing technique, tumbling is widely used in the meat industry (Zhu, Yin, Tian, Zhu, Zhao, & Zhao, 2019). These mechanical actions induced during tumbling process could transfer kinetic energy to extract meat protein and improve the quality of meat products (Krause, Plimpton, Ockerman, & Cahill, 1978). High-intensity ultrasound (HIU) has shown potential as an auxiliary tool to accelerate tumbling processing and modify the physicochemical properties of the myofibrillar proteins (MP) (Zhang, Zhang, Zhou, Wang, & Zhang, 2021). However, up to now, no systematic studies have evaluated the effects of HIU-assist- ed tumbling (UT) on the structure and rheological properties of MP. Therefore, this study aimed to investigate the impact of UT on the secondary and the tertiary structure and rheological properties of MP under different tumbling time.

Materials and Methods:

1. Tumbling treatment The single-tumbling (ST) was set as the control group, with the work/rest time ratio being 20 min/10 min for one cycle. The total tumbling time was set 4 and 6 h, respectively. The UT treatment was performed on the basis of the control group, assisted by the HIU (300 W, 20 kHz). The work and the rest time of HIU were synchronized with the ST group, and the total time of HIU was 40 min.
2. Determination of the secondary structure The secondary structure of MP was determined using a Raman spectrometer, as our pre- vious study reported (Zhang, Xing, et al., 2021).
3. Determination of the tertiary structure The tertiary structural change of MP was investigated by the intrinsic fluorescence intensity
   of aromatic amino acids. The excitation wavelength was 280 nm, and the emission wavelength was in the range of 300 to 400 nm.
4. Determination of rheological properties Temperature sweep measurement was performed with the MP equilibrated at 20 ℃ for 3 min, followed by an increase in the temperature from 20 ℃ to 80 ℃ and a subsequently decrease from 80 ℃ to 20 ℃. Shear rate sweep measurement was operated according to the method of Zhou et al. (Zhou, Zhang, Yin, Zhang, & Yang, 2021).

Results and Discussion:

1. Secondary structure The tumbling time, tumbling methods and their interaction had no significant influence on the α-helix, β- sheet, β-turn and random coil content. The α-helix content was significantly decreased after tumbling treatment compared to the untreated group. While the content of α-helix, β-sheet, β-turn and random coil presented no apparent change between different tumbling groups.
2. Tertiary structure In terms of the fluorescence spectroscopy, the UT treatment obviously increased the fluorescence intensity when the tumbling time was same for both tumbling methods. In addition, the fluorescence intensity reached the maximum value in the group of UT-6 h.
3. Rheological properties Regarding the results of the temperature sweep, the UT treatment significantly enhanced the G' in the end phase compared to the ST treatment. The results of the shear rate sweep showed a similar trend. The UT treatment provided the MP with a higher value of apparent viscosity.

Conclusion: Compared to the ST treatment, the UT treatment could unfold the tertiary structure of MP and enhance the gel-forming ability of MP.

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