IMPACTS OF SMART TUMBLING ON MUSCLE ULTRASTRUCTURE, PROTEOLYSIS, AND QUALITY ATTRIBUTES OF FRESH BEEF LOINS (*M. LONGISSIMUS LUMBORUM*)

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I. OBJECTIVES

Developing natural postharvest processing systems to improve meat tenderness is crucial for the beef industry. Tumbling is one of the most widely applied methods in processed meat applications. However, no studies have evaluated the impacts of tumbling fresh beef products without the use of brine enhancement on meat quality attributes. As tumbling disrupts the muscle structure and disintegrates muscle fibers, it is reasonable to postulate that tumbling will increase activity of endogenous proteolytic enzymes and thus tenderness of fresh beef products without using brine solution. The objective of this study was to determine the impacts of tumbling of vacuum-packaged beef (termed Smart Tumbling) on muscle ultrastructure, proteolysis, and quality attributes of fresh beef loins.

II. MATERIALS AND METHODS

Beef loin (*M. Longissimus lumborum*) muscles ($n = 9$; USDA Select grade) at 7 d postmortem were sectioned into 3 equal length sections and allocated among 3 tumbling (T) treatments (in minutes, T0 [control], T60, and T90). Beef sections were individually vacuum sealed and tumbled for the respective duration in a meat tumbler (Lance LT-30) at 8.5 rpm. Following tumbling, each section was further divided into 3 equal-length sections and randomly allocated among 3 additional aging durations (0 d, 7 d, and 14 d). Warner-Bratzler shear force (WBSF), water-holding capacity, myofibril fragmentation index (MFI), degradation of desmin and troponin-T, and transmission electron microscopy were performed. Quantitative data were analyzed using the PROC MIXED procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC), and least-squares means were separated at $P < 0.05$.

III. RESULTS

Smart Tumbling resulted in an immediate positive impact on tenderness of beef loin sections shown by WBSF, where T90 samples exhibited a significantly lower WBSF value compared to T0 and T60 samples ($P < 0.05$). It is of interest to note that beef loins assigned Smart Tumbling without any further aging (0 d) had numerically lower shear force values (2.5 kg and 2.2 kg for T60 and T90, respectively) compared to T0 (control) beef loins with additional 14 d of aging (2.6 kg). A considerable increase in MFI was observed with both Smart Tumbling and aging ($P < 0.001$). Western blot results showed the appearance of structural protein degradation products with tumbling at all postmortem aging durations, in line with the MFI result. The transmission electron microscopy images demonstrated distinct appearance of initial muscle fracture along with substantial degradation at the Z-line of beef loin muscles subjected to tumbling with further aging. Tumbling treatment did not affect purge or display weight losses ($P > 0.05$) but increased cooking loss ($P < 0.05$).

IV. CONCLUSION

The results of this study indicate the feasibility of tumbling vacuum-packaged fresh beef products to improve product tenderness. Smart Tumbling would result in a marked increase in tenderness through the result of physical disruptions generated by mechanical forces, whereas tumbling with further aging appears to increase proteolytic potential. This will in turn accelerate the tenderization process and subsequently shorten aging times for targeted eating quality outcomes.

Keywords: instrumental tenderness, meat tumbling, muscle ultrastructure, postmortem proteolysis, transmission electron microscopy