INVESTIGATING THE CONTRIBUTION OF MATURE COLLAGEN CROSSLINKS TO COOKED MEAT TOUGHNESS USING A STEWED BEEF SHANK MODEL

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I. OBJECTIVES

Connective tissue provides the "background toughness" in meat, and past research has demonstrated that this background toughness is the result of heat insoluble collagen content in meat after cooking. However, the characteristics of heat insoluble collagen are not well studied. Therefore, the objective of this study was to investigate mature collagen crosslink densities and their relationship to cooked beef tenderness and connective tissue texture using a stewed beef shank model.

II. MATERIALS AND METHODS

Beef shank cuts from both sides of the carcass, 3 from the foreshank (*biceps brachii*, *deep digital flexor* from foreshank [DDF-F], and *extensor carpi radialis* [ECR]) and 3 from the hindshank (*flexor digitorum superficialis* [FDS], *deep digital flexor* from hindshank [DDF-H], and a combination of *long digital extensor*, *medial digital extensor*, and *peroneus tertius*) were collected from 8 USDA Low Choice beef carcasses (n = 48). Each muscle was used as the experimental unit. Shanks from the left side of the carcasses were designated for the cooked treatment (stewed in water for 90 min at 93°C), and shanks from the right side were designated as the raw treatment. Asian consumers (n = 61) evaluated the connective tissue texture from cooked shanks, and Warner-Bratzler shear force (WBSF) value was also obtained. Mature collagen crosslinks densities (pyridinoline [PYD] and deoxypyridinoline [DPD]) and collagen content were measured for both raw and cooked shanks. The collagen contents were adjusted to dry matter basis to account for moisture loss during the cooking process. Finally, relative percentages of soluble and insoluble collagen content were calculated.

III. RESULTS

DDF-F had the toughest connective tissue texture, greatest shear force value, most cooked collagen content, and greatest insoluble collagen percentage as well as greatest raw and cooked PYD densities among all the beef shank cuts ($P < 0.05$). It was interesting to note that DDF-F, FDS, and the combination of *long digital extensor*, *medial digital extensor*, and *peroneus tertius* all started with similar raw collagen content ($P > 0.10$), but DDF-F ended with greater cooked collagen content than the others. Cooking only decreased PYD density for DDF-F ($P < 0.05$), and PYD density for the rest of the beef shank cuts was not affected by cooking ($P > 0.10$). For DPD density, ECR had the greatest DPD density among all cuts for both raw and cooked samples ($P < 0.01$). Again, there was a cooking effect in which cooking decreased DPD density for DDF-F, ECR, and FDS ($P < 0.01$), but not for the other cuts ($P > 0.10$). As expected, cooked collagen content and insoluble collagen percentage as well as raw PYD densities had positive correlations with connective tissue texture ($r = 0.550$, 0.498, and 0.560 respectively; $P < 0.01$) and WBSF ($r = 0.615$, 0.392, and 0.730, respectively; $P < 0.05$). There was a noted positive correlation between cooked PYD density with connective tissue texture ($r = 0.375$; $P < 0.05$) and WBSF ($r = 0.324$; $P < 0.10$), but the relationship was not as strong as for raw PYD density.

IV. CONCLUSION

Based on the results from this study, we confirmed that PYD is a heat-stable collagen crosslink that requires extensive heat treatment to degrade and allow for the solubilization of collagen. As a result, raw PYD density is a good indicator for cooked collagen content, cooked beef connective tissue texture, and ultimately, tenderness in beef cuts with high concentration of connective tissue prepared with moist heat cookery.

Keywords: beef shanks, collagen, collagen crosslinks, connective tissue texture, tenderness