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The Relationship between Marbling, Superoxide Dismutase, and Beef Tenderness

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Summary with Implications

This study was conducted to evaluate the relationships between animal oxidative status (as indicated by superoxide dismutase [SOD] activity) to marbling and beef tenderness. Prime and Select-grade strip loins were selected and aged for 2, 7, 14, 21, and 28 days for Warner Bratzler shear force, Troponin-T, and SOD activity. Results showed that meat exhibiting higher levels of marbling had lower shear force values and thus were more tender. Low-marbled samples tended to have a greater tenderness response to aging. The effect of oxidative stress, however, was not evident in this study as SOD values were similar. Although the effects of oxidative stress on beef tenderness are still unclear, results from this study provide a conceptual foundation for a new research perspective on meat tenderness.

Introduction

It has been long understood that Prime-grade beef is often more tender than Select-grade beef. The biological determinants explaining the tenderness differences, however, have not been well defined. Finishing diets regularly contain lipids which could increase overall oxidative stress in live cattle. For cattle with more marbling, there may be an inherent increase in oxidative properties caused by production of reactive oxygen species (ROS). Research has shown animals generate ROS in response to stress in the muscle. The most predominant ROS are superoxide, peroxide, and hydroxyl radicals. Their presence could disrupt

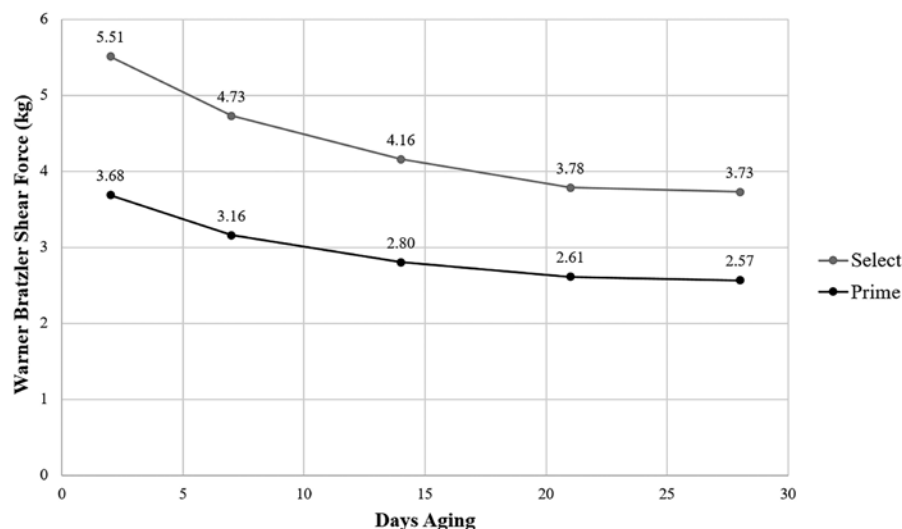


Figure 1. Analysis of Warner-Bratzler Shear Force (kg) on Prime and Select graded steaks across different wet aging periods.

typical postmortem biochemical changes in muscle, possibly promoting further protein degradation and enhancing tenderness. The potential mechanisms of these changes remain unclear. The presence of ROS in meat is difficult to evaluate because they dissipate so quickly. The body produces enzymes such as superoxide dismutase (SOD) to counteract ROS. This naturally occurring enzyme acts to reduce the active superoxide radical to a more stable state. Thus, muscle that has been exposed to ROS in the living state could be expected to exhibit elevated SOD activity post-mortem. Therefore, SOD activity might be an indicator of the long-term presence of ROS in living muscle. This project was conducted to evaluate the relationship between SOD activity and tenderness in high and low-marbled steaks.

Procedure

Prime (n = 32) and Select (n = 32) grade strip loins were collected, and fabricated into five individual 1 inch steaks and one half-inch lab sample per strip loin. Steaks from each strip loin were vacuum packaged and randomly selected to age for 2, 7, 14, 21,

or 28 days postmortem. After aging, steaks were cooked to 71°C, cooled, and cores were taken for Warner Bratzler Shear Force analysis. The half inch-thick lab samples were analyzed for Troponin-T and SOD activity. Samples aged 2 and 28 days were used for analysis of Troponin-T degradation while SOD activity was measured for 2 day aged samples only.

Shear Force (WBSF)

Six cores (one-half inch in diameter) were removed parallel to the fiber direction from cooked and cooled steaks and were measured for Warner-Bratzler Shear Force values (WBSF) for all steaks across all aging periods (2, 7, 14, 21, and 28 days). Shear force measures were obtained by averaging 6 cores from individual steaks. Results were expressed in lbs of force.

Troponin-T

Proteolysis was measured for Troponin-T for Prime and Select-grade steaks aged 2 and 28 days. Ten g of powdered meat with no subcutaneous fat was used to

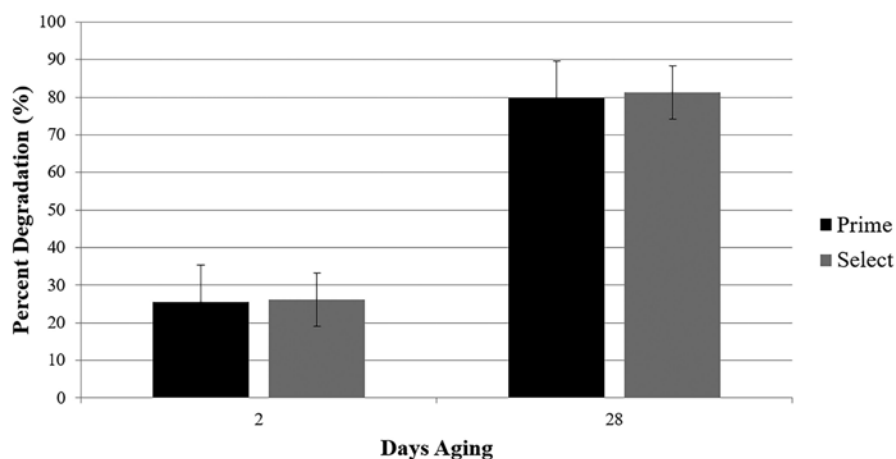


Figure 2. Analysis of Troponin-T degradation between Prime and Select graded steaks between 2 and 28 days aging.

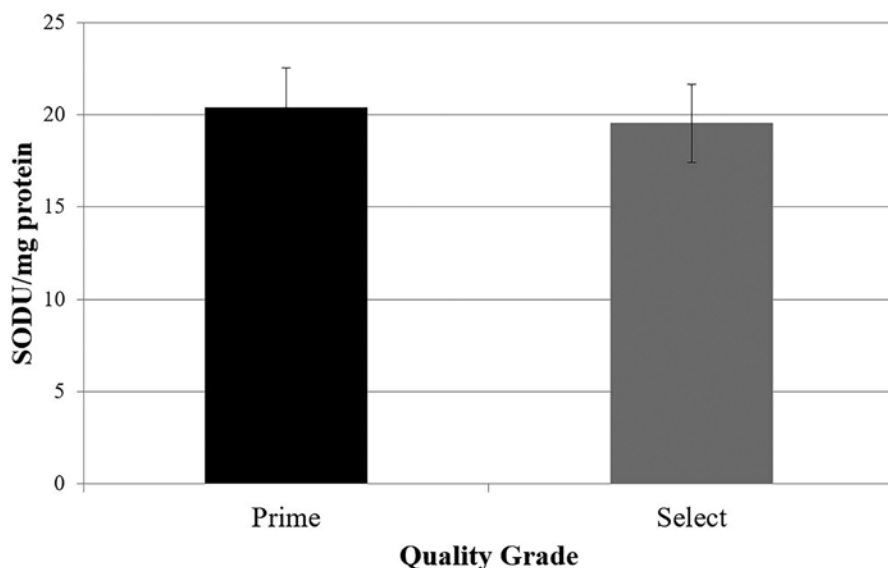


Figure 3. Analysis of Superoxide Dismutase activity across Prime and Select grades.

conduct the proteolysis protocol. Results were expressed as percent protein degradation (%).

Superoxide Dismutase Activity (SOD)

Superoxide Dismutase enzyme activity was measured on powdered meat sample with no subcutaneous fat utilizing an ELISA kit method. Results were expressed in units of SOD activity per mg of protein (SODU/mg).

Statistical Analysis

Warner-Bratzler Shear Force, Troponin-T, and SOD Activity were analyzed using SAS 9.4 program. Statistical significance was determined at $P < 0.05$ and tendencies were considered at a P -value of 0.15.

Results

Warner-Bratzler shear force confirmed Prime-grade steaks exhibit a lower overall shear force value ($P < 0.01$) compared to Select-grade steaks, regardless of aging

period (Figure 1). In addition, steaks from 14, 21, and 28 days aging exhibited greater ($P = 0.02$) tenderness than day 7 steaks; day 7 steaks were more tender ($P < 0.01$) than day 2 steaks. Interestingly, there tended to be an interaction ($P = 0.13$) between age and quality grade with Select grade steaks exhibiting a slightly greater overall decline in shear force values ($-1.78 \text{ kg} \Delta$ -Select; $-1.11 \text{ kg} \Delta$ -Prime). Typically, Prime-grade steaks require significantly less shear force, producing more tender meat than Select-grade steaks.

Aging had an effect on proteolysis as steaks aged 28 days exhibited more Troponin-T degradation ($P < 0.01$) than steaks aged 2 day, regardless of aging (Figure 2). However, there was no two-way interaction present between quality grade and Troponin-T degradation observed ($P = 0.36$) between aging periods. From these data, the proteolytic effects on Troponin-T degradation are most associated with the aging process. Troponin-T degradation can be used as an indicator of more tender meat.

Activities of SOD were $20.43 (+/-2.14)$ and $19.54 (+/-2.55)$ for Prime and Select, respectively (Figure 3). There was no difference in SOD activity between quality grades ($P = 0.71$)

Implication/Conclusion

Results suggest that further research into reactive oxygen species and enzyme activity is worthwhile to further evaluate the relationships between animal oxidative status to marbling and beef tenderness.

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