Meat Toughening Does Not Occur When Rigor Shortening Is Prevented[1]

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ABSTRACT: The objective of this experiment was to test the hypothesis that meat toughening during the first 24 h postmortem results from sarcomere shortening during rigor mortis development. Eleven market-weight lambs were used to measure changes in shear force of clamped longissimus during rigor development. Within 15 min of exsanguination, while attached at both ends, each longissimus was separated from the vertebrae body and clamped between three sets of metal plates to prevent muscle shortening (six clamped sections per lamb). Five of the clamped sections were placed at –1.1°C for 0, 3, 6, 12, or 24 h. After storage at their respective times at –1.1°C, the samples were placed at –30°C for 90 min and then at –5°C for 8 d. The sixth section (168-h section) was stored at –1.1°C for the first 24 h, at 4°C for 144 h, and then treated the same as other sampling times. Sections were sampled for pH, sarcomere length, shear force, and Western blot analyses before and after storage at –5°C. Shear force values were the same ($P > .05$) from 0 to 24 h (4.5 kg at 0 h to 4.9 kg at 24 h) then declined ($P < .05$) to 3.3 kg at 168 h postmortem. As evident by lack of statistical difference in the sarcomere lengths, we were successful in holding the muscle length constant. Western blot analyses of nebulin, vinculin, and troponin-T indicated that minimum degradation occurred through 12 h, was slightly increased by 24 h, and was relatively extensive by 168 h postmortem. Although limited proteolysis occurred during storage at –5°C for 8 d, this by itself had no effect on shear force. Results indicate that shear force values do not increase during rigor development when muscle is prevented from shortening; thus, the toughening that occurs during the first 24 h of slaughter is most likely due to sarcomere shortening.

Key Words: Tenderness, Sarcomeres, Shortening, Rigor, Proteolysis

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Introduction

In an experiment designed to determine the inherent level of meat tenderness at the time of slaughter, we demonstrated that lamb longissimus has intermediate shear force value immediately after slaughter (5.07 kg), toughens during the first 24 h (maximum toughness was achieved at 9 to 24 h; 8.66 kg), and then becomes tender during postmortem storage at 4°C (3.10 kg). These data were interpreted to mean that rigor shortening was the cause of toughening and postmortem proteolysis was the reason for tenderization (Wheeler and Koohmaraie, 1994; Figure 1). There is considerable evidence to support the idea that proteolysis of key myofibrillar proteins is responsible for the decline in shear force during postmortem storage (for review see Goll et al., 1983, 1995; Koohmaraie 1992a,b, 1994, 1995). Numerous studies have demonstrated that muscles that shorten less during rigor or are stretched (i.e., long sarcomeres) are more tender (for review see Locker, 1985; Marsh, 1985). However, no direct evidence exists to support the hypothesis that sarcomere shortening during rigor development is the cause of meat toughening from time of slaughter to 24 h postmortem. Previously, we demonstrated that shear force increased as sarcomere lengths decreased from at-death lengths (2.24 mm) to 24-h lengths (1.69 mm; Wheeler and Koohmaraie, 1994). Thus, the objective of this study was to determine the consequence of preventing sarcomere shortening on shear force of lamb longissimus during rigor development and extended postmortem storage at 4°C.

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