January 1999

Glycolytic Inhibition in Pre-rigor Muscle: An Alternative Method to Improve Beef Tenderness

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Glycolytic Inhibition in Pre-rigor Muscle: An Alternative Method to Improve Beef Tenderness

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Some glycolytic inhibitors were successful in improving beef tenderness, without detriment to lean color, by maintaining a high pH in pre-rigor muscle.

Summary

Flank muscle (FM) and loin eye muscle (LEM) were marinated with solutions of different glycolytic inhibitors to test their effect on tenderness, pH and color. The increase of pH was more evident in LEM than in FM. The improvement in tenderness was higher in FM. In LEM, the most desirable result (cherry-red color and more tender) was observed with sodium citrate. Flank muscle became more tender and had better color (cherry red) than the control with oxamic acid, iodoacetate, glucose and sodium acetate. Most of the compounds caused different responses between muscles. Potential inhibitors must be tested further to prove glycolytic inhibition is a feasible method to improve tenderness in low value cuts with no detriment to lean color.

Introduction

Tenderness is the most important factor in acceptance of meat. However, the most tender cuts comprise less than 25 percent of carcass weight. Improving tenderness of less-tender cuts would add value to the whole carcass. Beef tenderness depends on pH: high pH increases tenderness. After an animal is slaughtered, glycolysis (conversion of glucose to lactate) causes a decrease in pH from 6.9 to approximately 5.6.

Inhibition of glycolysis may improve tenderness. The inhibition of glycolysis prevents lactic acid formation, maintaining a high pH, which should provoke an increase in tenderness and water-holding capacity. Many compounds inhibit glycolysis at different steps of the pathway. However, effects of these inhibitors on other quality traits, such as color, are unknown. A preliminary experiment was conducted to determine the effect on pH, tenderness and color of several glycolysis-inhibiting compounds.

Procedure

Two beef animals were slaughtered at the University of Nebraska Meat Laboratory. Pre-rigor flank muscles (Rectus abdominis) and loin eye muscles (Longissimus lumborum) were excised and divided into pieces of approximately 100 grams that were randomly assigned to one of the treatments. Eleven compounds were tested, but eight compounds per muscle were considered for this report: calcium chloride (300 mM), sodium chloride (330 mM), sodium citrate (100 mM), sodium acetate (100 mM), iodoacetate (50 mM), oxamic acid (50mM), glucose (330 mM), sodium phosphate (110 mM) (only in loin eye muscle) and sodium fluoride (100mM) (only in flank muscle). These levels were selected on the basis of previously published research and anticipated regulatory limits.

At three hours postmortem, each muscle piece was injected with 10 ml of solution, using a manual syringe and 27-gauge needle. The injection was performed at various sites along the muscle section. Immediately, the muscle sections were marinated in 600 ml of the solutions for 24 hours at 40°F. One section per muscle was marinated with water (the control). Visual color and pH were registered before marinating and at six and 24 hours after marinating. After marination was completed, loin eye samples were cooked on a grill and flank samples were cooked in a convection oven. The endpoint temperature for both muscles was 158°F. Instron Warner-Bratzler shear force values were determined on muscle slices cut parallel to the fibers, about 6 mm x 6 mm in size. Visual color was determined using a six-point scale, with 1: very light cherry-red, 2: cherry red, 3: slightly dark, 4:moderately dark, 5: dark red and 6: very dark red. Results are presented as the difference between the treated muscle and the control.

Results

All treatments except sodium acetate and glucose in flank muscle, and calcium chloride in both muscles, resulted in higher pH than the control. These results could indicate glycolytic inhibition during marination, stopping pH decline. The higher pH and lower shear force of the samples with sodium chloride, sodium phosphate, sodium citrate and iodoacetate in comparison with the control (Figure 1) showed high pH favors tenderness in meat. In flank muscle, the increase of pH was less noticeable (pH increased slightly with sodium chloride, sodium fluoride, oxamic acid, sodium citrate and iodoacetate); all treatments decreased shear force values (Figure 2). There appears to be a relationship between these parameters, a high pH being associated with low shear force and vice versa.

To interpret color scores, "2" was considered the best color (cherry red), "1" was too light and color scores of "3" or more were considered dark (unacceptable). Lean color was lightest for the control (very light cherry-red). The most desirable result (more tender meat and cherry-red color) in loin eye muscle was observed in meat marinated with sodium citrate. This treatment was seven pounds more tender than the control and lean color score increased one point (Figures 1 and 3). This result is similar to marination with calcium chloride. Calcium chloride has been shown to effectively improve meat tenderness in pre-rigor or post-rigor muscle. Sodium chloride and iodoacetate also improved tenderness; however, lean color increased to unacceptable scores (moderately dark). Meat marinated with

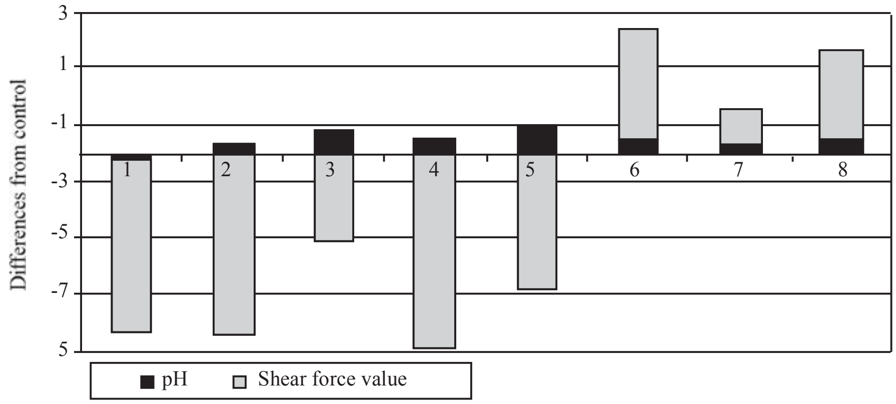

Figure 1. Effects of marination with (1) calcium chloride, (2) sodium chloride, (3) sodium phosphate, (4) sodium citrate, (5) iodoacetate, (6) oxamic acid, (7) sodium acetate and (8) glucose on pH and shear force in pre-rigor loin eye muscle. Control (marination with water) value for pH (5.46) and shear force (9.3 lbs) were equalled to zero.

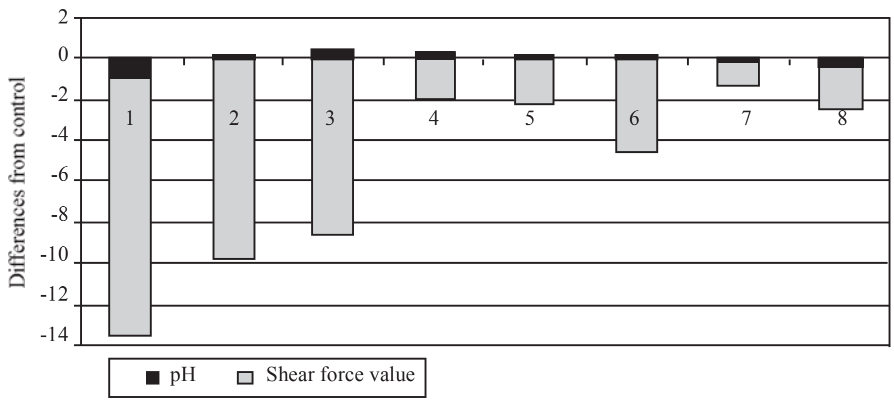

Figure 2. Effects of marination with (1) calcium chloride, (2) sodium chloride, (3) sodium fluoride, (4) oxamic acid, (5) sodium citrate (6) iodoacetate, (7) sodium acetate and (8) glucose on pH and shear force in pre-rigor flank muscle. Control (marination with water) value for pH (6.04) and shear force (17.9 lbs) were equalled to zero.

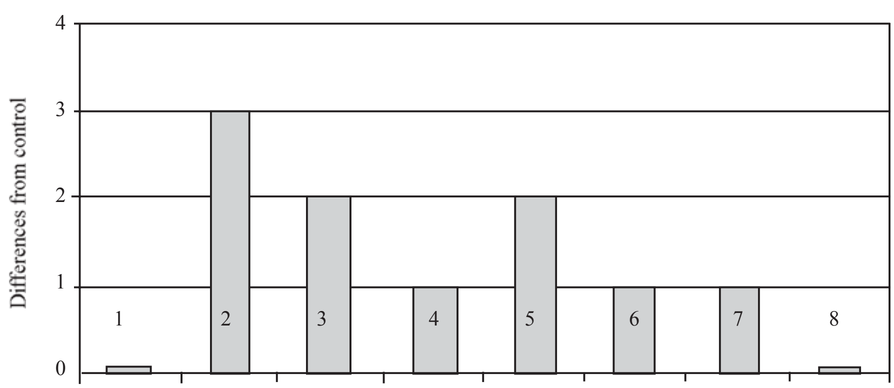

Figure 3. Effects of marination with (1) calcium chloride, (2) sodium chloride, (3) sodium phosphate, (4) sodium citrate, (5) iodoacetate, (6) oxamic acid, (7) sodium acetate and (8) glucose on visual color in pre-rigor loin eye muscle. Control (marination with water) value for visual color (1=very light cherry-red) was equalled to zero.

oxamic acid, sodium acetate and glucose exhibited better lean color (cherry red) than the control; however, shear force values increased by 4.5, 1.1 and 3.6 pounds, respectively, compared with the control.

In flank muscle, control meat was very light cherry-red. Meat treated with oxamic acid, iodoacetate, glucose and sodium acetate had the desirable characteristics (more tender than the control and with cherry-red color), as well as meat treated with calcium chloride. Although meat marinated with sodium chloride, sodium citrate and sodium fluoride were more tender than the control (8.2, 15.8 and 9.3 pounds versus 17.9 pounds, respectively) they made beef darker. Sodium chloride and sodium citrate scored moderately dark; sodium fluoride slightly dark (Figure 4).

Most of the compounds used in this study caused different responses between muscles. For example, the increase of pH was higher in loin eye muscle than in flank muscle, but the improvement in tenderness was more noticeable in flank muscle. Meat treated with iodoacetate and sodium citrate became more tender in both muscles. However, iodoacetate-treated loin eye muscle became darker and flank muscle color was cherry red; and sodium citrate-treated loin eye muscle had the best color (cherry red) and flank muscle was moderately dark. Another divergence: both glucose and oxamic acid improved lean color in both muscles, but only tenderized flank muscle. Further studies are needed to explain these differences in tenderness and muscle color. It is known that each muscle has its particular composition of muscle fiber types and connective tissue. Flank muscle has a higher proportion of red fiber types and a higher content of connective tissue. Loin eye muscle has a higher proportion of intermediate fibers. Fiber type composition affects glycolytic rate, pH decline and color, so different responses among muscles were expected.

Conclusion

In this preliminary study, we were able to identify several potential compounds

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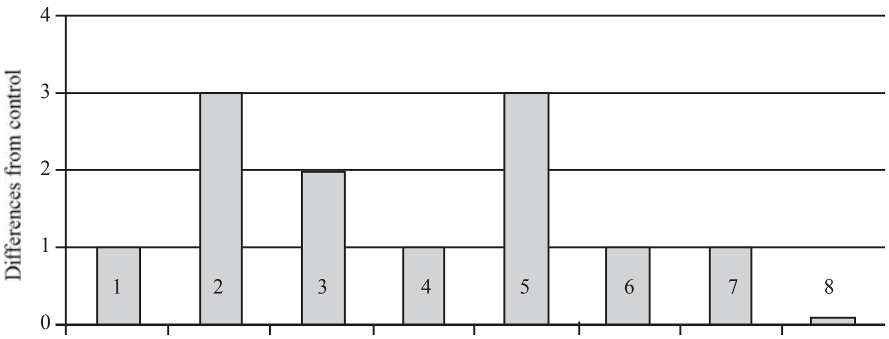

Figure 4. Effects of marination with (1) calcium chloride, (2) sodium chloride, (3) sodium fluoride, (4) oxamic acid, (5) sodium citrate, (6) iodoacetate, (7) sodium acetate and (8) glucose on visual color in pre-rigor flank muscle. Control (marination with water) value for visual color (1:very light cherry-red) was equalled to zero.

which could improve tenderness in pre-rigor muscle. Manipulation of glycolysis in pre-rigor muscles could be a feasible method to improve tenderness in low-value cuts by increasing pH and water-holding capacity, with no detriment to lean color.

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