Effects of Implanting Ram and Wether Lambs with Zeranol at Birth and Weaning on Palatability and Muscle Collagen Characteristics

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ABSTRACT: Thirty-five zeranol-implanted (I) and nonimplanted (NI) ram and wether lambs representing four treatments (implanted rams [IR], nonimplanted rams [NIR], implanted wethers [IW], and nonimplanted wethers [NIW]) were evaluated for meat palatability and muscle collagen characteristics. Rib (longissimus muscle, LM) chops from I lambs were juicier \( (P < 0.05) \) than rib chops from NI lambs. Chops from IR lambs had more \( (P < 0.05) \) detectable connective tissue and lower myofibrillar and overall tenderness scores than chops from NIR, IW, or NIW lambs. Warner-Bratzler shear (WBS) values tended to be higher \( (P = 0.03) \) for LM chops from rams than for those from wethers, but WBS values for Biceps femoris (BF) chops were similar \( (P > 0.05) \) for rams and wethers. Implanting did not affect \( (P > 0.05) \) collagen amount or solubility. RAM had more \( (P < 0.05) \) LM heat-labile (soluble, SC), nonheat-labile (insoluble, IC), and total collagen (TC) and a higher \( (P < 0.05) \) percentage of SC (SC/TC) than did wethers. Soluble collagen, TC, and percentage of SC for the BF were higher \( (P < 0.05) \) and IC tended \( (P = 0.09) \) to be higher in chops from rams than in those from wethers. Implanting did not affect \( (P > 0.05) \) collagen amount or solubility. Serum nonprotein hydroxyproline (NPHP) was higher \( (P < 0.05) \) in rams than in wethers throughout the feeding period and tended \( (P = 0.05) \) to be higher at slaughter. Implanting did not affect \( (P > 0.05) \) serum NPHP. We concluded that rams synthesize and accumulate more LM muscle collagen and have higher WBS values than do wethers. However, the observed reduction in sensory panel tenderness was only for chops from implanted rams compared with chops from other treatment groups.

Key Words: Lambs, Rams, Zeranol, Palatability, Collagen, Hydroxyproline

Introduction

Ram lambs produce leaner carcasses than do wethers (Field, 1971; Seideman et al., 1982). However, less tender and flavorful meat is considered a disadvantage of ram lambs (Seideman et al., 1982). Tenderness problems in intact males have been associated with connective tissue maturation (Boccard et al., 1979; Judge et al., 1984). Collagen accretion is stimulated by testosterone (Miller et al., 1990), resulting in ram lambs synthesizing and accumulating more intramuscular collagen than wethers do (Miller et al., 1989, 1990). Young bulls implanted with zeranol early in life and at regular intervals until slaughter had reduced serum testosterone (Juniewicz et al., 1985; Gray et al., 1986; Silcox et al., 1986), insoluble and total intramuscular collagen (Unruh et al., 1986), and improved taste panel evaluation scores for connective tissue amount (Greathouse et al., 1983; Unruh et al., 1986) and flavor intensity (Greathouse et al., 1983) compared with nonimplanted bulls. Limited information is available on the effects of zeranol implantation on lamb palatability. We hypothesized that implanting rams with zeranol at birth...
and weaning might reduce collagen accretion and improve tenderness while maintaining carcass leanness. Therefore, the objectives of our study were to determine the effects of implanting ram and wether lambs with zeranol at birth and weaning on meat palatability and muscle collagen characteristics.

**Experimental Procedure**

**Management.** Thirty-six spring-born male lambs were allotted randomly at birth to one of four treatment groups: nonimplanted rams (NIR), implanted rams (IR), nonimplanted wethers (NIW), and implanted wethers (IW). All lambs were born within 30 d of each other and reared as singles or twins on their natural dams. Birth weights were similar (P < .05) for all treatment groups (average of 4.9 kg). Dams were 2-, 3-, and 4-yr-old Polypay x Rambouillet × Dorset ewes. Most lambs were sired by purebred Rambouillet rams. One lamb from each treatment was sired by a Suffolk ram.

Castration and initial implanting with 12 mg of zeranol (Ralgro®, Pitman-Moore, Terre Haute, IN) were performed between 1 and 3 d of age. At an average age of 62 d, implanted (I) and nonimplanted (NI) lambs were weaned, and I lambs were reimplanted with 12 mg of zeranol. Lambs were fed a 70% concentrate finishing diet and slaughtered after 78, 93, or 107 d of feeding. Further management, performance, slaughter, testicular, serum testosterone, and fabrication procedures and traits have been described elsewhere (Nold et al., 1992). Rams compared with wethers in this study had greater daily gains (.33 vs .27 kg), heavier slaughter weights (51.1 vs 45.3 kg), less adjusted 12th rib fat (.58 vs .71 cm), and lower numerical yield grades (3.2 vs 3.8), respectively. Implantated lambs tended to have greater daily gains than NI lambs (.31 vs .29), but slaughter weights (49.0 vs 47.5), adjusted 12th rib fat (.66 vs .63), and yield grades (3.5 vs 3.5) were similar between the two respective groups. However, I rams had smaller scrotal circumferences and lighter single testicular weights (68.0 vs 90.5 g, respectively) than NI rams.

**Sample Preparation.** At 30 h postmortem, carcasses were fabricated into primal and trimmed subprimal cuts (Nold et al., 1992). Racks (NAMP #204A, left side) were aged for 6 d at 1.5°C before they were frozen and cut into rib (longissimus muscle, LM) chops (2.54-cm thick), from caudal to cranial, for sensory panel (three chops) and Warner-Bratzler shear force (WBS) determination (two chops). The Biceps femoris (BF) was removed from the left leg and aged for 6 d at 1.5°C, then two 2.54-cm-thick chops were obtained from the mid-point of the muscle for WBS determination. Two aged double loin (LM) chops (2.54-cm thick) were cut from the cranial edge of the loin (NAMP #232A), and the remainder of the BF was obtained for heat-labile collagen analysis. All samples were aged for 6 d at 1.5°C to allow natural postmortem enzymatic muscle degradation and then frozen at –20°C until they were analyzed.

**Sensory Panel and Warner-Bratzler Shear Evaluations.** Longissimus muscle chops were thawed for 16 h at 4°C and cooked in a Blodgett dual-air-flow oven to an internal temperature of 75°C (AMSA, 1978) that was monitored with thermocouples attached to a DORIC Minitreton 205 temperature monitor. Cores (1.27 cm in diameter) were removed with a mechanical coring device perpendicular to the chops' surface and served warm to an eight-member, trained sensory panel (AMSA, 1978). Evaluations for flavor intensity, juiciness, myofibrillar tenderness, connective tissue amount, overall tenderness, and off-flavor intensity were made using scores of 1 to 8 (1 = extremely bland, extremely dry, extremely tough, abundant amount of connective tissue, extremely tough overall, or extremely intense off-flavor; 8 = extremely intense flavor, extremely juicy, extremely tender, no detectable connective tissue, extremely tender overall, or no off-flavor).

Chops (LM and BF) used for WBS determinations were cooked according to the procedure outlined for the sensory panel. Chops were cooled at room temperature for 2 h before four cores (1.27 cm in diameter) were removed with a mechanical coring device perpendicular to the chops' cut surface and sheared through the center with a WBS device attached to the Universal Instron (Instron, Canton, MA).

**Heat-Labile Collagen Analysis.** Loin (LM) chops and BF muscles were thawed at 4°C for 5 h and pulverized in liquid nitrogen for 45 s in a Waring Blender. Pulverized samples were stored at –75°C until heat-labile collagen was extracted from duplicate 4-g samples by heating for 70 min at 77°C in .25 strength Ringer's solution (Hill, 1966). Samples were centrifuged, and supernatant and residue fractions were separated. After addition of 8 mL of .25-strength Ringer's solution to the remaining residue, samples were centrifuged again. Supernatant and residue fractions were hydrolyzed (autoclaved at 123°C under 1.4 kg/cm²) in 12 N HCl for 12 h. After neutralization, hydroxyproline content was determined in duplicate for both fractions by spectrophotometric methods (Bergman and Loxley, 1963). Heat-labile (soluble, SC) collagen and non-heat-labile (insoluble, IC) collagen contents were calculated by multiplying the hydroxyproline content of the residue and the
supernatant by 7.25 and 7.52, respectively (Cross et al., 1973). The percentage of SC was calculated by dividing SC by the sum of the SC and IC fractions (total collagen, TC) and multiplying by 100.

**Blood Collection and Analysis.** To investigate changes in serum nonprotein hydroxyproline (NPHP, an estimator of collagen turnover) throughout growth, blood samples were collected at slaughter and at an average age of 62, 90, 118, and 146 d. Serum was separated as described by Nold et al. (1992). Nonprotein hydroxyproline was extracted twice with five and two volumes, respectively, of absolute alcohol (Bannister and Burns, 1970) before determination by spectrophotometric methods (Bergman and Loxley, 1963). Serum testosterone was quantified and previously reported by Nold et al. (1992).

**Statistical Analyses.** Because of uneven sample size, all data were analyzed using the GLM procedure of SAS (1985). In a 2 × 2 factorial arrangement of treatments, gonadal status (ram vs wether) and implant (I vs NI) treatments were considered main effects and slaughter group a block effect for LM and BF collagen, WBS, and slaughter NPHP data. Taste panelist and taste panel session were added as block effects for LM sensory panel analysis. Differences between treatment groups for meat sensory and collagen traits for which there was an overall treatment effect (P < .05) were separated by least squares means (SAS, 1985). Results were reported and discussed as least squares means.

Serum NPHP was analyzed in a repeated measures design with gonadal status and implant as the main plots and animal age at serum collections as the repeated measure. When the respective F-tests were significant (P < .05), interaction means were separated using least squares means (SAS, 1985) and appropriate error terms for the repeated measures analyses. Results were reported and discussed as least squares means.

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### Results and Discussion

**Sensory Panel and Warner-Bratzler Shear Evaluations.** Sensory panel evaluations and WBS values of the LM and BF are presented in Table 1. A gonadal status × implant interaction occurred (P < .05). Sensory panel scores for myofibrillar tenderness, connective tissue amount, and overall tenderness are presented as interaction means (Table 2). Flavor intensity and off-flavor scores were similar (P > .05) for LM chops from rams and wethers and from I and NI lambs (Table 1). Juiciness scores of LM chops from rams and wethers were similar (P > .10), but chops from I lambs were juicier (P < .05) than chops from NI lambs. Myofibrillar tenderness, connective tissue amount, and overall tenderness scores were lower (less desirable) for chops from IR than for those from NIR, IW, and NIW. No tenderness differences (P > .05) were detected among chops from NIR, IW, and NIW. Longissimus chops from rams tended (P = .06) to have higher WBS values (Table 1) than LM chops from wethers. Similar (P > .05) WBS values were observed for BF chops from rams and wethers. Implanting did not affect (P > .05) WBS values for either muscle. Although analysis of WBS values indicated that LM chops from rams, whether I or NI, were tougher than those from wethers, sensory panel evaluations indicated that a difference existed only between chops from IR and wethers. Even though the interaction was not significant (P = .38), interaction means of WBS values indicated that the largest difference was between LM chops from IR (3.6 kg) and wethers (2.8 kg); NIR (3.1 kg) was intermediate. In contrast, meat from bulls implanted with zeranol from birth to slaughter, compared with controls, had less detectable connective tissue in sensory panel evaluations and lower WBS values (Greathouse et al., 1983; Unruh et al., 1986, 1987).

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### Table 1. Warner-Bratzler shear values of longissimus muscle (LM) and biceps femoris (BF) chops and sensory panel scores of longissimus chops from implanted (I) and nonimplanted (NI) rams (R) and wethers (W)

<table>
<thead>
<tr>
<th>Item</th>
<th>Gonadal status</th>
<th>Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>W</td>
</tr>
<tr>
<td>No. of lambs</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>LM shear force, kg</td>
<td>3.3</td>
<td>2.6</td>
</tr>
<tr>
<td>BF shear force, kg</td>
<td>3.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Flavor intensityab</td>
<td>6.0b</td>
<td>5.9c</td>
</tr>
<tr>
<td>Juicinessab</td>
<td>7.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Off-flavorab</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

abScores of 1 to 8; 2 = very bland, very dry, or very intense; 4 = slightly bland, slightly dry, or slightly intense; 6 = moderately intense, moderately juicy, or traces.
bMeans within a row and main effect with a different superscript differ (P < .05).
Collagen and Serum Nonprotein Hydroxyproline Analyses. Heat-labile collagen data are presented in Table 3. Rams had more (P < .05) SC, IC, and TC and a higher percentage of SC in the LM and more (P < .05) SC and TC and a higher percentage of SC in the BF than did wethers. Also, rams tended (P = .09) to have more IC in the BF than did wethers. Miller et al. (1989) also found that SC, IC, and TC were more abundant in the longissimus, supraspinatus, and infraspinatus muscles of rams than in those of wethers. In addition, they found that rams from 18 to 30 wk of age had a higher percentage of SC, and the magnitude of the difference between rams and wethers increased with age. They suggested that collagen synthesis and degradation persisted at rapid rates longer in rams than in wethers. Our data support this hypothesis. If collagen synthesis and degradation rates were more rapid in rams, this would result in more collagen (all fractions) and a higher percentage of newly synthesized collagen that would be more heat-labile. In contrast, Miller et al. (1990) found no differences in percentage of SC between rams, wethers, and testosterone-implanted wethers.

Serum NPHP was higher (P < .05) in rams than in wethers throughout the feeding phase (Figure 1) and at slaughter (Table 3). Furthermore, NPHP was higher (P < .05) at weaning (62 d average age) than at all later times for all treatments. Miller et al. (1989) also found higher NPHP concentrations in rams than in wethers and decreases in NPHP concentrations with age. Furthermore, they reported that NPHP was positively correlated to collagen solubility. Miller et al. (1990) reported that rams and testosterone-implanted wethers tended to have higher serum NPHP than nonimplanted wethers and observed a trend dependent on testosterone-implant dosage. Gerrard et al. (1987) found that bulls, up to 12 mo of age, had higher NPHP concentrations than did steers. In our data, NPHP concentrations indicated that more collagen synthesis and degradation occurred in rams than in wethers at all ages. Implanting did not affect (P > .05) serum NPHP.

Testosterone has been shown to affect collagen accretion (Miller et al., 1990). Those authors found that testosterone-implanted wethers were similar to their intact male contemporaries for collagen traits and that both were different from nonimplanted wethers. Zeranol implantation has been shown to reduce serum testosterone concentrations in bulls (Gray et al., 1986; Silcox et al., 1986). However, a large reduction in testosterone concentrations was not detected in our study with lambs despite a large reduction in testicular weight (Nold et al., 1992). Because only minimal differences in testosterone were detected between IR and NIR, we would expect implanting to have minimal effects on collagen accretion and turnover in rams.

Warner-Bratzler shear values were higher for rams than for wethers. Even though rams had less external fat (.58 vs .72 cm) than wethers, differences in shear values may only be partially

![Graph](image-url)
explained by myofibrillar or cold toughening. Sensory panel analysis indicated a gonadal status 
× implant interaction, whereby implanting rams increased detectable connective tissue and 
decreased myofibrillar and overall tenderness. However, chemical determination of collagen 
properties indicated that the difference between I and NI rams was not due to the collagen 
component. Conflicting results for the effects of zeranol on collagen traits in young bulls have been 
reported, ranging from no effects (Calkins et al., 1986) to less collagen accretion and a delay in 
collagen maturation (Unruh et al., 1986). Results from this and other studies indicate that the 
influence of implanting with zeranol on palatability and muscle collagen traits may depend on the 
species and/or implanting regimen.

Implications

Decreased collagen accretion in wethers compared with rams results from lower serum testosterone concentrations. However, these differences in collagen do not cause differences, as perceived by a sensory panel, in tenderness traits of longissimus chops from wethers and nonimplanted rams. Implanting ram and wether lambs with zeranol at birth and weaning has minimal influences on muscle collagen traits, serum nonprotein hydroxyproline, and testosterone concentrations. Therefore, the observed reduction in tenderness of chops from implanted rams compared with nonimplanted rams cannot be attributed to collagen properties evaluated in this study.

Table 3. Longissimus and biceps femoris heat-labile collagen properties and serum hydroxyproline concentrations of implanted (I) and nonimplanted (NI) rams (R) and wethers (W)

<table>
<thead>
<tr>
<th>Item</th>
<th>Sex</th>
<th>Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>V</td>
</tr>
<tr>
<td>Longissimus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC, mg/g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC, mg/g</td>
<td>.05f</td>
<td>.54g</td>
</tr>
<tr>
<td>TC, mg/g</td>
<td>3.39f</td>
<td>3.06b</td>
</tr>
<tr>
<td>SC, %</td>
<td>18.0f</td>
<td>14.8g</td>
</tr>
<tr>
<td>Biceps femoris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC, mg/g</td>
<td>1.12f</td>
<td>.87g</td>
</tr>
<tr>
<td>IC, mg/g</td>
<td>5.66</td>
<td>5.09</td>
</tr>
<tr>
<td>TC, mg/g</td>
<td>6.89f</td>
<td>5.93g</td>
</tr>
<tr>
<td>SC, %</td>
<td>18.6f</td>
<td>14.5g</td>
</tr>
<tr>
<td>Hydroxyproline, mg/mL</td>
<td>5.4f</td>
<td>4.8g</td>
</tr>
</tbody>
</table>

aSC = heat-labile (soluble) collagen
bIC = non-heat-labile (insoluble) collagen
cTC = total collagen (SC + IC)
bcPercentage of SC = SC/TC × 100.
dConcentration on days of slaughter.
eMeans within a row and main effect with a different superscript differ (P < .05).

Literature Cited

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