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Keith E. Gregory, J. Joe Ford, Steven C. Seideman, and W. Gordon Hays[1]

Introduction

It is generally recognized that intact bovine males gain weight faster and require less feed per unit of gain than castrate bovine males. Further, carcasses from intact bovine males have a higher percentage of retail or edible product, but meat from intact males is generally evaluated slightly lower on palatability characteristics, particularly tenderness, than carcasses from castrate bovine males. It has been suggested that much of the advantage of intact *vs* castrate males for rate of gain, efficiency of gain, and composition of gain may be expressed by an age of about 1 year and the disadvantages, including aggressive male behavior, that result in reduced rate and efficiency of gain, begin at about 1 year of age (at or immediately after puberty). Thus, there was need to determine the effects of castration at about 1 year on rate of gain, efficiency of gain, composition of gain, meat characteristics, and behavioral characteristics. Reports have shown that, when the anabolic agent zeranol [6-(6,10-dyhydroxyundecyl)-B-resorcyclic acid-d-lactone] is implanted in intact male calves at or before weaning, rate of gain is increased and rate of testicular growth is decreased. These experiments were conducted to determine the effects of castration and zeranol implants at 13 months of age on rate of gain, efficiency of gain, behavioral characteristics, and carcass and meat traits of bovine males.

Procedure

Two experiments were conducted. In experiment I, a total of 280 young bulls from five breed groups with an average age of 13 months were assigned to five experimental treatments as follows: (1) emasculator castration at day 0; (2) surgical castration at day 0; (3) intact; (4) intact, implanted in ear at days 0 and 70 with 36 mg of zeranol; and (5) intact, implanted in ear at day 0 with 72 mg of zeranol (Table 1). Average initial weight on experiment was 1,023 lb. Breed groups included in the experiment were either seven-eighths or purebreds of the Gelbvieh, Charolais, and Limousin breeds and two composite populations (MARC I and MARC II). MARC II population has one-fourth of their ancestry contributed by each of the Hereford, Angus, Gelbvieh, and Simmental breeds, and MARC I population averaged the following breed composition: one-fourth each of Charolais, Limousin, and Brown Swiss (dual-purpose type), and one-eighth each of Hereford and Angus.

The two types of castrates were fed together by breed group. Samples of MARC I, MARC II, and Limousin were fed separately for each treatment to provide three of the five replicates per treatment; 28 Gelbvieh and 32 MARC II that had been fed together since weaning were assigned to each of the five treatments as one replicate, and 30 Charolais and 28 MARC I that had been fed together since weaning were assigned to each of the five treatments as one replicate (Table 1). There were 20 pens in the experiment. Animals were assigned to treatment by breed group at random within initial weight strata. Animals in each pen had been fed together since weaning at about 200 days. Further detail of experimental design is provided in Table 1. Feeding period for experiment I was 141 days.

In experiment II, a total of 231 bulls representing seven breed groups (Table 2) were assigned to one of four treatments: (1) surgical castration at 13 months of age; (2) intact; (3) intact, implanted in scrotum with 36 mg of zeranol; or (4) intact, implanted in ear with 36 mg of zeranol (Table 2). Zeranol implants were inserted into the ear as described by the manufacturer or were placed into the septum of the scrotum, approximately one-third of the distance from the body to the epididymal end of the testis. From weaning until initiation of the experiment, bulls were penned by breed group. Thus, animals from seven different source pens were mixed when experiment II was initiated (Table 2). Mean age at initiation of the 103-day experimental period was 395 days. Animals were stratified by weight, within breed group, assigned randomly within strata to treatments, and were fed in pens of 28 to 30 with two pens/treatment. All breeds were represented within each pen (Table 2).

Diet fed since weaning and for the first 57 days in experiment I and the first 29 days in experiment II on a dry matter (DM) basis was 22 percent corn, 66 percent corn silage, and 12 percent protein-mineral-vitamin supplement composed primarily of soybean oil meal. The diet fed for the last 84 days of experiment I and the last 74 days of experiment II on a DM basis, was 70 percent corn, 25 percent corn silage, and 5 percent protein-mineral-vitamin supplement. Dietary energy density was 2.69 Mcal metabolizable energy (ME)/kg DM for the first 57 days of experiment I and the first 29 days of experiment II, and 3.04 Mcal ME/kg DM for the last 84 days of experiment I and the last 74 days of experiment II. Dietary

Table 1.—Number of animals by treatment and breed group - experiment I

	Treatment					
Breed group	Emasculator castration	Surgical castration	Intact	Intact 36-mg implant[a]	Intact 72-mg implant[b]	Total
MARC I[ce]	16	15	15	18	15	79
MARC II[de]	21	19	20	20	19	99
Gelbvieh[d]	5	6	5	6	6	28
Charolais[c]	5	6	7	6	6	30
Limousin[e]	9	9	8	9	9	44
Total	56	55	55	59	55	280

[a]Implanted at days 0 and 70 with 36 mg of zeranol.
[b]Implanted at day 0 with 72 mg of zeranol.
[c]Twenty-eight MARC I (1/8 Hereford, 1/8 Angus, 1/4 Charolais, 1/4 Brown Swiss, 1/4 Limousin) and 30 Charolais that had been fed together previously were assigned at random by breed group to each of the five treatments as one replicate.
[d]Twenty-eight Gelbvieh and 32 MARC II (1/4 Hereford, 1/4 Angus, 1/4 Gelbvieh, 1/4 Simmental) that had been fed together previously were assigned at random by breed group to each of the five treatments as one replicate.
[e]The three other replicates in each treatment were MARC I, MARC II, and Limousin.

Table 2.—Number of animals by treatment and breed group - experiment II[a]

	Treatment				
Breed group	Intact	Surgical castration[b]	Scrotal implant[c]	Ear implant[d]	Total
Red Poll	11	11	10	10	42
Hereford	9	9	10	10	38
Angus	12	9	10	10	41
Pinzgauer x Angus	11	11	11	10	43
Brown Swiss	9	9	9	8	35
Simmental	5	5	6	6	22
Gelbvieh	2	3	3	2	10
Total	59	57	59	56	231

[a]Two pens were used for each treatment.
[b]Castration at day 0; mean age of 395 days.
[c]Implanted in scrotum at day 0 with 36 mg of zeranol.
[d]Implanted in ear at day 0 with 36 mg of zeranol.

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crude protein was 12.88 percent for the first 57 days of experiment I and the first 29 days of experiment II, and 10.93 percent for the last 84 days of experiment I and the last 79 days of experiment II. Diets were fed *ad libitum* throughout the experiment. Feed bunk space was 90 ft in each pen, and each pen was 220 ft deep. Animals were weighed initially and on days 11, 29, 57, 85, 113, and 141 of experiment I and initially and on days 11, 29, 57, 85, and 103 of experiment II. Feed consumption was recorded by pen for each gain period.

Testicular weights were recorded at castration for surgical castrate males and at slaughter for all other males except the emasculator castrates. Scores for degree of development of secondary sex characteristics were recorded on days 0, 85, and 141 of experiment I and on days 0 and 85 of experiment II (8 = high degree of masculinity, 5 = medium degree of masculinity, 2 = small degree of masculinity). Different types of aggressive male behavior (fighting, riding, and pushing-shoving) were recorded for all treatment groups at different hours of the day throughout both experiments. Animals were hauled about 40 miles and slaughtered immediately after arrival at a commercial slaughter facility. Preslaughter stress associated with mixing animals from different pens was avoided. Carcass data were recorded approximately 24 h postslaughter. Cutability and retail product percentage and retail product weight were estimated by prediction equations.

Four treatment groups from experiment I were sampled (94 carcasses) to determine the effects of experimental treatment on meat traits (Table 3). Average liveweight at slaughter of the carcasses sampled was 1,385 lb at an average age of 17 months and a carcass weight of 884 lb.

Boneless 5th through 12th rib cuts were taken 24 h postslaughter from the right side of 94 carcasses representing the four treatment groups. Marbling scores were determined before ribs were removed. Ribs were vacuum packaged and frozen for about 4 months at −4°F, after which they were removed from storage and prepared for chemical analysis and sensory evaluation. Number of animals by treatment and breed group from which ribs were sampled is shown in Table 3.

Table 3.—Number of animals by treatment and breed group - meat traits

	Treatment				
Breed group	Castrate	Intact	Intact 36-mg implant[a]	Intact 72-mg implant[b]	Total
MARC II	8	17	13	12	50
Charolais	8	7	4	4	23
Limousin	4	9	4	4	21
Total	20	33	21	20	94

[a]Implanted in ear at days 0 and 70 with 36 mg zeranol.
[b]Implanted in ear at day 0 with 72 mg zeranol.

Ribs were cut into steaks 1 in thick starting at the 12th rib. The longissimus muscle was removed from the first steak from the 12th rib end and fat and moisture percentage of the longissimus muscle were determined by ether extract and by oven-drying. Longissimus muscle protein percentage was determined by difference. Steaks two and four were used for sensory panel evaluation. Steak three was used for shear force measurement with a Warner-Bratzler shear device.

Steaks were thawed 24 h at 37°F and then cooked on Farberware Open Hearth broilers to an internal temperature of 162°F as monitored by copper constantan thermocouples placed in the geometric center of each steak. A 10-member trained sensory panel evaluated 3/4 in cubes of each steak for juiciness (8 = extremely juicy, 1 = extremely dry), overall tenderness (8 = extremely tender, 1 = extremely tough), beef flavor intensity (8 = extremely intense, 1 = extremely bland), amount of panel detectable connective tissue (8 = none, 1 = abundant) and ease of fragmentation (8 = extremely easy, 1 = extremely difficult).

Table 4.—Least-squares means and standard errors for gains and weights - experiment I

Item	Initial weight, lb	ADG[a] 0-141 day, lb	Total gain 141 day, lb	Final weight, lb
Treatment				
Level of significance[b]	NS	**	**	**
Emasculator castrates	1,025 ± 15.6	2.0 ± .07[e]	282 ± 8.2[e]	1,308 ± 8.2[e]
Surgical castrates	1,021 ± 15.0	2.0 ± .04[e]	278 ± 7.7[e]	1,299 ± 7.8[e]
Intact	1,021 ± 15.2	2.6 ± .04[f]	388 ± 7.9[f]	1,409 ± 8.0[f]
Intact 36-mg implant[c]	1,023 ± 14.8	3.1 ± .04[g]	421 ± 7.5[g]	1,444 ± 7.7[fg]
Intact 72-mg implant[d]	1,028 ± 15.0	3.1 ± .04[g]	441 ± 7.7[g]	1,466 ± 7.8[g]

[a]ADG = average daily gain.
[b]NS = not significant.
[c]Implanted in ear at days 0 and 70 with 36 mg of zeranol.
[d]Implanted in ear at day 0 with 72 mg of zeranol.
[efg]Values having no superscript letter in common differ at P≤.05 level.
**P<.01.

Table 5.—Least-squares means for feed efficiency (141 days) - experiment I

Item	Mcal ME/ kg gain	Kg dry matter/ kg gain	Mcal ME/kg estimated retail product	Kg dry matter/ kg estimated retail product
Treatment				
Level of significance	**	**	*	*
Castrates	29.91 ± .52[c]	10.32 ± .18[c]	14.27 ± .34[c]	4.93 ± .12[c]
Intact	21.31 ± .52[d]	7.34 ± .18[d]	12.65 ± .34[d]	4.36 ± .12[d]
Intact 36-mg implant[a]	20.45 ± .52[d]	7.05 ± .18[d]	12.64 ± .34[d]	4.36 ± .12[d]
Intact 72-mg implant[b]	19.77 ± .52[d]	6.81 ± .18[d]	12.82 ± .34[d]	4.42 ± .12[d]

[a]Implanted in ear at days 0 and 70 with 36 mg zeranol.
[b]Implanted in ear at day 0 with 72 mg zeranol.
[cd]Values having no superscript letter in common differ at P≤.05 level.
*P<.05.
**P<.01.

Table 6.—Least-squares means and standard errors for secondary sex characteristics score and testicular weight - experiment I

Item	Secondary sex characteristics score[a]			Testicular weight	
	Initial	Day 85	Day 141	Initial, lb	Slaughter, lb
Treatment					
Level of significance[b]	NS	**	**		NS
Emasculator castrates	5.0 ± .12	3.8 ± .12[e]	2.7 ± .11[e]		
Surgical castrates	5.0 ± .11	3.7 ± .11[e]	2.6 ± .10[e]	1.1 ± .04	
Intact	5.1 ± .11	6.3 ± .11[f]	7.3 ± .10[f]		1.3 ± .04
Intact 36-mg implant[c]	4.8 ± .11	6.2 ± .11[f]	7.4 ± .10[f]		1.3 ± .04
Intact 72-mg implant[d]	5.1 ± .11	6.4 ± .11[f]	8.0 ± .10[g]		1.2 ± .04

[a]8 = high degree of masculinity, 5 = medium degree of masculinity, 2 = small degree of masculinity.
[b]NS = not significant.
[c]Implanted at days 0 and 70 with 36 mg of zeranol.
[d]Implanted at day 0 with 72 mg of zeranol.
[efg]Values having no superscript letter in common differ at P≤.05 level.
**P<.01.

Shear force measurements were made after thawing and cooking steaks by the same procedures used for the sensory panel evaluations. Three .5 in² cores were taken from each cooled steak, parallel to fiber direction and sheared perpendicular to fiber direction in a Warner-Bratzler shear device.

Results

Experiment I. Method of castration did not affect rate of gain (Table 4). Intact males not implanted with zeranol gained 38.6 percent more (P<.01) during the 141-day period than castrate males. Intact males from the two zeranol implant treatment groups did not differ from each other in gain, but averaged 11.1 percent more (P<.01) during the 141-day period than males from the intact treatment group not implanted (Table 4). Castrate males required 40.4 percent more (P<.01) metabolizable energy (ME) and dry matter (DM)/unit of gain than intact males not implanted, but intact males implanted with zeranol did not require less (P>.05) ME or DM/unit of gain than intact males not implanted (Table 5). Males castrated at 13 months showed a progressive decrease in secondary sex characteristics during the 141-day feeding period, while males from the three intact treatments showed a progressive increase (Table 6). Zeranol did not have an effect on testicular weight (Table 6) or on aggressive male behavioral characteristics. Castrate males had greater (P<.01) fat thickness at 12th rib, higher (P<.01) marbling score, and lower (P<.01) cutability and retail product percentage than the males from the three intact treatments, which did not differ (P>.05) from each other in traits associated with carcass composition (Table 10). The effect of treatment on lean color score, though significant, was not of major importance; all treatments produced meat of acceptable color (Table 10). The longissimus muscle of castrate males had a finer texture (P<.01) than longissimus muscle from males from intact treatments, which did not differ (P>.05) from each other (Table 10).

Experiment II. Intact males gained 24 percent faster (P<.05) and consumed 22 percent less (P<.01) feed/unit of gain than males castrated at 13 months of age (Tables 7 and 8). Zeranol implants did not have a significant effect on average daily gain, feed efficiency, or carcass traits (Tables 7, 8, and 11). Late castration reduced (P<.01) carcass weight, estimated cutability (percentage), and estimated retail product (percentage). Dressing percentage and scores for marbling, final maturity, lean color, and lean texture were not affected significantly by late castration or zeranol treatment (Table 11). Secondary sex characteristic scores for males castrated at 13 months of age decreased during the experiment and on day 85 were lower (P<.01) than observed in intact males (Table 9).

Meat Traits. Samples of longissimus muscle from 94 males from experiment I representing four treatments [(1) castrated at 13 months; (2) intact; (3) intact, implanted with 36 mg zeranol at days 0 and 70; and (4) intact, implanted with 72 mg zeranol at day 0] were evaluated for a series of composition and palatability characteristics (Table 12). Longissimus muscle from castrate males generally had a higher score for marbling, a higher percentage of fat, a lower shear force value, and was evaluated more desirable by sensory panel scores for ten-

Table 7.—Least-squares means and standard errors for gains and weights - experiment II

Treatment	Initial weight, lb	ADG[a] 0 to 103 days, lb	Total gain 103 days, lb	Final weight, lb
Castrate	942 ± 11.9	2.2 ± .07[b]	216 ± 6.8[b]	1,160 ± 6.3[b]
Intact	953 ± 12.6	2.9 ± .07[c]	284 ± 7.5[c]	1,237 ± 6.7[c]
Scrotal implant	944 ± 11.7	2.6 ± .07[c]	280 ± 6.8[c]	1,222 ± 6.2[c]
Ear implant	948 ± 12.6	2.6 ± .07[c]	267 ± 7.3[c]	1,215 ± 6.8[c]

[a]ADG = average daily gain.
[bc]Means within columns with different superscripts differ (P<.05).

Table 8.—Least-squares means and standard errors for feed efficiency (103 days) - experiment II

Treatment	Mcal/kg gain	Kg dry matter/kg gain	Mcal/kg retail product	Kg dry matter/kg retail product
Castrate	25.7 ± .38[b]	8.77 ± .13[b]	11.8 ± .28	4.02 ± .10
Intact	20.0 ± .38[a]	6.81 ± .13[a]	10.4 ± .28	3.54 ± .10
Scrotal implant	20.9 ± .38[a]	7.01 ± .13[a]	11.1 ± .28	3.79 ± .10
Ear implant	21.2 ± .38[a]	7.22 ± .13[a]	10.6 ± .28	3.62 ± .10

[ab]Means within columns with different superscripts differ (P<.01).

Table 9.—Least-squares means and standard errors for testicular weight and initial and final live animal secondary sex characteristics score - experiment II

Treatment	Secondary sex characteristics score[a]		Testicular weight, lb
	Initial	Final	
Castrate	4.8 ± .1	3.9 ± .1[b]	
Intact	4.7 ± .1	5.8 ± .1[c]	1.2 ± .05
Scrotal implant	4.9 ± .1	6.0 ± .1[c]	1.1 ± .05
Ear implant	5.2 ± .1	6.2 ± .1[c]	1.1 ± .05

[a]Nine point scoring system; 8 = high degree of masculinity, 5 = medium degree of masculinity, 2 = small degree of masculinity.
[bc]Means within columns with different superscripts differ (P<.01).

Table 10.—Least-squares means and standard errors for carcass traits - experiment I

Traits	Level of signif-icance	Treatment				
		Emasculator castrates	Surgical castrates	Intact	Intact 36-mg implant[g]	Intact 72-mg implant[h]
Hot carcass weight, lb	**	803 ± 13.4[i]	809 ± 12.8[i]	904 ± 13.2[j]	919 ± 12.8[jk]	946 ± 12.8[k]
Dressing percentage	**	61.4 ± .33[i]	62.4 ± .32[i]	64.0 ± .32[j]	63.8 ± .31[j]	64.5 ± .32[j]
Adj. hot carcass weight[a], lb	**	807 ± 12.7[i]	807 ± 12.1[i]	902 ± 12.3[j]	924 ± 12.1[jk]	950 ± 12.3[k]
Adj. fat thickness[a], in	**	.30 ± .02[i]	.26 ± .02[i]	.17 ± .02[j]	.18 ± .02[j]	.21 ± .02[j]
Longissimus area, in[2]	**	14.8 + .28[i]	15.2 ± .26[i]	17.7 ± .26[j]	16.9 ± .26[j]	16.9 ± .26[j]
Est. KPH fat[a], percent	**	1.9 ± .07[i]	2.0 ± .07[i]	1.6 ± .07[j]	1.6 ± .07[j]	1.6 ± .07[j]
Est. cutability[a], percent	**	63.5 ± .29[i]	64.4 ± .27[i]	67.1 ± .28[j]	66.7 ± .27[j]	66.3 ± .27[j]
Est. retail product[a], percent	**	77.8 ± .34[i]	78.9 ± .33[i]	82.2 ± .34[j]	81.7 ± .32[j]	81.2 ± .33[j]
Secondary sex char. score[b]	**	3.3 ± .2[i]	3.5 ± .2[i]	7.3 ± .2[j]	7.6 ± .2[j]	7.5 ± .2[j]
Marbling score[c]	**	9.3 ± .3[i]	8.4 ± .3[i]	6.6 ± .3[k]	6.4 ± .3[k]	6.3 ± .3[k]
Final maturity score[d]	**	2.3 ± .08[i]	2.4 ± .08[i]	2.9 ± .08[j]	2.7 ± .08[j]	2.7 ± .08[j]
Lean color score[e]	*	4.6 ± .1[i]	4.5 ± .1[i]	4.3 ± .1[ij]	4.2 ± .1[j]	4.5 ± .1[i]
Lean texture score[f]	**	5.7 ± .2[i]	5.7 ± .2[i]	5.3 ± .2[ij]	4.9 ± .2[j]	4.9 ± .2[j]

[a]Adjusted for differences in date of birth; est. = estimated; KPH = kidney, pelvic, and heart.
[b]Char. = characteristics; 8 = high degree of masculinity, 5 = medium degree of masculinity, 2 = small degree of masculinity.
[c]11 = small-, 8 = slight-, 5 = traces-, 2 = practically devoid.
[d]1 = A-, 2 = A°, 3 = A+, 4 = B-, 5 = B°, 6 = B+.
[e]1 = very dark red, 2 = dark red, 3 = moderately dark red, 4 = slightly dark red, 5 = cherry red, 6 = very light cherry red, 7 = light grayish red (pink).
[f]1 = very coarse, 2 = coarse, 3 = moderately coarse, 4 = slightly coarse, 5 = slightly fine, 6 = moderately fine, 7 = very fine.
[g]Implanted in ear at days 0 and 70 with 36 mg of zeranol.
[h]Implanted in ear at days 0 with 72 mg of zeranol.
[ij k]Values having no superscript letter in common differ at P≤.05 level.
*P<.05.
**P<.01.

Table 11.—Least-squares means and standard errors for carcass traits - experiment II

Traits	Level of signif-icance[h]	Treatment			
		Castrate	Intact	Scrotal implant	Ear implant
Hot carcass weight, lb	**	697 ± 12.6[i]	763 ± 13.4[j]	732 ± 12.3[j]	747 ± 13.4[j]
Dressing percentage	NS	60.2 ± .69	61.6 ± .74	60.0 ± .68	61.6 ± .74
Adjusted hot carcass weight[a], lb	**	697 ± 9.3[i]	763 ± 9.7[j]	741 ± 9.0[k]	750 ± 9.9[jk]
Adjusted fat thickness[ab], in	**	.38 ± .02[i]	.22 ± .02[j]	.23 ± .02[j]	.22 ± .02[j]
Longissimus area, in[2ab]	*	12.2 ± .26[i]	13.9 ± .28[j]	14.6 ± .25[j]	14.7 ± .28[j]
Est. KPH fat[a], percent	**	2.5 ± .08[i]	1.8 ± .08[j]	1.8 ± .08[j]	1.9 ± .08[j]
Est. cutability, percent	**	61.1 ± .28[i]	64.5 ± .30[j]	64.6 ± .28[j]	65.0 ± .30[j]
Est. retail product, percent	**	75.2 ± .34[i]	79.2 ± .37[j]	79.3 ± .34[j]	79.8 ± .37[j]
Secondary sex characteristics score[c]	NS	3.7 ± .3	6.3 ± .3	5.7 ± .3	6.7 ± .3
Marbling score[d]	NS	8.4 ± .39	6.2 ± .43	6.6 ± .38	5.7 ± .42
Final maturity score[e]	NS	2.5 ± .10	2.8 ± .10	2.7 ± .09	2.9 ± .10
Lean color score[f]	NS	4.4 ± .1	4.2 ± .1	4.0 ± .1	4.1 ± .1
Lean texture score[g]	NS	5.7 ± .2	5.3 ± .2	4.5 ± .2	4.6 ± .2

[a]Adjusted for differences in date of birth; Est. = estimate; KPH = kidney, pelvic, and heart.
[b]Determined at the 12th rib.
[c]8 = high degree of masculinity, 5 = medium degree of masculinity, 2 = small degree of masculinity.
[d]11 = small, 8 = slight, 5 = traces, 2 = practically devoid.
[e]1 = A−, 2 = A°, 3 = A+, 4 = B−, 5 = B°, 6 = B+.
[f]1 = very dark red, 2 = dark red, 3 = moderately dark red, 4 = slightly dark red, 5 = cherry red, 6 = very light cherry red, 7 = light grayish red (pink).
[g]1 = very coarse, 2 = coarse, 3 = moderately coarse, 4 = slightly coarse, 5 = slightly fine, 6 = moderately fine, 7 = very fine.
[h]NS = not significant; * P<.05; ** P<.01.
[ij k]Means within rows with no superscript in common differ (P<.05).

derness, amount of connective tissue, and ease of fragmentation than longissimus muscle from intact males (Table 12). Intact males implanted with zeranol (two treatments) generally did not differ from each other nor from untreated intact males in either composition or palatability characteristics (Table 12). Neither fat percentage nor marbling score of the longissimus muscle were significantly associated with any of the characteristics relating to meat palatability. Sensory panel scores for amount of connective tissue and ease of fragmentation were highly associated (P<.01) with each other (r = .95) and with sensory panel score for tenderness (r = .95 and .96); the relationship of each of these three variables with shear force value was approximately equal (r = –.52, –.53, and –.55).

General. Animals on both experiments continued to consume feed and water and to gain weight immediately following castration; they gained weight during the 11 days following castration. Even though emasculator and surgically castrated animals did not differ in rate of gain, discomfort was believed to be less in the males castrated by emasculation. In experiment I, one surgically castrated animal died as a result of infection. Based on observations at slaughter, castration was complete in all males castrated by emasculation. These results suggest that castration may be delayed until 13 months of age in order to take advantage of the increased rate and efficiency of gain of intact males. Differences between intact males and late castrate (13 months) males in meat palatability characteristics were of about the same magnitude as has been reported between intact males and males castrated at a young age. Thus, these results suggest that castration may be delayed until about one year of age while obtaining meat palatability characteristics similar to early castrate males provided castration is followed by a long feeding period on a diet with high energy density.

Table 12.—Least-squares means and standard errors for meat traits by treatment and breed group

Traits	Level of signif-icance[h]	Treatment			
		Castrate	Intact	Intact 36-mg implant	Intact 72-mg implant
Fat in longissimus muscle, percent	**	3.1 ± .21[i]	2.2 ± .17[j]	2.8 ± .23[jk]	2.4 ± .23[jk]
Water in longissimus muscle, percent	NS	74.1 ± .28	74.2 ± .22	74.0 ± .30	74.3 ± .30
Protein in longissimus muscle, pct	NS	22.8 ± .24	23.6 ± .19	23.2 ± .26	23.3 ± .26
Marbling score[a]	**	8.1 ± .40[i]	6.5 ± .31[j]	6.8 ± .42[j]	5.9 ± .43[j]
Warner-Bratzler shear force[b], lb	**	7.9 ± .20[i]	8.8 ± .16[ij]	9.5 ± .21[i]	10.4 ± .21[i]
Juiciness score[c]	NS	5.3 ± .18	5.6 ± .14	5.6 ± .19	5.4 ± .19
Overall tenderness score[d]	**	6.0 ± .18[i]	5.5 ± .15[j]	5.2 ± .20[j]	5.0 ± .20[j]
Flavor intensity score [e]	*	5.8 ± .11[i]	5.7 ± .10[i]	5.8 ± .12[i]	5.4 ± .12[j]
Amount of connective tissue score[f]	**	5.6 ± .18[i]	5.3 ± .14[ij]	4.9 ± .19[j]	4.7 ± .19[j]
Ease of fragmentation score[g]	**	5.9 ± .17[i]	5.5 ± .14[ij]	5.1 ± .19[j]	4.9 ± .19[j]

[a]Practically devoid- = 2, traces- = 5, slight- = 8, small- = 11.
[b]Lb/.5 in^2.
[c]8 = extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, 1 = extremely dry.
[d]8 = extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough.
[e]8 = extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, 1 = extremely bland.
[f]8 = none, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant.
[g]8 = extremely easy, 7 = very easy, 6 = moderately easy, 5 = slightly easy, 4 = slightly difficult, 3 = moderately difficult, 2 = very difficult, 1 = extremely difficult.
[h]NS = not significant.
[ijk]Values having no superscript letter in common differ at P≤.05 level.
*P<.05.
**P<.01.