EFFECTS OF AGE AT CASTRATION, IMPLANT STRATEGY AND AGING ON THE TENDERNESS OF *LONGISSIMUS* MUSCLE STEAKS DERIVED FROM STEERS, LATE CASTRATES, AND INTACT BULLS.

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Introduction

Controversies arise every day within the cattle industry regarding the effects of gender and of the use of growth promotants on tenderness of beef. Cost of production favors use of intact males over castrate males and implanted steers over non-implanted steers. Failure to castrate and use of excessively aggressive implant strategies for steers decreases percentages of Prime and Choice carcasses, increases percentages of Standard carcasses and increases percentages of dark-cutting carcasses. Numerous studies have been conducted to compare the palatability of beef produced by cattle of different genders, and have suggested that intact males generally produce carcasses of inferior eating satisfaction when compared to steers. Decisions by producers pertaining to whether castration of male cattle should occur at different ages (7 months vs 20 months)--or at all--and the ramifications of such decisions relative to consumer satisfaction of the beef produced must be made based on sound science and economic considerations. There is a controversy regarding which of the different implant strategies for growth promotion to use and, so, these strategies employed are not consistent across the industry. And, although the scientific research literature clearly shows that implant strategy can dramatically lower marbling scores and quality grades, it is not clear how implant strategies affect the palatability of the beef. This study investigated the effects of postmortem aging time and the use of different implant strategies, from among several that are commonly used in the cattle industry, in terms of their effects -- combined with aging interval (10, 20, or 30 d of aging) effects -- on the tenderness of beef produced by steers vs. late-castrates vs. intact bulls.

Objectives

1) Evaluate differences in the shear force (as a measure of tenderness), as it is affected by aging, of beef produced from steers, late-castrates and intact bulls.
2) Determine if interrelationships exist between the time of castration (steers, late-castrates) and implant strategy relative to the shear force, and aging effects on tenderness, of beef.
3) Within steer and late-castrate groups of fed cattle, compare the effect of a moderately-aggressive vs. a very-aggressive implant strategy on beef shear force values.
4) Determine if postmortem lean color differences exist between steers vs. late-castrates vs. intact bulls using CIE L*, a*, and b* values.

Materials and Methods

Three hundred ninety three (n= 393) feedlot cattle of three genders (steers = 196, late-castrates = 156 and intact bulls = 41) were fed to a point where they were estimated (phenotypically) to grade approximately 80 percent U. S Choice. Each steer and late-castrate was assigned to one of the ten implant strategy treatment groups. Implus (20 mg estradiol benzoate / 200 mg of progesterone), Ralgro (36 mg of zeranol), Revalor-S (24mg estradiol / 120 mg trenbolone acetate) and Synovex-P (28 mg estradiol benzoate / 200 mg trenbolone acetate) implants (Table 3.2) were employed. The implant treatments were as follow: (a) no implant at day 0 plus no implant at day 60, (b) no implant at day 0 plus Revalor-S at day 60, (c) Ralgro at day 0 plus Revalor-S at day 60, (d) Ralgro at day 0 plus Synovex-P at day 60, (e) Implus at day 0 plus Revalor-S at day 60, (f) Implus at day 0 plus Synovex-P at day 60, (g) no implant at day 0 plus Synovex-P at day 60, (h) Synovex-P at day 0 plus no implant at day 60, (I) Revalor-S at day 0 plus Revalor-S at day 60, and (j) Synovex-P at day 0 plus Synovex-P at day 60. Intact bulls were not given growth-promoting implants.

Upon reaching approximately .45 inches of backfat (a point at which it was presumed that 80% of the cattle were fat enough to grade U.S. Choice), cattle were transported from the feedlot in Wellington, Colorado to a commercial beef packing plant in Greeley, Colorado and slaughtered using conventional procedures. Cattle were shipped to the slaughter plant, during the first four weeks of the study, in groups of 16 animals (two per gender x implant-strategy group) twice per week (usually for harvest during the A shift of the plant schedule). After the fourth week of the study, cattle were processed only once per week (90, 90, 88 and 32 head that compensated for previous dates on which data were not collected due to misplacing of the carcasses inside of the packing plant) for each one of the four remaining weeks of slaughtering/dressing to assure proper chilling time (36 hr) and to enhance the probability of assembling a cutability fabrication crew (assembled and conducted by Monfort, Inc.).

At the Packing Plant

Carcasses were separated between the 12^{th} and 13^{th} ribs to expose the longissimus muscle for grading. USDA meat grading officials at the slaughter plant assigned yield grades and quality grades to the carcasses. After official USDA grading, all individual carcass measurements (fat thickness, *longissimus* muscle area, kidney/pelvic/heart [KPH] fat percentage, carcass maturity, lean maturity, marbling score, texture of the meat, secondary sex characteristics) were evaluated and recorded by trained Colorado State University personnel. Color measurements for the ribeye (12^{th}-13^{th} ribs) were obtained using a portable spectrophotometer (HunterLab MiniScan, Hunter Lab Associates Laboratory, Inc., Reston VA) to obtain CIE values for L* (psychometric lightness; dark = 0, white =100), a*(red = positive values, green = negative values) and b* (yellow = positive values, blue = negative values). HunterLab CIE L*, a* and b* values were determined for each carcass by making three measurements at random locations in each ribeye, and averaging the measurements.

The left side of each carcass was fabricated, by an experienced crew of meat cutters from Monfort, Inc., to obtain cutability yields. Each of the beef sides was fabricated into primal cuts that were then fabricated into subprimals; weights of the trimmed cuts were obtained to generate corresponding cutability values for the carcass of each animal (an analysis that was conducted by Monfort in conjunction with the portion of the project relating to beef palatability that was conducted by personnel of CSU). A cutting crew was assigned on a daily basis, by the packing plant, to collect the cutability data. When carcass sides were fabricated, the strip loin (*longissimus* muscle) was removed as soon as was possible after the side exited the sales/storage cooler. These samples were weighed, packaged and transported to the Colorado State University Meat Laboratory.

At the Colorado State University Meat Laboratory

At CSU, each strip loin (*longissimus* muscle) was divided into four (4) steaks approximately 1.0 inch in thickness. Steaks were individually identified, vacuum packaged and aged for predetermined lengths of time such that, starting at the posterior end of the strip loin and moving anteriorly, the first steak (day 0) was not aged, the second steak (day 10) was aged for ten days, the third steak (day 20) was aged for twenty days and the fourth steak (day 30) was aged for thirty days. Each steak was vacuum packaged; those steaks identified as day 0 were immediately frozen after processing, the remaining steaks (identified as day 10, day 20 and day 30) were stored at approximately 35° F to allow the aging process to occur. When each steak reached the pre-designated aging time period, it was frozen at approximately -16° F.

When all steak samples were collected (all 393 carcasses were sampled), each steak to be used for shear force analysis was thawed at 35° F for 24 hr and subsequently broiled on a Hobart Char Broiler (model CB 51, Hobart Corp., Troy, OH). Each steak was turned at 4, 8, 12 and, if necessary, at 16 minutes until an internal temperature of 160° F was reached. Cooked steaks were allowed to cool to room temperature (≈ 68° F) and then six to ten .5 inch diameter cores were removed (by the use of a mechanical coring device) from each steak, parallel to the muscle fiber orientation. A single shear force measurement was obtained from each core using a Warner-Bratzler shear force machine, and the shear force for each steak was determined by computing the mean of the force required to shear the six to ten cores removed from each steak.

Statistical Analysis

Data were analyzed using the General Linear and Mixed Model analysis of variance procedures of SAS (1996). For carcass data, a simple AOV model was used that incorporated fixed effects of gender and implant-strategy group within gender. Shear force data were evaluated in a repeated measures design that included fixed effects for "treatment levels" comprised of the gender by implant-strategy group subclasses, as well as the repeated measures effect of aging time. Data are presented as least-squares means that were separated -- when AOV indicated a significant effect ($P <. 05$) -- using the multiple comparisons t-test of SAS (1996).

Results and Discussion

Mean carcass quality grades differed ($P < .05$) among the three gender subclasses while mean carcasses yield grades were lowest for intact bulls but did not differ between steers and late-castrates. Bulls had carcasses with the lowest mean yield grade and differed from steers and late-castrates ($P < .05$; Table 3.1). Among the gender subclasses, steers produced carcasses with the highest mean quality grades (Table 3.1). Of the six implants strategies tested on both steers and late-castrates, four treatments, when applied to steers, allowed one or more animals to produce U. S. Choice carcasses while none of the late-castrates carcasses graded U.S. Choice. Mean USDA quality grades for late-castrates and bull carcasses were U.S Select; the mean USDA quality grade for steer carcasses was U.S Choice (Table 3.1). These results agree with studies conducted by Nichols et al. (1964), Bailey et al. (1966), Jacobs et al. (1977) and Landon et el. (1978) in which steer carcasses had more marbling, less *longissimus* muscle area and higher USDA quality grades.

Application of six common implant strategies (denoted by implant given at the initiation of the feeding period / implant given 60 d later such as None/Revalor-S; Ralgro/Revalor-S; Ralgro/Synovex-P; Implus/Revalor-S; Implus/ Synovex-P; Synovex-P/None in Table 3.2) had similar impact on USDA quality grades for carcasses from late-castrates (Table 3.3), but use of None/Revalor-S and Ralgro/Revalor-S resulted in carcasses with higher mean quality grades than the use of Ralgro/Synovex-P. Mean carcass quality grades for steers treated with as None/Revalor-S; Ralgro/Revalor-S; Implus/Revalor-S and Synovex-P/None were U.S Choice (Table 3.3). Implant strategies involving use of Ralgro/Synovex-P; Implus/Synovex-P, Revalor-S/Revalor-S and Synovex-P/Synovex-P resulted in carcasses with mean quality grades of U.S. Select (Table 3.3). Carcasses from intact bulls produced carcasses with a mean quality grades of U.S. Select (Table 3.3).

Table 3.1 Mean Yield Grades and Quality Grades by Gender Subclass.

Gende Subclass	**n**	**Yield Grade Mean**	**Yield Grade SD**	**Quality Grade [1] Mean**	**Quality Grade [1] SD**
Intact Bull	41	2.4^c	± 0.58	233^c	± 58
Late-Castrate	156	3.0^b	± 0.61	276^b	± 48
Steer	196	3.3^b	± 0.59	301^a	± 49

[1]Where USDA Low Select = 200 to 249; High Select = 250 to 299; Low Choice = 300 to 333.
[a,b,c] Means within a column bearing a different superscript letter differ (P < .05).

Table 3.2 Chemical Composition and Dosage of the Implants used in this Study [1].

Implant	**Chemical Composition**	**Dosage**
Implus	Estradiol Benzoate/Progesterone	20 mg / 200 mg
Ralgro	Zeranol	36 mg
Revalor-S	Estradiol/Trenbolone Acetate	24 mg / 120 mg
Synovex-P	Estradiol Benzoate/trenbolone Acetate	28 mg / 200 mg

[1] Implants strategies were administered during the finishing period to steers and late-castrates but not to intact bulls.

Table 3.3 – Means Values for Quality Grade[a.] by Gender Subclass and Implant-Strategy Group.

Implant-Strategy Group	Bull Mean	Bull SD	Bull n	Late-Castrate Mean	Late-Castrate SD	Late-Castrate n	Steer Mean	Steer SD	Steer n
None / None	233	± 58	41						
None / Revalor-S				286[b]	± 41	21	310[bc]	± 30	25
Ralgro / Revalor-S				297[b]	± 33	22	317[b]	± 57	24
Ralgro / Synovex-P				255[c]	± 48	24	293[bc]	± 40	23
Implus / Revalor- S				272[bc]	± 42	21	309[bc]	± 59	24
Implus / Synovex-P				271[bc]	± 57	25	283[c]	± 42	25
None / Synovex-P				271[bc]	± 53	20			
Synovex-P / None				286[b]	± 51	23	304[bc]	± 51	27
Revalor-S / Revalor-S							293[bc]	± 54	22
Synovex-P / Synovex-P							296[bc]	± 50	26

[a] USDA quality grades (determined by USDA personnel) were coded (by CSU personnel) as follow: 100 to 199= Standard; 200 to 249 = Low Select; 250 to 299 = High Select; 300 to 322 = Low Choice; 333 to 366 = Average Choice; 367 to 399 = High Choice.

[b,c] Mean within a columns bearing a different superscript letter differ ($P < .05$).

Distribution of quality grades for carcasses are presented in Tables 3.4 and 3.4a. Data in Table 3.4b characterize the incidence of carcasses with dark-cutting beef by treatment group. Intact bulls produced carcasses that were USDA Choice only 24.4 % of the time, while 29.3 % of the intact bull carcasses graded USDA Standard and 43.9 % of the intact bull carcasses were reduced in quality grade because they were dark-cutters (the latter a percentage well above that for either steers or late-castrates). These results agreed with studies by Field (1971) and Seideman et al. (1982) which demonstrated that bull carcasses had less marbling, lower USDA quality grades, darker lean color and produced less tender beef than carcasses/beef from steers. Crouse et al. (1983) reported that bull carcasses have higher frequency of dark-cutters than steers. Arthaud et al. (1977) and Crouse et al. (1983) found that carcasses of steers have a more desirable lean color rating than do carcasses of bulls.

Table 3.4 Distribution of Quality Grades and Percentages by Implant-Strategy Group for Steers Carcasses.[a]

	Implant Strategy Group			Quality Grade Consist			
Gender Subclass	**Day 0**	**Day 60**	**n**	**Prime, No. (%)**	**Choice, No. (%)**	**Select, No. (%)**	**Standard, No. (%)**
Steer	None	Rev-S	25	0 (0.0)	23 (92.0)	2 (0.0)	0 (0.0)
Steer	Ralgro	Rev-S	25	0 (0.0)	20 (80.0)	4 (16.0)	1 (4.0)
Steer	Ralgro	Syn-P	22	1 (4.5)	17 (77.3)	4 (18.2)	0 (0.0)
Steer	Implus	Rev-S	23	2 (8.7)	17 (74.0)	3 (13.0)	1 (4.3)
Steer	Implus	Syn-P	25	0 (0.0)	16 (64.0)	8 (32.0)	1 (4.0)
Steer	Rev-S	Rev-S	22	1 (4.5)	11 (50.0)	10 (45.5)	0 (0.0)
Steer	Syn-P	Syn-P	26	0 (0.0)	19 (73.1)	5 (19.2)	2 (7.7)
Steer	Syn-P	None	27	1 (3.7)	22 (81.5)	4 (14.8)	0 (0.0)

[a] Six of these eight Implant Strategies were also applied to Late-Castrates.

Table 3.4a. Distribution of Quality Grades and Percentages By Implant-Strategy Group Intact Bull and Late-Castrate.[a]

	Implant-Strategy Group			**Quality Grade Consist**			
Gender Subclass	**Day 0**	**Day 60**	**n**	**Prime, No. (%)**	**Choice, No. (%)**	**Select, No. (%)**	**Standard, No. (%)**
Bull	None	None	41	0 (0.0)	10 (24.4)	19 (46.3)	12 (29.3)
Late-Castrate	Ralgro	Rev-S	23	0 (0.0)	17 (74.0)	6 (26.0)	0 (0.0)
Late-Castrate	Ralgro	Syn-P	23	0 (0.0)	9 (39.1)	13 (56.5)	1 (4.4)
Late-Castrate	Implus	Rev-S	23	0 (0.0)	9 (39.1)	13 (56.5)	1 (4.4)
Late-Castrate	Implus	Syn-P	24	0 (0.0)	14 (58.3)	10 (41.7)	0 (0.0)
Late-Castrate	None	Rev-S	22	0 (0.0)	13 (59.1)	9 (40.9)	0 (0.0)
Late-Castrate	None	Syn-P	20	0 (0.0)	10 (50.0)	7 (35.0)	3 (15.0)
Late-Castrate	Syn-P	None	22	0 (0.0)	16 (72.7)	5 (22.8)	1 (4.5)

[a] Six of these seven Implant Strategies were also applied to Steers. Bull were not implanted.

Table 3.4 b. Incidence Of Dark-Cutting Carcasses Within Gender By Implant-Strategy Group.[a]

	Implant Strategy Group			Dark Cutting Carcasses				
Gender	**Day 0**	**Day 60**	**n**	**none**	**1/3**	**2/3**	**Full**	**Total %**
Steer	None	Rev-S	25	24	0	0	1	4.0
Steer	Ralgro	Rev-S	25	24	0	0	1	4.0
Steer	Ralgro	Syn-P	22	20	0	2	0	9.1
Steer	Implus	Rev-S	23	20	1	2	0	13.0
Steer	Implus	Syn-P	25	22	2	0	1	12.0
Steer	Rev-S	Rev-S	22	18	2	2	0	18.2
Steer	Syn-P	Syn-P	26	22	1	0	3	15.4
Steer	Syn-P	None	27	26	1	0	0	3.7
Bull	None	None	41	23	6	7	5	43.9
Late-Castrate	Ralgro	Rev-S	23	22	0	0	1	4.3
Late-Castrate	Ralgro	Syn-P	23	21	0	1	1	8.7
Late-Castrate	Implus	Rev-S	23	20	0	3	0	13.0
Late-Castrate	Implus	Syn-P	24	22	1	0	1	8.3
Late-Castrate	None	Rev-S	22	21	1	0	0	4.5
Late-Castrate	None	Syn-P	20	17	1	1	1	15.0
Late-Castrate	Syn-P	Syn-P	22	22	0	0	0	0.0

[a] Distribution of the incidence of dark-cutting carcasses produced by the same implant strategies applied to steers and late-castrates fed under similar conditions.

The most desirable consist of carcasses (92.0 % USDA Choice and Prime, 0.0 % USDA Standard and 4.0 % dark- cutters) was produced by steers treated with no implant on day 0 of feeding and Revalor-S (24 mg estradiol [E2] + 120 mg trenbolone acetate) on day 60 of feeding (Table 3.4) while the second most desirable consist of carcasses (85.7 percent USDA Choice and Prime, 14.8 percent USDA Select, 0.0 percent USDA Standard and 3.7 percent dark cutters; Table 3.4) was produced by steers treated with Synovex-P (28mg estradiol benzoate + 200 mg of trenbolone acetate) (Table 3.4) on day 0 and no implant on day 60. These results were in disagreement with results presented by Duckett et al. (1997), who reported that a combination implant consisting of a strong estrogen plus an androgen, when given as a first implant, and no second implant resulted in a lower percentage of USDA Choice carcasses (n= 3006, Choice percent = 59.7) which was considerably lower than the percentage obtained in our study using the same implant strategy. That study also reported larger *longissimus* muscle areas when a strong estrogen plus an androgen were used as a first implant and without reimplanting.

In the present study, carcasses from bulls which were not implanted, had the largest *longissimus* muscle area across all three gender subclasses (13.7 in^2; Table 3.11). The administration, to both steers and late-castrates, of Ralgro (36 mg of Zeranol; mild estrogen) at day 0 and the application of Synovex-P at day 60 of feeding (28 mg estradiol benzoate + 200 mg trenbolone acetate; strong estrogen plus androgen) resulted in the second largest *longissimus* muscle area (12.4 in^2; Table 3.11). Inasmuch as profitability of cattle feeding is determined, in part, by grading percentages and the incidences of "out cattle" (USDA Standard grade and dark-cutters), if cattle are sold on the rail, grade and yield or on-the-formula, results shown in Tables 3.4, 3.4a and 3.4b must be considered as decisions are made regarding gender and implant strategies.

As was described previously (Table 3.1), intact bulls had carcasses with the most desirable mean yield grade, while carcasses from steers and late-castrates had similar and less desirable, higher numbered (less desirable) mean yield grades (P < .05); steer carcasses had the best mean quality grade while bull carcasses had the worst mean quality grade. Late-castrate carcasses were intermediate in quality grade (Table 3.3). Wierbicki et al. (1955) reported that bulls produced carcasses with lower quality grades and slightly lower dressing percentages (less fat), but that the superiority in consumer quality and tenderness of beef from steers was perhaps not worth the increased cost of production. Results of this study and those of Wierbicki et al. (1955) disagree with Bocsor et al. (1958) as cited by Turton et al. (1962) who reported no appreciable difference in quality between carcasses of bulls and steers slaughtered at around 21 months of age. Klastrup et al. (1984) reported that steer carcasses had significantly lower ribeye areas and poorer yield grades than intact bull carcasses, but that differences between bull and steer carcasses in quality grades were not statistically significant, which did not agree with the results observed in this study.

Yield grades for carcasses from cattle of each gender and from cattle treated with each implant strategy are presented in Tables 3.5 and 3.6. Steers produced carcasses of the most consistent yield grade. Although, yield grades were more consistent for steers, there were no statistical differences between implant strategies within gender. These results were in agreement with those of Dolezal et al. (1997) who reported that implants may slightly lower the percentage of kidney, pelvic and heart fat but they have minimal effect on external fat thickness and mean USDA yield grade.

Table 3.5 Mean and Standard Deviations for Yield Grades by Gender and Implant Strategy.

Implant-Strategy Group	Mean	SD	n
Bulls None/None	2.4	± .58	41
Late-Castrates			
Synovex-P/None	3.3[a]	± .57	23
Ralgro/Revalor-S	3.2[ab]	± .55	22
None/Revalor-S	3.1[abc]	± .58	21
Implus/Revalor-S	3.0[abc]	± .44	25
Implus/Synovex-P	2.9[bc]	± .51	22
Ralgro/Synovex-P	2.8[c]	± .58	24
None/Synovex-P	2.8[c]	± .53	20

[a,b,c] Means within column bearing a different superscript differ (P < .05).

Table 3.6 Means and Standard Deviations for Yield Grades of Steer Carcasses.

Implant-Strategy Group	Mean	SD	n
Synovex-P/None	3.5	± .71	27
Ralgro/Revalor-S	3.4	± .48	24
Implus/Synovex-P	3.4	± .43	25
Synovex-P/Synovex-P	3.4	± .65	26
Implus/Revalor-S	3.3	± .60	23
Revalor-S/Revalor-S	3.3	± .42	22
Ralgro/Synovex-P	3.3	± .54	23
None/Revalor-S	3.3	± .56	25

Means within column did not differ (P > .05)

Results presented in Table 3.7 show that steers treated with no implant on day 0 and with Revalor-S on day 60, produced steaks with the lowest mean shear force values. These results did not agree with those of Samber et al. (1996) who evaluated different treatments involving the use of the Revalor-S implant and reported higher shear force values for steers implanted with Revalor-S than for steers that were not implanted with Revalor-S. Other studies have shown that implanting steers with Revalor-S or with Finaplix-S, late in the finishing period (Foutz et al., 1990), adversely affects shear force values. However, Belk and Savell (1992) found no detrimental effect of implants on beef tenderness in steers implanted one time.

The administration of no implant at day 0 plus the implantation with Revalor-S on day 60 did not (P < .05) generate differences in tenderness of steaks in comparison to treatment of steaks from steers implanted with Implus on day 0 plus Revalor-S on day 60, or of steaks from steer carcasses with Synovex-P on day 0 plus no implant on day 60, of late-castrates with Ralgro on day 0 plus Revalor-S on day 60 with late-castrates with no implant on day 0 plus Revalor-S on day 60. Steaks from steers treated with no implant on day 0 plus Revalor-S on day 60- or with Implus on day 0 plus Revalor-S on day 60 did not differ (P < .05) in shear force values from each other, but both treatments produced steaks that differed significantly (lower shear force values) in shear force values from steaks produced by steers treated with Implus on day 0 plus Synovex-P day 60 or with Revalor-S on day 0 plus Revalor-S on day 60 or produced by late castrates treated with Implus on day 0 plus Synovex-P at day 60.

Steaks from late-castrates treated with Implus (estrogen) on day 0 plus Synovex-P (androgen/estrogen combination) on day 60, from steers treated with Implus (estrogen) on day 0 plus Synovex-P (androgen/estrogen combination) on day 60 or steers treated with Revalor-S (androgen/estrogen combination) on day 0 plus Revalor-S (androgen/ estrogen combination) on day 60 had the highest mean Warner-Bratzler shear force values among the gender x treatment groups compared in this study. Steaks from steers treated with Revalor-S on day 0 plus Revalor-S on day 60 had one of the highest mean shear force values among the gender x implant-strategy groups studied. These results agreed with those of Samber et al. (1996) who reported that the application of Revalor-S, two or three times, caused higher shear force values in steaks from those cattle and were detrimental to meat tenderness. However, the administration of estrogen

(Implus) plus a combination of androgen/estrogen (Synovex-P) to steers or late-castrates, or the use of a combination of androgen/estrogen (Revalor-S) plus a combination of androgen/estrogen for steers, resulted in steaks that had the highest mean values for shear force in this study, and they were considered to have a decidedly detrimental effect on the tenderness of products generated by the use of these implant strategies. Warner-Bratzler shear force values for steaks from all three groups are presented in Table 3.9. Contrary to previous research results, steaks from bulls were not significantly different ($P < .05$) in shear force from steaks of late-castrates or steers probably due to the fact that all of the cattle sampled in this study were treated with moderately-aggressive to aggressive implant and because no negative controls was included in the experimental design. The stressor effect of late-castration (overall WBS = 4.0 kg) and application of an aggressive implant strategy can be expected to have a negative impact on the tenderness of steaks from cattle managed by employing such practices. Marbling scores in carcass from, bulls and late castrates were consistent and low (carcasses of both gender classes graded USDA Select), while steers had higher marbling scores and a higher percentage of USDA Choice grade carcasses (Table 3.1).

Table 3.7. Least Square Means for Warner-Bratzler Shear Force Values Across Gender and Implant Treatments for the Combined Three aging Periods.

Gender Subclass	**Day 0 Implant**	**Day 60 Implant**	**WBS Force Mean (lbs)**	**Standard Error**
Steer	Implus	Synovex-P	9.0[a]	. 18
Steer	Revalor-S	Revalor-S	9.0[a]	. 20
Late-Castrate	Implus	Synovex-P	9.0[a]	. 18
Steer	Ralgro	Revalor-S	8.4[ab]	. 17
Steer	Ralgro	Synovex-P	8.4[ab]	. 19
Steer	Synovex-P	Synovex-P	8.1[ab]	. 18
Bull	No Implant	No Implant	8.6[ab]	. 14
Late-Castrate	Ralgro	Synovex-P	8.1[ab]	. 19
Late-Castrate	Implus	Revalor-S	8.6[ab]	. 20
Late-Castrate	No Implant	Synovex-P	8.4[ab]	. 20
Late-Castrate	Synovex-P	No Implant	8.1[ab]	. 19
Steer	Synovex-P	No implant	7.9[abc]	. 17
Late-Castrate	Ralgro	Revalor-S	7.9[abc]	. 19
Late-Castrate	No Implant	Revalor-S	7.9[abc]	. 20
Steer	Implus	Revalor-S	7.5[bc]	. 19
Steer	No Implant	Revalor-S	6.8[c]	. 18

[a,b,c] Means in the same column bearing a common superscript letter did not differ ($P > .05$).

Mean Warner-Bratzler shear force values for different postmortem aging periods and across all treatment subclasses are presented in Table 3.8. As expected, tenderness increased as aging time increased. Regardless of the implant strategy used for (steers or late-castrates) and the fact that the intact bulls were not implanted, beef from cattle in all three gender subclasses increased in tenderness as aging time increased. Tenderness has been identified as the most important attribute to consumers when assessing quality (Dikeman, 1987; Miller et al., 1997). Smith et al. (1978) stated that aging of U.S. Choice beef carcasses for 11 days will optimize tenderness, flavor and overall palatability of the majority of the muscles in steaks and/or roasts from the chuck, rib, loin and round when such cuts are ultimately broiled or roasted. In the present study, WBS force values decreased between 10 and 30 d of aging.

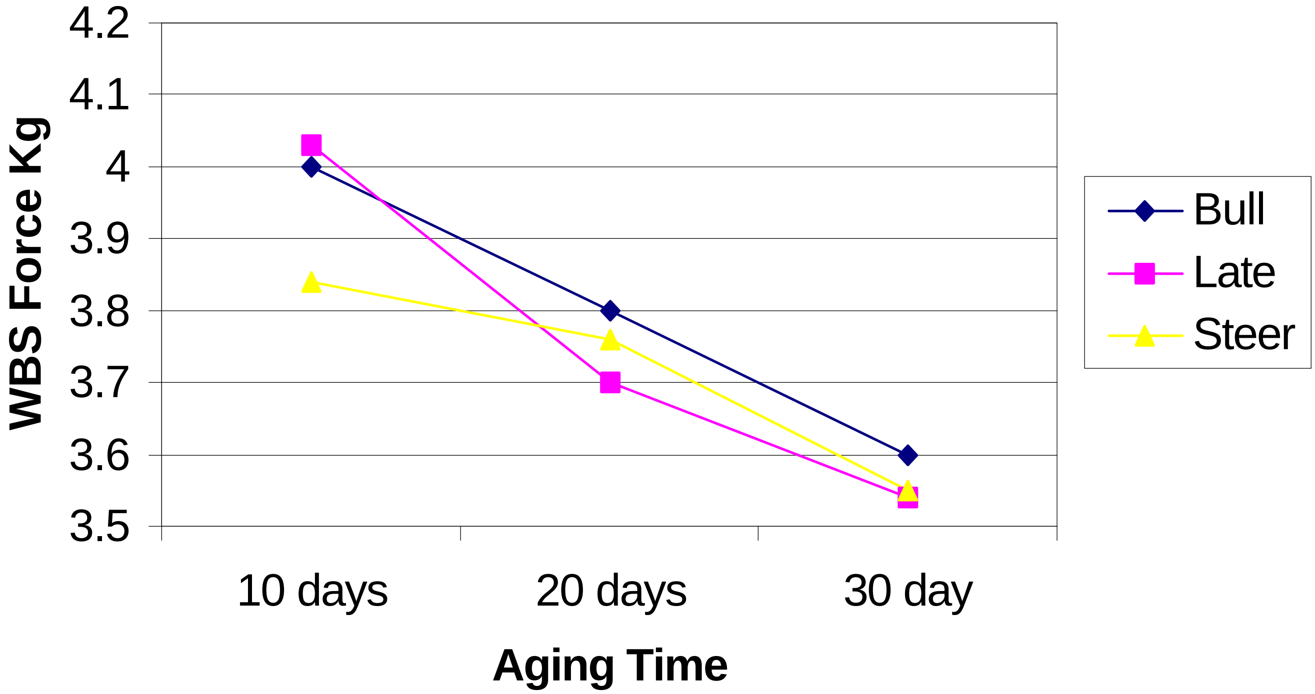
There were no differences in shear force values by gender (steers, late-castrates and intact bulls) within aging period (Figure 3.1). However, the latter conclusion must be viewed with great caution because steaks of both normal color (bright red) and undesirable color (dark-cutters) were combined in the analysis. Dark cutting beef is acceptably tender, but it is not acceptable to retail customers (because of its dark color) and it has a flat, metallic flavor that is not acceptable to some supermarket or food service consumers. Steaks from the carcasses of late-castrates had higher mean shear force values (Figure 3.1) at 10 days of aging but were not statistically different in tenderness from steaks from bulls or steers at that same aging time. By 20 days of aging, average shear force values were not significantly different among steaks from the three gender subclasses; and that pattern continued through 30 days of aging. Aging did have an effect on tenderness of the steaks, but the rate of decrease in shear force values with increased aging time was comparable for steaks from carcasses in all three gender subclasses.

Table 3.8. Least Square Means of Warner-Bratzler Shear (WBS) Force at Different Aging Periods.

Aging (Days)	**WBS Force Mean (lbs)**	**Standard Error**
10	8.6^{a}	0.11
20	8.4^{b}	0.11
30	7.9^{c}	0.11

^{a,b,c} Means within a same column bearing a different superscript letter differ ($P < .05$)

Figure 3



Warner Bratzler Shear Force Values By Gender Subclasses and Aging Period

Boleman et al. (1995) demonstrated that consumers are willing to pay for beef tenderness. There seems to be a relationship between ultimate muscle pH and/or muscle color and meat tenderness (Purchas, 1990; Jeremiah et al., 1991; Watanabe et al., 1995). Presented in Table 3.9 are results of color evaluation of steaks derived from the steer, late-castrate and bull carcasses evaluated in the present study. The present study included steaks from all three gender subclasses, and steaks from carcasses with dark-cutting beef also were evaluated without segregation within gender subclass. Our results indicated that intact bulls produced the highest percentage of carcasses with dark-cutting beef (43.9 percent) but steaks from intact bulls were not different ($P < .05$) in WBS values from steaks derived from late-castrates or steer carcasses (Table 3.7). These results did not agree with those of Wulf et al. (1996) who reported that dark-colored lean had higher shear force values than normally colored lean, which also had higher shear force values than pale-colored lean. Jeremiah et al. (1991) reported that carcasses with very dark lean were tender, but when those carcasses were excluded, a negative relationship existed between lean darkness and tenderness among steer and heifer carcasses. Lately, meat color has been used as a method to predict beef tenderness. In the present study, meat color did not have an influence on the overall tenderness (using Warner-Bratzler shear force as a measure of tenderness) of the meat. Accordingly, lean color was not an objective means to assess differences in lean color between steers vs. late-castrates vs. intact bulls (Table 3.10). Lean color L*, a*, and b* measurements were taken shortly after cattle were graded, perhaps allowing the exposed muscle in those carcass too short of a period of time to fully "bloom". Boakye and Mittal (1995) repeated similar results when they found that the replication effect for color parameters (L*, a*, b*) was not significantly different ($P < .05$).

Table 3.9. Means and Standard Deviations for Lean Color Differences of Steaks derived from Steer, Late-Castrate and Intact Bull Carcasses described by the use of CIE L*, a* and b* values.

Gender Subclass	n	Value	Mean[a]	SD
Steer	195	L*	34.51	± 9.60
		a*	9.73	± 2.33
		b*	11.47	± 2.48
Late-Castrate	157	L*	33.05	± 9.51
		a*	9.60	± 2.40
		b*	11.24	± 2.48
Bull	41	L*	31.87	± 11.26
		a*	9.00	± 2.45
		b*	10.77	± 2.32

[a] Mean values did not differ ($P < .05$) across genders subclasses.

Table 3.10. Means and Standard Deviations for Warner Bratzler Shear Force Values for Steaks From Bulls, Late-Castrates and Steers under the Combined three Aging Periods.

Gender Subclass	n	Mean (lbs)	SD	Minimum	Maximum
Bull	41	8.6[ab]	3.3	2.86	17.16
Late-Castrate	157	8.8[a]	2.6	3.96	18.70
Steer	195	8.1[b]	2.4	3.30	16.28

[a,b] Means within a column bearing a different superscript letter differ ($P < .05$).

Table 3.11. Means and Standard Deviations for Certain Carcass Traits of Bulls, Late-Castrates and Steers as Affected by Implant Strategies [d].

Trait	Bull		Late-Castrates		Steers	
	Mean	Std	Mean	Std	Mean	Std
Ribeye Area[e]	13.7[a]	± 1.2	12.4[b]	± 1.1	12.3[b]	± 1.0
Hot Carcass Weight[f]	739.6[ab]	± 45.5	734.1[b]	± 56.1	754.4[a]	± 47.3
Marbling Score[g]	270.5[b]	± 63.0	299.0[b]	± 67.0	351.5[a]	± 96.1
KPH %	2.1[ab]	± .44	2.1[b]	± .41	2.2[a]	± .40
Yield Grade[h]	2.4[c]	± .58	3.0[b]	± .61	3.3[a]	± .59

[d] Implant Strategies: A = None/None; B = None/Revalor-S; C = Ralgro/Revalor-S; D = Ralgro/Synovex-P; E = Implus-Revalor-S; F = Implus-Synovex-P; G = None/Synovex-P; H =Synovex-P/None; I = Revalor-S/Revalor-S; J = Synovex-P/Synovex-P, given on day 0 and on day 60 of the finishing period.

[e] Ribeye area, in square inches

[f] Carcass weight in pounds

[g] Marbling Scores: 250 to 299 = High Select; 300 to 332 = Low Choice; 333 to 366 = Average Choice.

[h] USDA Yield Grades: 1 through 5.

[a,b,c] Means in the same row bearing a different superscript letter differ ($P < .05$).

Implications

Decisions regarding use of managerial practices such as late-castration (immediately before the start of the finishing period, or even during finishing), or leaving males intact throughout feeding, should be made based on productivity and profitability; but ramifications of such practices on quality of carcasses and tenderness of beef should also be considered. Although no negative controls were available for comparison in this study, implant strategies did generate differences in beef tenderness. The use of specific implant strategies is undoubtedly beneficial to profitability in the cattle feeding industry given today's marketing and price discovery systems but were detrimental to beef tenderness in certain gender x treatment comparisons in this study. In addition, gender and gender x implant treatment differences were large and important if quality grade percentages and dark-cutter incidence were considered. Therefore, those relationships would need to be considered by producers when deciding to use a specific implanting and gender management practice.

Based on the results of this study, late-castrates and steers—when fed under the same conditions—can be expected to yield beef that differs in tenderness; and the extent of the differences between genders in beef tenderness will differ, depending on the implant strategy employed. Application of implant strategies can benefit aspects of productivity in the cattle industry such as weight gain, feed efficiency and cost of gain, but management practices -- including both implanting and castration practices -- must be evaluated in terms of the end-product that is generated if the beef industry is really intent on changing from being “production-driven” (as it is at present) to becoming truly “consumer-driven".

In order to generate beef carcasses that can satisfactorily grade a high percentage of USDA Choice, the use of low to moderately aggressive implant-strategies should be implemented. Feeding finishing rations to intact males (bulls) would not be recommended if quality of the beef produced does not meet the beef industry quality requirements. Castration of intact males is recommended by the beef industry at an early age (7 months approximately) to avoid stressor factors caused if cattle are castrated in later stages of life (around 17 to 18 months). If castration of the intact males occurs during the finishing period, a reduction in USDA Choice grade and an increment of USDA Select and Standard grades is produced.

Study Limitations

We must justify that this research project was limited in experimental design. Specifically, no negative control group was included to test against it for any of the gender x implant strategy subclasses. Additionally, there were no mild implant strategies included for comparisons with moderately and/or very aggressive implant strategies. Investigators had no control over cattle feeding, or any other managerial practice applied.

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