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Rate and Efficiency of Gains in Beef Cattle

I. The Response to Injected Testosterone

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Introduction

Beef is one of the better-liked meats but increasing our beef production in proportion to our population increase may be difficult. One possibility for an increased production of beef may be through increasing beef cattle numbers. However, greater numbers would require more acreage of forage or greater forage productivity. Methods should be developed for increasing rate and efficiency of production as well as increasing production by increasing numbers of beef cattle.

Many studies have shown that bulls gain at a more rapid rate and require less feed per unit of gain than heifers of a corresponding age and of a similar line of breeding. The male hormone is likely to be the most important factor in bringing about this difference in rate and economy of gains. It is important also to know whether male hormones administered to steers and heifers at physiological levels will stimulate rate and economy of gains. If hormone administrations are to be commercially feasible, tenderness, palatability, and other meat qualities should not be reduced; the hormone should not leave harmful residues in the meat tissues.

This bulletin reports a study of the effects of testosterone on rate and efficiency of gain, influence on carcass and meat quality, and the endocrine interrelationships when the hormone is injected.

Review of Literature

Administration of male hormones to farm animals has been attempted occasionally for the purpose of increasing gains in body weight and efficiency of feed utilization. According to work by Sleeth and associates (1952), testosterone propionate when injected intramuscularly into weanling pigs at the rate of 1 mg/kg. of body weight for 6 weeks and then at bi-weekly intervals during a 150-day feeding period, resulted in a rate of gain greater than the control of 0.15 pound per day. The hormone treatment had no significant effect on thickness of backfat, tenderness, carcass scores, or palatability. In a second trial by Sleeth and associates (1952) weanling pigs receiving 0.5 mg. of testosterone propionate bi-weekly were no different from control pigs in average daily gain. Woehling and associates (1951) demonstrated that the rate of gain, feed efficiency, and carcass characteristics of pigs were not affected by the implantation of two 15 mg. pellets of testosterone at 12-week intervals.

Subcutaneous implantation of a 10 mg. pellet of testosterone in wether lambs was found by Andrews and associates (1949) to

increase the average daily gain and efficiency of feed utilization during the 68-day feeding period. Implantation of an additional 10 mg. pellet of testosterone 43 days after the first implantation did not cause significant differences from the control lambs, in average daily gain, or feed consumption, although carcass quality of the testosterone-treated lambs appeared to be higher than that of control lambs. Implantation of a 12 mg. pellet of testosterone in ewe and wether lambs did not improve rate of gain or feed efficiency when compared with control lambs under similar feeding conditions according to O'Mary and associates (1952). On the other hand, weekly injections of 20 mg. of testosterone were found to increase the average daily feed consumption and average daily gain of ewe and wether lambs (Means and associates, 1953). Treated wethers had slightly more external fat while treated ewes had considerably less external fat than control animals. Subcutaneous implantation of pellets containing a total of 30 mg. of testosterone resulted in increased rate of gain and feed efficiency during 10- and 12-week feeding periods according to work reported by Means and associates (1953).

Temporary growth stimulus together with increased daily feed consumption were reported by Dinusson, Andrews, and Beeson (1950) in beef heifers receiving an intramuscular injection of 50 mg. of testosterone propionate in oil, followed by a second injection of 32.5 mg. of testosterone propionate 56 days later. Average daily gain and efficiency of feed utilization were not significantly different from those of control calves. In contrast to the above mentioned study in which injections were used, the subcutaneous implantation of a 50 mg. pellet of testosterone in beef heifers had no significant effect on rate of gain, efficiency of feed utilization, or average daily feed intake. Carcass quality and dressing percentage were not affected by this treatment. The subcutaneous implantation of a 180 mg. pellet of testosterone in yearling steers did not significantly affect growth rate, efficiency of feed utilization, or carcass grade.

Materials and Methods

A group of 24 grade Hereford calves made up of 3 sire progeny groups of 4 heifers and 4 steers each was divided into 2 experimental lots as follows: 2 heifers and 2 steers from each sire group, a total of 12 calves, were randomly selected for testosterone treatment. These calves received weekly intramuscular injections of 1 mg. of testosterone per kg. of body weight beginning when the calf reached a weight of 500 pounds. The remaining 2 heifers and 2 steers

in each sire progeny group, a total of 12 calves, served as controls and received no injections.

At the beginning of the test period each calf was placed on individual feed test and records were kept of feed consumption. The calves, in groups of 6, were restricted to pens during the entire feeding period, steers and heifers being fed in separate pens. Before feeding, each calf was tied to an individual compartment from which only the feed allotted to the calf was available. When the majority of the calves had finished eating, the unconsumed feed was removed and weighed. Calves were allowed water at all times and given freedom of their pens between feedings.

The roughage fed was good quality chopped alfafa hay. The concentrate mixture was: rolled barley 60%, ground oats 20%, dried beet pulp 10%, wheat bran 5%, soybean meal 2.5%, linseed meal 1%, dried skim milk .5%, bone meal .5%, salt .45%, and irradiated yeast .05%. A ratio of 1 pound of concentrate to 3 pounds of hay was fed until the calves reached a weight of 600 pounds. From 600 to 700 pounds the ratio was 1 pound of concentrate to 2 pounds of hay, and from 700 to 800 pounds the ratio was 1 pound of concentrate to 1 pound of hay.

Most of the refused feed was hay, hence the ratio of concentrate to hay for the overall feeding period was less than 1 part of concentrate by weight to 2 parts hay. The animals were allowed all the feed they would consume within the restrictions of hay (concentrate ratio). When each calf reached 800 pounds of weight, its feeding trial was terminated. The individual feed consumption during the feeding trial was determined by subtracting the weight of unconsumed feed from the total feed offered. The number of days on test were calculated. From these data the feed requirements per unit gain in weight were determined. Feed consumption was expressed in terms of total digestible nutrients using the values given in Morrison's tables for feed composition (1948).

Disposition of carcass

Within a few days after reaching 800 pounds, each calf was slaughtered, following a 24-hour shrinking period. At the time of slaughter the following glands and organs were taken out, trimmed, weighed and certain organs prepared for histological study or assay of hormone content: pituitary, thyroid, adrenals, liver, and heart. Ovaries were dissected from female calves, seminal vesicles from steer calves, and weights were taken.

After carcasses were chilled, and graded by a federal meat inspector, they were weighed, the dressing per cent being determined

from the shrunken live weight and the chilled carcass weight. The left side was divided into wholesale cuts, each of which was weighed. The standard method of cutting the wholesale or primal cuts was followed with the exception that all of the knuckle piece was left in the loin. A five-rib chuck, seven-rib section was cut.

The prime rib was set aside to be used for chemical analysis and for evaluation of cooking and eating quality. A slice $\frac{1}{2}$-inch in thickness was taken from between the 12th and 13th rib for determination of protein, water, fat, and ash. The 6th- to 9th-rib roast cut was boned out and the relative weights of bone and flesh determined. The 10th- and 12th-rib roast was used for evaluation of cooking qualities and palatability.

Chemical analysis

Water, ether extract, nitrogen, and ash were determined by conventional methods. From these determinations figures were available for calculation of the percentages of water, protein, fat, and ash in the prime rib.

Histological studies

Sections of the thyroid gland were fixed in Bouin's fixative and later prepared for histological examination. In addition to visual examination of this tissue, measurements were made with a micrometer eyepiece calibrated with a micrometer slide. The remainder of the thyroid gland and the pituitary gland were stored at -10°C. until all calves had finished the test. The ovaries were examined externally and internally for the presence of follicles and recent corpora lutea.

Hormone assay

The thyrotropic hormone content of the anterior pituitary gland of the calves was estimated by the ability of pituitary material to increase the weight of the thyroid glands of baby chicks.

The gonadotropic hormone content of the anterior pituitary gland of the calves was estimated by the ability of pituitary material to increase the weight of the testes of baby chicks.

Groups of calves consisting of 4 animals from 1 sire, 2 heifers and 2 steers, one of each sex having been treated with testosterone and one of each sex having been a control animal, were handled as assay units. In addition, the pituitary gland of a young bull handled under similar conditions was included in each unit.

Within an hour after the calves had been slaughtered the pituitary glands were placed in the freezing compartment of a

refrigerator and kept frozen until shortly prior to the assay period. The anterior pituitary of each calf was ground in a mortar with a pestle until thoroughly macerated. Distilled water was then added to the tissue until a volume of 12.5 ml. was attained.

The assay animals used in this experiment were White Leghorn cockerel chicks from commercial flocks. A group of 100 chicks was the most desirable size to work with from the standpoint of availability of equipment and time for treatment and autopsy. The chicks were banded with wing tags numbered consecutively. Each lot of 100 chicks was divided into 5 equal sub-lots. Of each sub-lot of 20 chicks, 6 received 0.02 cc., 6 received 0.04 cc., and 6 received 0.08 cc. of the aqueous solution of the anterior pituitary of the calf assigned to that sub-lot. The above dosage levels were given by subcutaneous injection in the breast area for 4 consecutive days beginning when the chicks were 4 days old. The response of each pituitary was thus measured in 18 chicks. The remaining chicks served as controls and were not injected with any material.

Chicks were killed by chloroform in groups of about 10 each, killing and autopsy being at random. Thyroid glands were first dissected, then testes were removed. Glands were weighed immediately after separation in order that loss due to evaporation be kept to a minimum. All chicks were autopsied 21 to 28 hours after the last injection.

The samples of thyroid gland were placed in the freezing compartment of a refrigerator and stored at below freezing temperatures until they were to be used. Samples of thyroid tissue from all calves in one progeny group were macerated in a Waring blender for approximately 10 minutes and the material diluted with distilled water to a volume of 7.5 ml. for each gram of tissue. The assay animals were mice, 10 weeks of age, which had been on a ration of 0.1 per cent thiouracil in the feed for 4 weeks preceding the test period. A 0.2 ml. dosage of the water extract of thyroid from each calf was injected subcutaneously into 3 male and 4 female mice. Thirty-six hours post-injection the mice were asphyxiated in ½-pint jars sealed with Mason lids. The time required for asphyxiation was used as an indication of comparative oxygen consumption.

Cooking and palatability

Each rib roast was cooked individually in an uncovered pan. A thermometer was inserted with the bulb centered in the rib eye muscle. The roasts were seared at an oven temperature of 200° C. for 20 minutes. The temperature was then lowered to 125° C. for the remainder of the cooking period. The roasts were cooked for

3½ to 4 hours until an interior temperature of 73° C. was reached. At this temperature, and with this method of cooking, the meat was medium-rare. Drip and evaporation losses during cooking were calculated as a per cent of the weight of the raw meat. Samples of the rib eye muscle were used for press fluid and shearing strength determinations. The press fluid determinations were made by subjecting a 2.00 gram sample of cooked lean meat to a pressure of 8,000 p.s.i. at 40° C. for 5 minutes. The loss in weight of the meat sample was the weight of press fluid. Shearing strength was the force required to shear a one-inch sample of cooked meat when a uniform shearing speed of 20 inches per minute was applied. The cooked meat while still warm was scored by a panel of 7 judges for the following factors: texture, tenderness, juiciness, the intensity and desirability of aroma and flavor of the fat and lean, and the flavor of juice obtained during the roasting process. A score of "1" indicated "least intense" or "least desirable", while a score of "7" indicated "most intense" or "most desirable" for these characteristics. The judges indicated the approximate color of lean and fat by checking one of the score card descriptions.

Statistical analysis

The analysis of variance was used to determine the significance of treatment means. When F values exceeded those given for the F distribution at the .05 level, the differences were considered significant. The analysis of covariance was used to adjust the total digestible nutrients per 100 pounds gain for the effects of average daily gain (Snedecor, 1948).

Experimental Results

In determining the response of beef calves to administered male hormones, several characteristics must necessarily be considered. Of importance are feed lot performance, carcass quality, meat characteristics, any alteration of organ form or function, and induced sexual development which may result from hormone treatment. Careful integration of all results is essential for accurate interpretation and comprehensive conclusions.

Rate of gain

The weekly intramuscular injection of 1 mg. of testosterone per kg. of body weight significantly affected the rate of gain of calves during the entire test period. (Table 1, Figure 1.) Average daily gains in pounds were 2.61 for testosterone-treated heifers

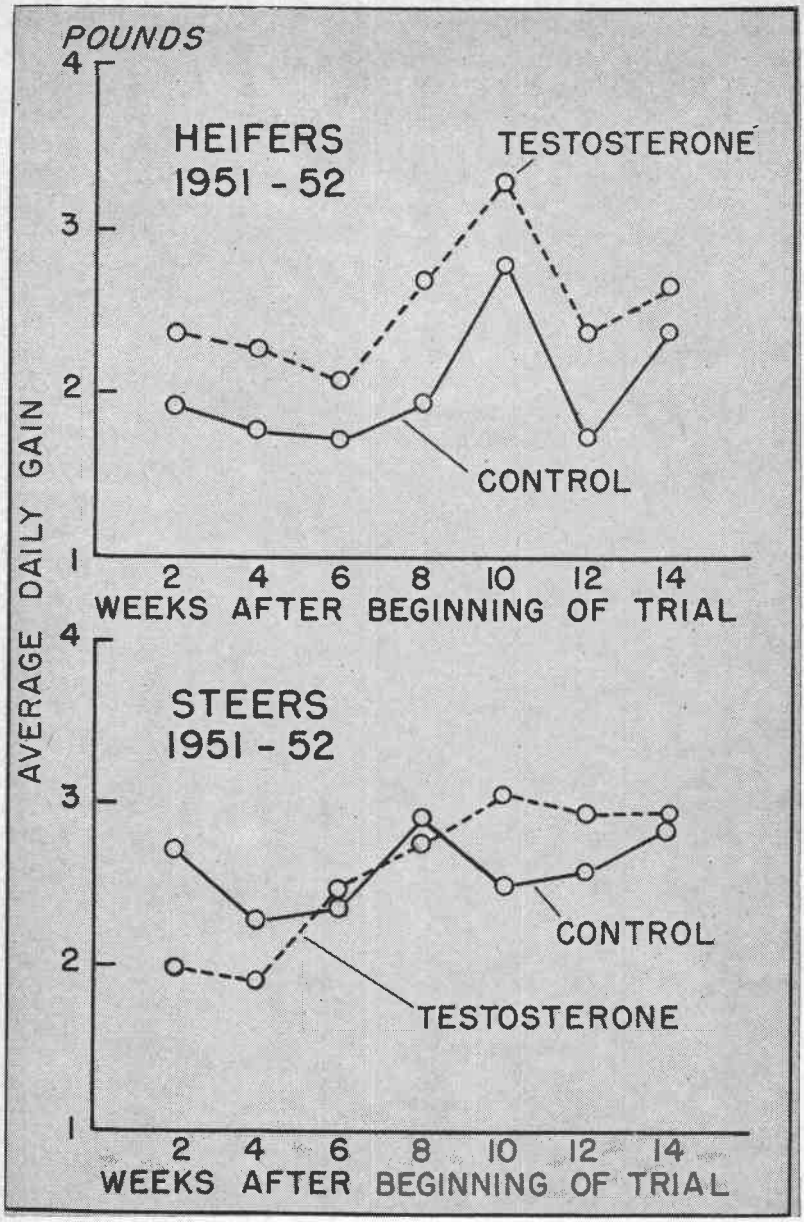

Figure 1. Average daily gain of testosterone-treated and control heifers and steers.

and 2.09 for control heifers with testosterone-treated steers averaging 2.74; the control steers 2.65.

When the entire feeding period is considered, heifer calves receiving testosterone gained 0.52 pound more per day than control heifer calves, while steer calves receiving testosterone gained 0.09 pound more per day than control steer calves. The much greater response to hormone injections of the heifers as compared to that of steers indicates a possible interaction between the sexes and the hormone treatment.

During the period when calves weighed 675 to 800 pounds, those receiving testosterone treatment had a somewhat greater rate of gain than the control calves as compared with the overall feeding period. During this period the average daily rate of gain for the testosterone-treated heifers and steers was 2.82 and 3.19 pounds respectively as compared with gains of the control heifers and steers of 2.26 and 2.80 pounds respectively.

Table 1. AVERAGE DAILY GAIN OF HEIFER AND STEER CALVES AS INFLUENCED BY TESTOSTERONE ADMINISTRATION

Weeks after beginning of test	Treatment groups			
	Control		Testosterone	
	Heifers	Steers	Heifers	Steers
	Pounds	*Pounds*	*Pounds*	*Pounds*
0- 2	1.93	2.57	2.38	1.98
2- 4	1.79	2.27	2.29	1.91
4- 6	1.74	2.36	2.10	2.45
6- 8	1.96	2.91	2.71	2.75
8-10	2.81	2.50	3.31	3.06
10-12	1.77	2.60	2.42	2.94
12-14	1.89	2.85	2.66	2.93
Average	1.98	2.58	2.55	2.57

Steer calves gained at a significantly faster rate than heifer calves throughout the over-all feeding period as well as during the interval from 675 to 800 pounds live weight. Average daily gains during these periods were: from 500 to 800 pounds live weight, heifer calves gained 2.35 pounds daily; steer calves gained 2.70 pounds. From 675 to 800 pounds live weight, heifers gained 2.54 pounds and steers 2.99 pounds. Thus steer calves gained 0.35 pound more per day than heifer calves during the overall test period, while during the period from 675 to 800 pounds the steer calves gained 0.45 pound more per day than did the heifer calves. This would

indicate that the steer calves were able to make faster gains at heavier weights, whereas, at lighter weights, the steers and heifers gained at approximately equal rates. Heifer calves receiving testosterone demonstrated consistently greater gains than control heifers, whereas testosterone-treated steers showed great fluctuation when compared with the controls in average daily gain (Figure 1).

Daily feed intake

The average daily consumption of total digestible nutrients during consecutive 2-week periods following the beginning of the test period is given in Table 2 for the sex and treatment groups. Data on feed consumption are plotted in Figure 2, illustrating the increase in feed consumption with time and indicating the comparative consumption by testosterone-treated and control animals.

Table 2. AVERAGE DAILY INTAKE OF TOTAL DIGESTIBLE NUTRIENTS OF TESTOSTERONE-TREATED AND CONTROL HEIFERS AND STEERS

Weeks after beginning of test	Total digestible nutrients			
	Heifers		Steers	
	Control	Testosterone	Control	Testosterone
	Pounds	*Pounds*	*Pounds*	*Pounds*
0- 2	8.81	8.60	8.96	8.94
2- 4	9.45	8.90	9.16	8.78
4- 6	9.97	8.78	9.51	9.53
6- 8	9.86	9.32	10.37	9.88
8-10	10.33	9.94	11.11	10.46
10-12	10.76	10.39	11.41	10.88
12-14	10.52	11.28	11.67	11.48
Average	9.96	9.60	10.27	9.99

Average daily intake of total digestible nutrients, in pounds, for the entire test period, was 10.13 for the heifers and 10.26 for the steers. During the period from 675 to 800 pounds live weight, the total digestible nutrient consumption in pounds per day was 11.40 for the heifers and 11.53 for the steers. Hence, the heifer and steer groups differed but slightly, whether during the overall test period or during the 675 to 800 pound live weight period. The differences were not significant.

Average daily intake of total digestible nutrients was somewhat less for testosterone-treated than for control calves. This was true for the overall test period as well as for the period from 675 to 800 pounds live weight.

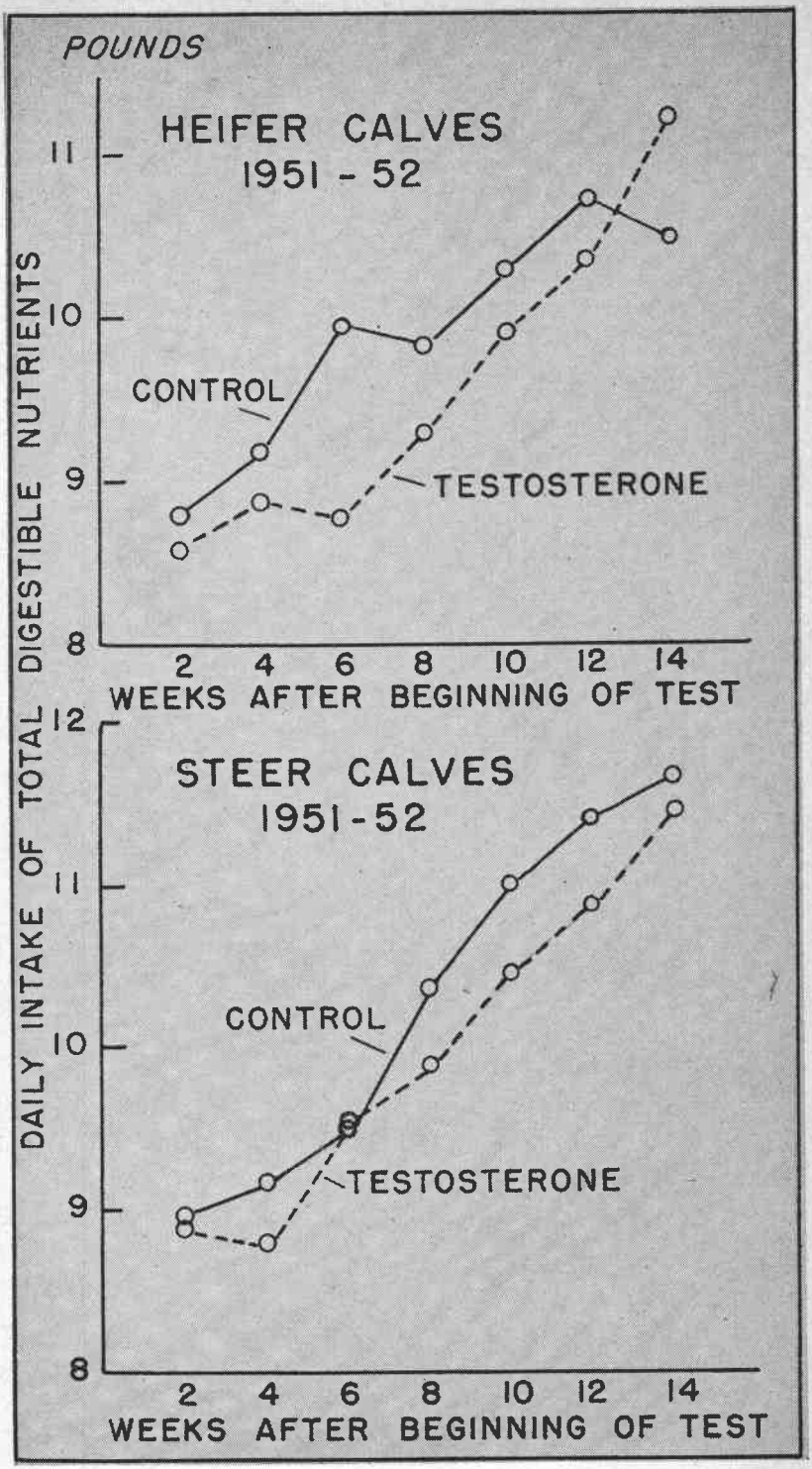

Figure 2. Daily intake of total digestible nutrients for testosterone-treated and control heifers and steers.

During the complete test period the average daily intake of TDN in pounds was: testosterone-treated heifers, 9.89; control heifers, 10.39; testosterone-treated steers, 10.05; and control steers, 10.48. The testosterone-treated heifers consumed 0.50 pound less; the treated steers consumed 0.43 pound less than their respective controls. These differences in daily feed intake by treatment groups were not significant for the overall period. However, the differences during the 675 to 800 pound weight period were significant. During this period, total digestible nutrients consumed daily averaged: 11.17 pounds for testosterone-treated heifers and 11.63 pounds for control heifers (a difference of 0.46 pound); 11.26 pounds for testosterone-treated steers and 11.81 pounds for control steers (a difference of 0.55 pound).

Efficiency of gain

The average total digestible nutrients required per 100 pounds of gain during consecutive 2-week periods after the beginning of the feed test are given in Table 3 for the various treatment groups. Feed efficiency estimates are plotted in Figure 3.

Table 3. TOTAL DIGESTIBLE NUTRIENTS REQUIRED PER 100 POUNDS OF GAIN, FOR TESTOSTERONE-INJECTED AND CONTROL STEER AND HEIFER CALVES

Weeks after beginning of test	TDN per 100 pounds gain			
	Heifers		Steers	
	Control	Testosterone	Control	Testosterone
	Pounds	*Pounds*	*Pounds*	*Pounds*
0- 2	457	361	348	452
2- 4	529	389	403	461
4- 6	573	419	404	389
6- 8	502	344	357	359
8-10	368	300	444	342
10-12	607	430	440	370
12-14	557	425	410	392
Average	513	381	401	395

The weekly intramuscular injection of testosterone resulted in a lowered requirement for total digestible nutrients per unit of gain in weight of both heifer and steer calves. During the entire test period testosterone-treated heifers required 379 pounds TDN while control heifers required 498 pounds TDN per 100 pounds of gain. Similarly, testosterone-treated steers required 369 pounds TDN and control steers required 396 pounds TDN per 100 pounds of gain.

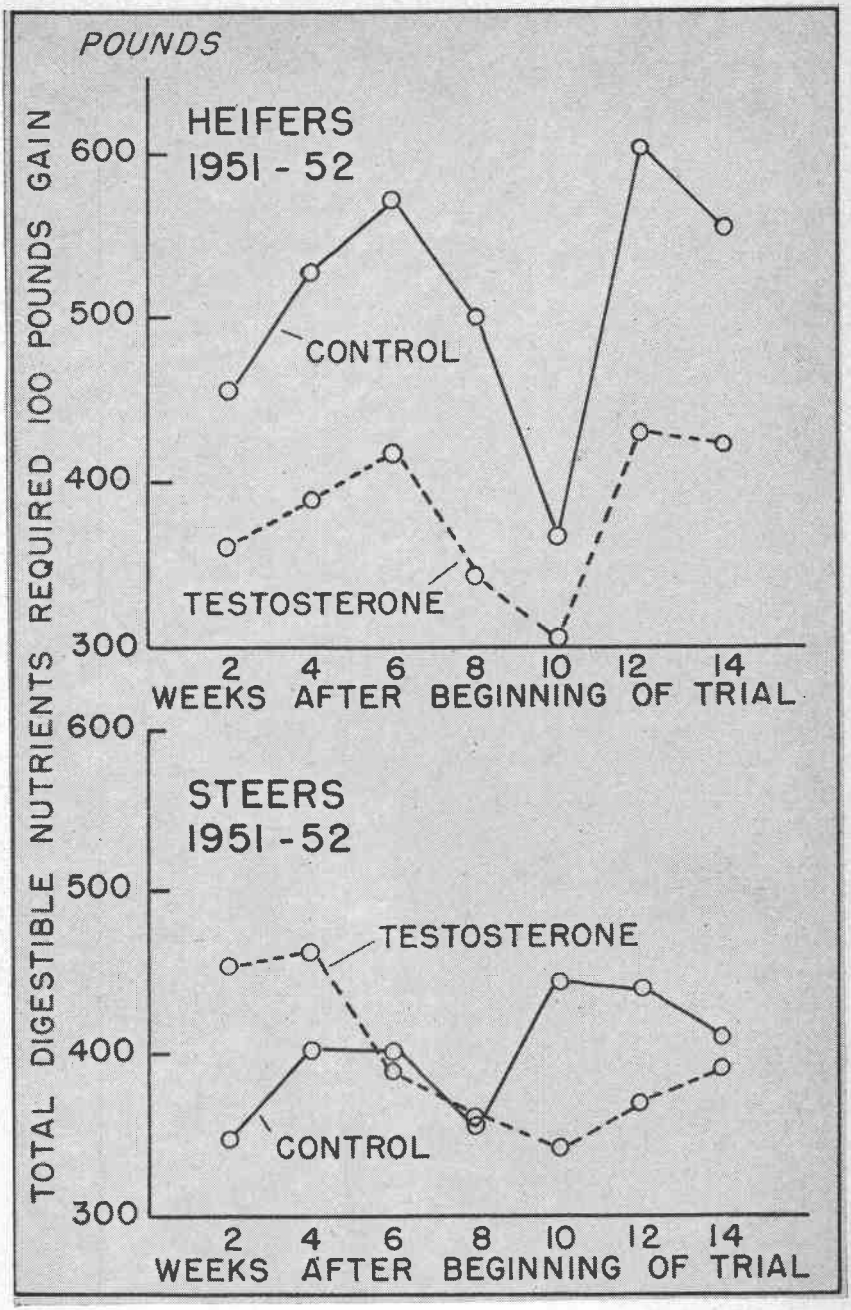

Figure 3. Total digestible nutrients required per 100 pounds gain by testosterone-treated and control heifers and steers.

Analysis of variance of the treatment effects showed a significant interaction between sex and hormone treatment, indicating that the reduction in feed required per unit of gain due to the testosterone treatment was not the same for both sexes. Thus, for the total test period, testosterone-treated heifer calves required 119 pounds less total digestible nutrients per 100 pounds of gain than did control heifers, whereas testosterone-treated steer calves required only 29 pounds less total digestible nutrients per 100 pounds of gain than the control steers.

The TDN required per 100 pounds of gain during the latter part of the test period, from 675 to 800 pounds live weight, averaged 404 pounds for testosterone-treated heifers; 516 pounds for control heifers; 354 pounds for testosterone-treated steers and 423 pounds for control steers.

The advantage of testosterone treatment for steer calves did not appear until the latter weeks of the test. The difference between the control and testosterone-treated steers was much greater in the period from 675 to 800 pounds than during the early part of the test period. On the other hand, heifer calves receiving testosterone demonstrated throughout a lower requirement for total digestible nutrients per unit of gain than did the control heifers. Steer calves utilized feed more efficiently than the heifer calves throughout the test period as indicated by the lower TDN per 100 pounds of gain. This advantage was more pronounced in the latter part of the test. During the period from 675 to 800 pounds live weight, the steer calves required 389 pounds TDN per 100 pounds of gain as compared with 460 pounds required by the heifers; whereas, from 500 to 800 pounds live weight, the feed requirements were 383 pounds TDN for the steers compared with 438 pounds for the heifers.

The regression of total digestible nutrients required per 100 pounds of gain on the average daily gain was —166 pounds. This indicated that for each increase in average daily gain of one pound, the requirement for TDN decreased 166 pounds per 100 pounds of gain in live weight. This source of variation accounted for 84 per cent of the total variance of total digestible nutrients required per 100 pounds of gain. The analysis of covariance of total digestible nutrients required per 100 pounds of gain on the average daily gain (Table 4) demonstrates a significant effect of treatment and interaction between the hormone treatment and the sex of the calf.

This demonstrates that the hormone used is effective in increasing feed efficiency beyond its effect in increasing an average daily gain.

Table 4. ANALYSIS OF COVARIANCE OF TOTAL DIGESTIBLE NUTRIENTS REQUIRED PER 100 POUNDS OF GAIN ON RATE OF GAIN, OF TESTOSTERONE-INJECTED AND CONTROL HEIFERS AND STEERS

Source of variance	Degrees of freedom	Adjusted mean square	F
Treatments	1	6,286.7	16.10*
Sexes	1	1,174.0	.50
Treatments x sexes	1	2,327.9	5.96*
Error	19	390.8	.....

* Significance at 5 per cent level.

Carcass characteristics

Dressing per cent, proportion of certain cuts, and carcass grade are given in Table 5 for carcasses of calves in the hormone treatment and sex groups.

Table 5. DRESSING PER CENT AND CARCASS CHARACTERISTICS OF HEIFERS AND STEERS, TESTOSTERONE-TREATED AND CONTROLS

	Heifers		Steers	
	Control	Testosterone	Control	Testosterone
	Per cent	*Per cent*	*Per cent*	*Per cent*
Dressed weight (per cent of shrunk live weight)	60.7	59.7	57.9	60.1
Hindquarter (per cent of dressed weight)	51.0	50.4	49.8	48.9
Round (per cent of dressed weight)	19.8	21.8	21.6	21.0
Chuck (per cent of dressed weight)	26.0	27.1	27.1	28.0
Flesh (per cent of flesh plus bone of 6th to 9th rib section)	85.3	83.6	83.1	83.2

Heifers of the control graded 6 choice; steers of the control, 2 choice and 4 good. Heifers testosterone-treated graded 3 choice and 3 good; steers graded 1 choice and 5 good.

There was an interaction of testosterone treatment and sex of calf on dressing per cent. The dressing per cent of heifers was reduced by testosterone treatment; that of steers was increased.

The per cent of hindquarter of heifers was significantly greater than that of steers. The testosterone-treated calves were significantly lower in per cent of hindquarter than control calves. The difference

between testosterone-treated and control heifers in amount of hindquarter was 0.6 per cent and that for the steers was 0.9 per cent.

A significant interaction was found between the effect of testosterone and sex of calf on the per cent of round. The per cent of round of testosterone-treated heifers was greater (2.0 per cent) than that of control heifers, while the per cent of round of testosterone-treated steers was less (0.6 per cent) than that of control steers.

The per cent of chuck of testosterone-treated calves was significantly greater than that of control calves. The difference between the chucks of testosterone-treated and control heifers was 1.1 per cent, and between the chucks of testosterone-treated and control steers was 0.9 per cent.

Per cent of flesh to flesh plus bone of the 6th to 9th-rib cuts was significantly greater for heifer than steer rib cuts. Testosterone had no significant effect on the per cent of flesh of the 6th to 9th-rib cut. A slight reduction in carcass grade resulted from the administration of testosterone. This response was more striking in the heifers than in the steers.

Cooking and palatability

Average values for evaporation and drip loss during cooking of the rib roasts, press fluid, shearing strength, and palatability scores are shown in Tables 6 and 7.

Table 6. EVAPORATION AND DRIP LOSS DURING COOKING, PRESS FLUID, AND SHEARING STRENGTH OF MEAT SAMPLES

Source of meat	Evaporation loss	Drip loss	Press fluid	Shearing strength
	Per cent	*Per cent*	*Per cent*	*Pounds*
Heifers				
Control	8.1	5.7	59.1	13.4
Testosterone-treated	9.7	2.8	58.3	12.3
Steers				
Control	8.9	2.8	60.5	9.9
Testosterone-treated	9.7	2.5	58.6	15.5

The analysis of variance, Tables 8 and 9, revealed a difference due to hormone treatment only for drip loss and shearing strength when *all* treated animals were compared with the controls. In a few instances interaction or primary effects other than treatment were significant. Sex influenced the color of fat. Steer fat had a lighter color and less drip loss. Treatment by sex interactions for drip

Table 7. Average Palatability Scores of Meat From Control and Testosterone-treated Calves

Characteristics	Score of meat			
	Heifers		Steers	
	Control	Testosterone	Control	Testosterone
Intensity:				
Aroma	4.6	4.5	4.9	4.6
Texture	5.3	5.5	5.5	5.2
Tenderness	5.8	5.7	6.2	5.4
Flavor of fat	3.7	3.8	3.7	3.6
Flavor of lean	4.8	5.1	4.9	4.9
Flavor of juice	5.9	5.6	6.0	6.1
Juiciness	5.5	5.5	5.7	5.4
Desirability:				
Aroma	5.5	5.2	5.4	5.3
Flavor of fat	4.7	5.1	5.3	5.0
Flavor of lean	5.6	5.5	5.8	5.5
Color:				
Fat	2.7	2.7	2.3	2.4
Lean	3.7	3.8	3.9	3.7

Table 8. Analysis of Variance of Cooking Tests for Roasts From Testosterone-injected and Control Beef Animals

Source of variance	Degrees of freedom	Mean squares				
		Cooking losses			Press fluid	Shearing strength
		Evaporation	Drip	Total		
Sire	2	4.1654	6.4613	17.6817	9.3529	2.7255
Treatment	1	7.9350	15.0417*	1.1266	10.6666	31.5104*
Sex	1	.9600	15.0417*	8.4016	3.8400	.1838
Sire x Treat.	2	.5338	.7554	1.7267	2.2405	4.4479
Sire x Sex	2	2.8288	2.2004	9.8117	.1138	.4587
Treat. x Sex	1	.8816	10.9349*	5.6068	1.7067	68.3437*
Sire x Treat. x Sex	2	5.2705	2.6663	7.7716	7.8379	2.6863
Error	12	1.9000	1.8467	4.6233	6.2725	5.6663
Total	23					

* Significant at 5% level.

Table 9. Analysis of Variance of Palatability Scores for Roasts From Testosterone-injected and Control Beef Animals

Source of variance	Degrees of freedom	Mean squares											
		Intensity						Quantity of juice	Desirability			Color	
		Aroma	Texture	Tenderness	Flavor fat	Flavor lean	Flavor juice		Aroma	Flavor fat	Flavor lean	Fat	Lean
Sire	2	.0313	.0467	.2180	.0163	.2817*	.1955	.4829*	.0013	.0538	.2617	.0650	.3405
Treatment	1	.1837	.0704	.3538	.0037	.1504	.0338	.0816	.1350	.0267	.2400	.0037	.0104
Sex	1	.1504	.0204	.0704	.0704	.0104	.5104	.0150	.0017	.2400	.0600	.7004*	.0104
Sire x Treat.	2	.0488	.0717	.4062	.2038	.0867	.0112	.1005	.0263	.0279	.0350	.0150	.0054
Sire x Sex	2	.0179	.2617	.2329	.4204*	.0867	.0504	.3488	.0704	.0713	.0350	.0617	.2404
Treat. x Sex	1	.0504	.3505*	.8437*	.0704	.1505	.2604	.2017	.0600	.8066*	.0150	.0504	.0938
Sire x Treat. x Sex	2	.0555	.0617	.0163	.0380	.0017	.2280	.8229*	.0788	.3555	.0950	.0817	1.0588*
Error	12	.0788	.0696	.1754	.1004	.0588	.1479	.1242	.1308	.1558	.1192	.0721	.1563
Total	23												

* Significant at 5% level.

loss during cooking, shearing strength and scores for texture of flesh, tenderness and desirable flavor of fat indicated that hormone treatment had more effect on one sex than the other.

Treatment reduced drip loss from heifer meat and apparently had no effect on steers. Treatment increased the shearing strength and lowered scores for tenderness as well as lowering texture scores for steer meat. There was little effect on these qualities in heifers. The flavor of fat of steer meat was adversely affected by treatment, as indicated by significantly lower scores.

Chemical composition

The chemical composition of meat samples representative of each treatment and sex group is given in Table 10. The meat from control heifers contained a higher per cent of fat than did the other groups and was therefore lower in protein and water. Treatment of heifers with testosterone resulted in a decreased fat content and a corresponding increase in protein and water percentages. Although meat samples from control steers were much lower in fat and higher in protein than those from control heifers, treatment with testosterone appears to have also decreased the per cent of fat in steers; however, the reduction was not as great as with the heifers.

Table 10. CHEMICAL COMPOSITION OF MEAT SAMPLES*

Treatment groups	Moisture	Dry weight basis		
		Fat	Protein**	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*
Control heifers	46.0	72.2	24.9	1.2
Testosterone-treated heifers	56.8	57.0	41.0	1.9
Control steers	55.8	51.0	46.9	2.2
Testosterone-treated steers	50.5	47.4	49.6	3.0

* Averages based on 8 samples (except control steers, av. of 4 samples).
** Percentage of protein determined by difference in some cases.

Hormone content of tissues

The thyroid glands of chicks receiving injections of pituitary extract from testosterone-treated calves were heavier than those from chicks receiving pituitary tissue from control calves (Table 11). Extract from testosterone-treated heifers produced a greater average response by 0.65 mg. in the chick thyroid than did that of control heifers. Pituitary extract of testosterone-treated steers produced a 0.77 mg. greater average response in the chick thyroid than did that

Table 11. AVERAGE WEIGHT OF THYROID GLANDS FROM CHICKS INJECTED WITH WATER EXTRACT OF ANTERIOR PITUITARY GLANDS FROM CONTROL AND TESTOSTERONE-TREATED CALVES

Source of anterior pituitary material	Average weight of chick thyroid glands
	Milligrams
None (chicks not injected)	2.83
Control heifer calves	3.81
Testosterone-treated heifer calves	4.46
Control steer calves	4.10
Testosterone-treated steer calves	4.87
Bull calves (without hormone treatment)	4.37

from control steers. Calves receiving testosterone had, therefore, a greater content of thyrotropic hormone in the anterior pituitary gland than did control calves. The anterior pituitary gland of control bull calves was intermediate between those of control and testosterone-treated calves in thyrotropic hormone content.

A significant difference in thyrotropic hormone content of the anterior pituitary gland of calves of the two sexes occurred (Table 12). The thyroid glands of injected chicks averaged 0.29 mg. heavier when the source of the pituitary extract was from the group of control steers as compared with control heifers. Similar differences between steers and heifers were found in the testosterone-treated group. The thyrotropic hormone content of the anterior pituitary gland of steers was therefore greater than that of heifers.

Table 12. ANALYSIS OF VARIANCE OF THE WEIGHT OF BABY CHICK THYROID GLANDS AS STIMULATED BY THE ANTERIOR PITUITARY GLAND OF CALVES

Source of variation	Degrees of freedom	Mean square	F
Replications	5	28.485	16.72*
Sex	1	12.813	7.52*
Treatment	1	53.905	31.63*
Levels	2	20.541	12.05*
Sex x treatment	1	.403	.24
Sex x levels	2	.310	.18
Treatment x levels	2	4.145	2.43
Sex x treatment x levels	2	5.006	2.97
Error	412	1.686	

* Indicates statistical significance at 5 per cent level.

The testes of chicks receiving anterior pituitary extract from testosterone-treated calves were not as heavy as those from chicks receiving extract from control calves (Table 13). This difference between the testosterone-treated and control calves was significant.

Table 13. AVERAGE WEIGHTS OF TESTES FROM CHICKS INJECTED WITH WATER EXTRACT OF ANTERIOR PITUITARY GLANDS FROM CONTROL AND TESTOSTERONE-TREATED CALVES

Sources of anterior pituitary material	Average weight of chick testes
	Milligrams
Control heifer calves	16.9
Testosterone-treated heifer calves	15.3
Control steer calves	16.0
Testosterone-treated steer calves	15.8

The effect of testosterone was greater in the heifers than in the steers. There was no significant difference between the weights of testes of chicks receiving pituitary extract from heifer and steer calves.

Thyroid tissue extract from all calves, when injected into mice, altered the metabolic rate as shown by the time required for asphyxiation of the mice (Table 14).

The sex of calf from which the thyroid gland was obtained had no significant effect on its content of thyroid hormone as mea-

Table 14. TIME REQUIRED FOR ASPHYXIATION OF MICE INJECTED WITH THYROID GLAND EXTRACT

Source of thyroid gland tissue	Sex of mice used		
	Male	Female	Average
	Minutes	*Minutes*	*Minutes*
Heifers			
Control	33.6	50.4	43.2
Testosterone	36.0	57.1	48.1
Steers			
Control	35.3	53.3	45.6
Testosterone	37.0	56.9	48.4
Both heifers and steers			
Control	34.5	51.9	44.4
Testosterone	36.5	57.0	48.2
Non-injected control mice	46.1	58.0	54.0

sured by asphyxiation time of injected mice. Tissue extract from control calves shortened the asphyxiation time of mice as compared with that from testosterone-injected calves.

Tissue structure

Microscopic examination of the thyroid tissue revealed a rather striking demonstration of the effect of testosterone treatment. The area of the colloid follicles of the animal which received testosterone were very small and the epithelial cells surrounding the colloid areas appeared tall. The thyroid glands of control calves had larger colloid areas and the epithelium appeared to be of a flat or cuboidal form. The total area of the field was taken up largely by colloid in the case of the control calves while in the case of testosterone-treated calves a small part of the total area was made up of colloid areas, the remainder being epithelial tissue and interstitial and connective tissue (Figures 4, 5, 6 and 7).

There was a rather striking absence of corpora lutea in the ovaries of 4 of the 6 heifers receiving testosterone (Table 15). The average diameter of the largest follicle in the ovaries was slightly greater for the calves receiving testosterone than for the control calves. The number of follicles exceeding 4 mm. in diameter in the ovaries was much greater for control calves than for testosterone-treated calves.

Table 15. CHARACTERISTICS OF OVARIES OF CONTROL AND TESTOSTERONE-TREATED HEIFER CALVES

	Recent corpora lutea	Average weight and size		
		Ovarian weight	Diameter of largest follicle	Follicles over 4 mm. diameter
	Per cent	*Grams*	*Millimeters*	
Control	100	10.9	12	7
Testosterone-treated	33	10.2	14	3

Sexual characteristics

Calves receiving testosterone injections developed many masculine characteristics, both in form and behavior, which were often evident as early as the 10th week of test and continued until the conclusion of the test period. Both heifers and steers receiving testosterone developed pronounced crests in the neck region, caused

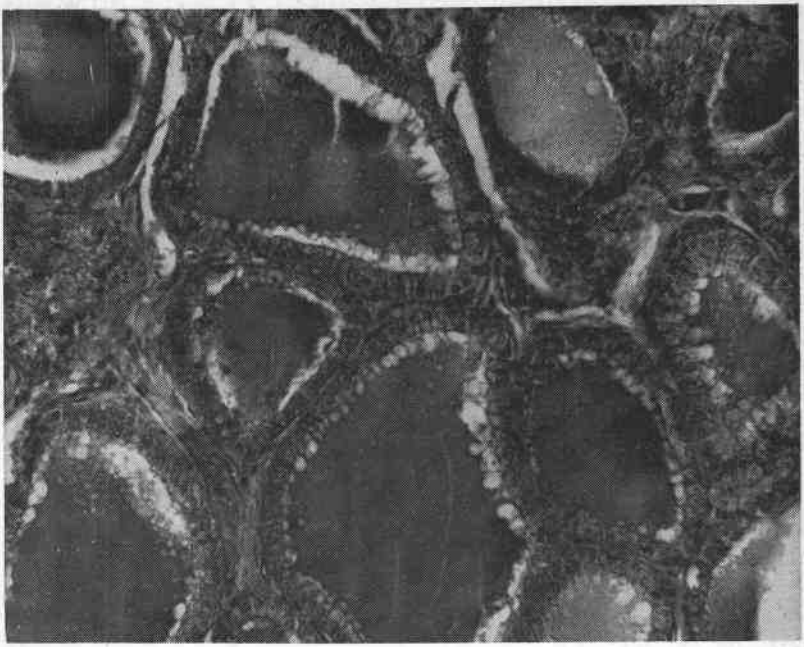

Figure 4. Thyroid gland from control steer. X300.

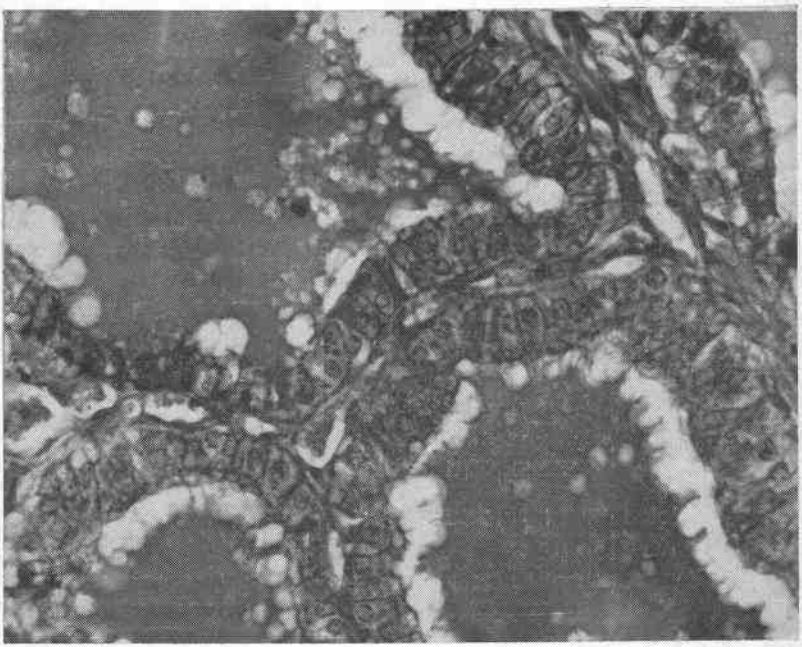

Figure 5. Thyroid gland from steer receiving injections of testosterone. Note increased height of epithelium of follicle compared with control (Figure 4).

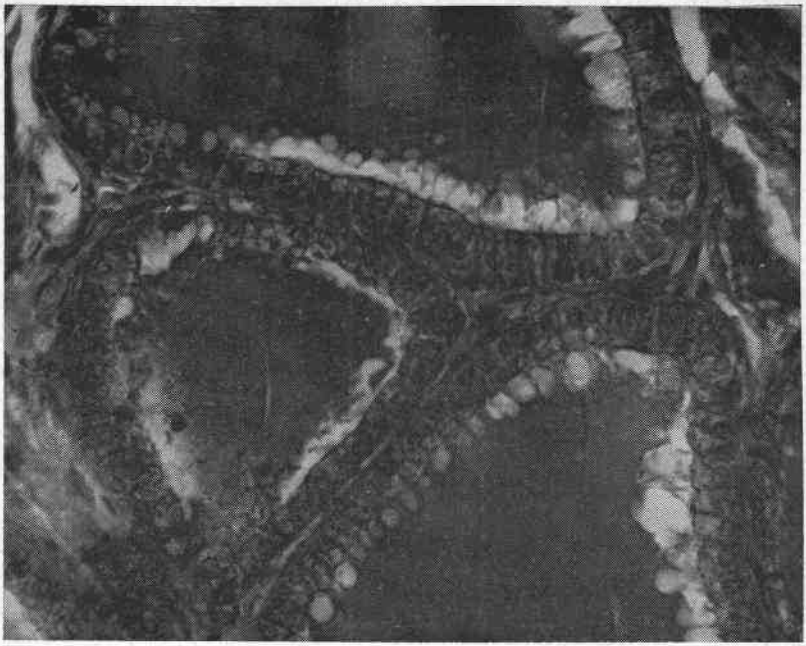

Figure 6. Thyroid gland from control steer. X150. Note large amount of colloid in follicles.

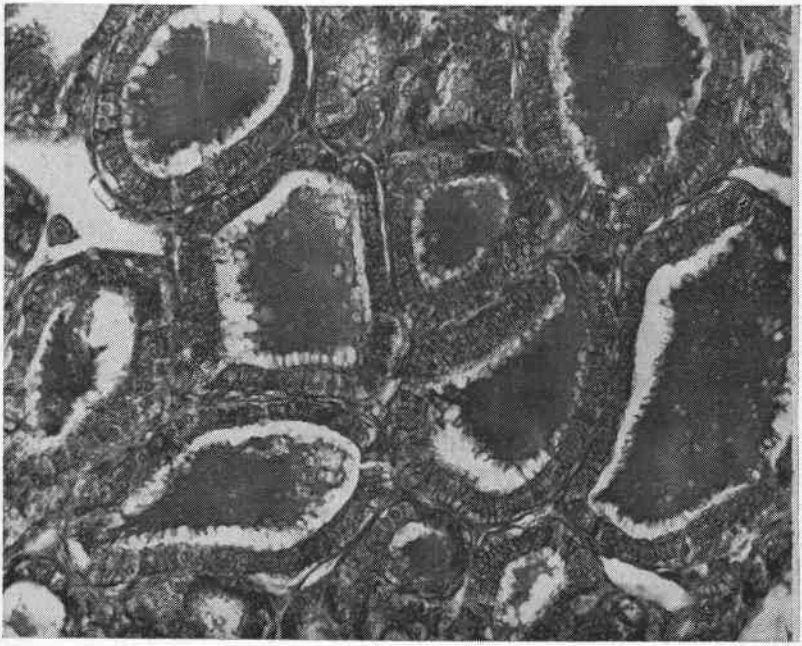

Figure 7. Thyroid gland from steer receiving testosterone injections. X150. Note reduction in colloid and greater proportion of cellular material.

apparently by intense development of muscles in this area (Figure 8). This condition closely resembles that of normal bulls of comparable size and age. The musculature throughout the carcass, particularly in the round and loin, showed the characteristic bulging of bull or stag carcasses as compared with a rather flat or smoothly filled round and loin of the control heifers and steers. Alterations in the hair coat of the testosterone-treated animals were particularly striking since the white areas developed a yellowish discoloration. Hair coat was curly and unruly as compared with the straight hair coat of control calves. Treated animals were often wet, and steaming from sweat (on cool mornings), a condition frequently observed in young bulls when stabled in pens adjoining those where a female might be in estrus. This sweating may also be the cause for some of the discoloration and curliness of the hair coat. Voices of the testosterone-treated calves changed to the deep bellow and snort characteristic of bulls.

Size of organs and glands.

Testosterone produced a significant increase in the weight of the thyroid glands (Table 16). Adrenal glands of testosterone-treated calves were significantly heavier than those of the control calves. Weights of heart, liver, and the length of the small intestine were not significantly altered by the testosterone treatment. Since all calves were slaughtered at the same weight (800 pounds) it was not necessary to record weights of glands and organs as a per cent of live weight.

Table 16. SIZE OF ORGANS AND GLANDS OF CONTROL AND TESTOSTERONE-TREATED CALVES

	Pituitary gland	Thyroid glands	Adrenal glands	Heart	Liver	Small intestines	Seminal vesicles
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Centimeters*	*Grams*
Heifers							
Control ..	1.42	16.3	12.2	1,343	4,007	101	.....
Testosterone-treated	1.59	19.4	13.9	1,400	4,213	100	.....
Steers							
Control ..	1.57	17.2	13.3	1,389	4,264	101	5.5
Testosterone-treated	1.67	19.6	14.1	1,358	4,388	104	30.1

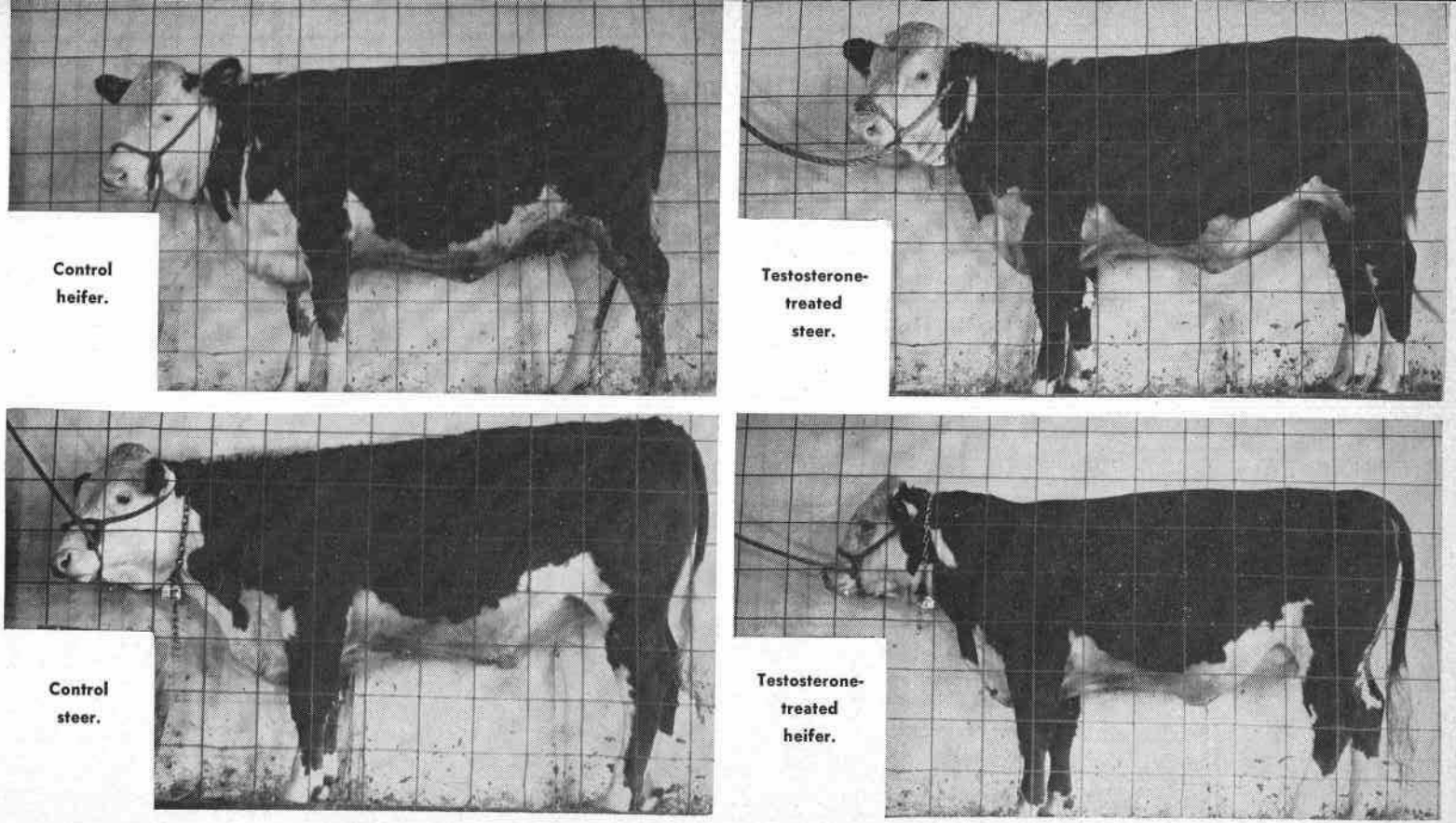

Figure 8. Representative control and testosterone-treated steers and heifers.

Discussion

Feed-test performances

Weekly injections of testosterone at the level of 1 mg/kg of body weight resulted in a considerable increase in average daily gain as compared with the growth rate of control calves. The graphical representation of growth rate of testosterone-treated and control calves indicates that differences in average daily gain between the heifer groups occurred soon after beginning of the hormone treatment and persisted or increased up to 14 weeks thereafter. During the period from 675 to 800 pounds live weight, the testosterone-treated calves had a greater advantage in average daily gain over control calves than when the entire feeding period is considered. These observations show that during the period following the beginning of testosterone injection there was a constant and continuous advantage of the testosterone animals over control animals in average daily gain. This phenomenon in beef cattle may be an indication of a permanent stimulation by the hormone; however, a temporary period of effectiveness in beef cattle might expire at a time later than that chosen for the termination of this trial.

Data on total digestible nutrients required per 100 pounds of gain indicate animals receiving testosterone were able to convert a given amount of feed to a greater increase in body weight than could control calves. Steer calves without hormone treatment were likewise able to make greater gains on a given amount of feed than heifer calves. Heifer calves had a much greater reduction in total digestible nutrients required per 100 pounds of gain than did steer calves due to the administration of testosterone. These comparisons indicate differences in efficiency of feed utilization if total-weight gain compared to total-digestible-nutrients-ingested is used as the measure of efficiency. If the measure of efficiency is the total-calories-ingested, however, the weight gain is a valid estimate of efficiency only as long as the calorie content of stored materials is constant for both groups. Samples of meat from these calves had the following chemical composition on a dry weight basis: control heifers, 72 per cent fat, 25 per cent protein; control steers, 51 per cent fat, 47 per cent protein; testosterone-treated heifers, 57 per cent fat, 41 per cent protein; and testosterone-treated steers, 47 per cent fat, 50 per cent protein. Although these values cannot be taken as representative for the carcass in its entirety, they are indicative of differences in the proportion of different body stores laid down by the animals in each treatment group. Thus, on a calorie-stored to calorie-consumed basis, the four groups may not vary greatly in efficiency.

On a basis of nutritional value the best measure of feed efficiency might be—protein-produced to calories-consumed. On this basis the testosterone-treated animals would greatly exceed the control animals in efficiency. Part of the reduction in feed required per 100 pounds of gain in the heifers by testosterone treatment can readily be explained on the differences in storage of fat by animals in the control and treated groups. Since the fat contains 2.25 times as many calories per gram, lean animals, storing low amounts of fat and high amounts of protein, would be expected to gain weight on less feed than animals storing high amounts of fat and low amounts of protein, other conditions being equal.

The more rapid gaining animals required less feed per 100 pounds of gain than slow gaining animals. In these trials an average decrease of 166 pounds of total digestible nutrients per 100 pounds of gain resulted for each increase in daily gain of one pound during the test period. After adjusting total digestible nutrients required per 100 pounds of gain for an individual animal's differences in gain, testosterone treatment was found to decrease the total digestible nutrients required per 100 pounds of gain. This effect was independent of the effect of testosterone in increasing average daily gain. The rate of gain may be explainable on the differences in relative amounts of fat and protein tissue deposited. It is difficult to compare deposition of protein and fat as similar processes since, of course, the retention of protein is dependent upon N retention in addition to the necessary energy supply. More rapid growth with protein deposition than with fat deposition might well be expected on a given calorie intake since fewer calories are required per gram of protein than per gram of fat. If a constant per cent of all nutrients above maintenance will be converted to body gain, a larger amount of protein will be deposited than if fat of the same quantity of nutrients were available for fat deposition. On a given calorie intake a growing animal would thus be expected to gain faster than a fattening animal if maintenance requirements were equal.

Average daily feed consumption becomes important as it affects the efficiency of gain and average daily gain. A general rule having practical application is: the more feed a growing animal eats above maintenance requirements the faster and more efficient will be its gains. This is not necessarily true under many situations. Treatment of calves with testosterone in these trials tended to result in a lower daily intake of total digestible nutrients as compared with control calves, particularly in the latter weeks of the trials. Yet, the rate of gain and feed efficiency of the calves were higher than those of control calves during the same periods. The increased rate of gain

and feed efficiency produced by testosterone treatment is not, therefore, due to stimulation of feed consumption but rather is dependent upon the animal's ability to use a limited food supply more effectively.

Carcass characteristics

Dressing per cent differed consistently between heifers and steers in the control groups. Treatment of heifers with testosterone tended to decrease dressing per cent in both trials. In the steers there was no consistent effect of testosterone on dressing per cent. This difference between sexes in dressing per cent may be at least partially explained on the basis of fat content of the carcass. As indicated in the section on chemical composition, fat content of meat samples from control heifers was very high, while samples from steers were relatively low in fat content. Heifers would be expected to have a greater dressing per cent since stores of fat in the carcass are often not accompanied by proportional weight increases in other organs and tissues such as the skin, viscera, and head. Heifers receiving testosterone had a much lower per cent of fat in the sample taken. On this basis, they would be expected to have a lower dressing per cent.

Relative weights of the round, hindquarter, and chuck may also reflect differences in fat deposition depending on the presence of preferential sites and gradients for fat deposition. For instance, fat deposition in the area of the kidneys was much more marked in animals with higher condition than in animals of lower condition, thus causing an increase in the weights of wholesale cuts from this area and resulting in a decrease in per cent of other cuts. Although steers had a higher per cent of round than heifers, the per cent of the hindquarter, which included the loin and kidney area, was greater for the heifer calves. This would be expected if the kidney area of heifers was very heavy in fat deposits in comparison with other parts of the carcass. The higher per cent of fat in heifer carcasses as compared to steer carcasses may well explain the corresponding higher per cent of flesh to flesh plus bone since an additional layer of fat was deposited over the muscle and bones. The testosterone treatment tended to increase the per cent of chuck and round of heifer calves, a condition which would be expected if the deposits of fats were decreased, particularly in the kidney and loin area.

The carcass grades of heifer calves were higher than those of steer calves indicating a greater degree of finish in the heifers. The carcass grades of testosterone-treated calves were slightly lower than

those of control calves, a possible indication of decreased fat deposition and a lower degree of finish.

The decrease in fat deposited was accompanied by a greater per cent of protein and water in the carcass. This is shown by the chemical analyses of the meat samples which showed increased protein and water content of steers as compared to heifers and of testosterone-treated calves as compared with control calves.

These findings are in agreement with a concept of greater output of thyroxine by the thyroid gland in calves receiving testosterone. Certainly the increase in thyroxine secretion would be conducive to greater water and protein retention and reduced fat storage.

Meat characteristics

Observations made on cooked meat samples offer interesting information which ties in rather closely with other observations. Drip loss of meat samples during cooking was greatest for the group of control heifers which was also the group with the highest per cent of fat in the meat samples. During cooking much of the water which leaves the roast may be evaporated; the drip will then be largely fatty in nature. The samples, therefore, which lost the greatest amout due to drip in cooking, would be expected to be from the calves highest in fat. Conversely, roasts from calves which had higher protein and water content might be expected to lose larger amounts of water by evaporation. This trend, however, was not consistent for all groups although the control heifers were somewhat lower both in per cent of evaporation loss and in per cent of protein than the other groups.

Effect of testosterone on shearing strength of samples from heifers and steers is difficult to explain on a basis of existing knowledge of male hormone activity. The increase in shearing strength of steers receiving testosterone might well be expected from the protein anabolic activity of male hormones and from the results by Herrick (1945) indicating increased strength of the skin and the gastrocnemius muscle of the fowl following the administration of testosterone propionate. However, the lack of effect or decrease in shearing strength in meat from the heifer calves was not consistent with observations in the fowl.

Hormonal activity

Considerable evidence exists to indicate that the thyrotropic hormone content of the anterior pituitary gland is a rather reliable indication of the activity of that gland in secreting the hormone. Work by Reece and Turner with beef cattle (1937) indicates an

increase in thyrotropic hormone content of the anterior pituitary during the period of most rapid growth (from 4-10 months). The period of most active growth was presumably the time of greatest secretion of the thyrotropic hormone. Likewise, the more rapid-gaining bulls had a much higher thyrotropic hormone content than the slower-growing heifers in the trials conducted by Reece and Turner. In the rabbit, there was increasing thyrotropic hormone content of the hypophysis as the animals reached their most rapid period of growth. As growth rate declined upon nearing maturity, thyrotropic hormone content decreased (1939). Castration of young male rats which results in a decrease in growth rate was also found to decrease thyrotropic hormone content of the anterior pituitary (1940).

In the beef cattle trial reported here thyrotropic hormone content of the anterior pituitary gland of steer calves was greater than that of heifer calves. Thyrotropic hormone content of the anterior pituitary was markedly increased by the testosterone injections. Growth rate of calves was also markedly increased by the use of testosterone. A tendency for those two traits to occur together indicates a definite association between them. The thyrotropic hormone acts first and principally on the thyroid gland to cause secretion of the thyroid hormone, thyroxine, but it may have other functions and could possibly act synergistically with the growth hormone.

In the gonadotropic assay of the anterior pituitary it is necessary to remember that follicle-stimulating hormones, and luteinizing hormones are known to be important, often acting synergistically in stimulating weight increases in the testes. The absence or reduction of numbers of corpora lutea in the ovaries of testosterone-treated heifer calves indicates an interference with the activity of the luteinizing hormones due to suppression of formation or secretion, or to an antagonistic effect of other hormones which prevents the normal action of luteinizing hormones. Hellbaum and Greep (1943) observed follicular development only in the ovaries of 21-day-old female rats after injection of the anterior pituitary tissue from castrated male rats which had received 0.5 mg. of testosterone propionate daily for periods of 30 days or longer. The pituitary gland tissue from non-treated castrated male rats produced both follicular stimulation and corpora lutea formation in the ovaries of 21-day-old female rats. This would indicate the deficiency or antagonistic material existed as such in the anterior pituitary, thus demonstrating an action of male hormone on this gland. The assay of total gonadotropic hormone content of the anterior pituitary gland of calves clearly indicates a decreased hormone content of calves receiving testosterone treatment as compared with normal

controls. This finding is in agreement with the lowering of luteinizing hormone activity by testosterone treatment as was indicated by examination of the ovaries.

A decrease in thyroid hormone content per gram of thyroid gland of calves receiving the testosterone treatment is the condition expected in a highly active gland where a large amount of thyroxine is being produced, but a greater amount is being discharged. Colloid areas containing stores of thyroxine are being depleted, and, although the production of thyroxine is quite high, the actual amount in the gland is relatively low. A further indication of the increased activity of the thyroid of testosterone-treated calves was shown by the histological structure of the gland. Testosterone-treated calves had thyroids with very small colloid areas surrounded by tall columnar secretory epithelium, while the thyroids of control calves had large colloid deposits and low cuboidal or flat cells surrounding the colloid. The large size of the thyroid glands may have been a result of thyroid stimulation, either directly by the testosterone or indirectly through the anterior pituitary gland. Although thyroxine content of the thyroid of testosterone-treated calves was lower per unit weight than that of control calves, the large size of the thyroid glands of testosterone-treated calves means that the total thyroxine content of the thyroid glands of testosterone-treated calves may have been equal to or even greater than that of the control calves. In the control calves the secretory activity was low while in the calves receiving testosterone it was probably quite high. The thyroid gland here is an excellent example of a condition in which the hormone content of a gland is not directly proportional to the activity of the gland in secreting that hormone.

Gross changes in organs and glands

There were no consistent effects of testosterone treatment on pituitary gland size. Though there were significant changes in the thyrotropic hormone content and the gonadotropic hormone content, there were no corresponding changes in the size of the pituitary gland. The data indicate that testosterone treatment produces increases in the size of thyroid glands. This increase in the size apparently is accompanied by an increased hormone production and cellular activity of the thyroid gland as is indicated by biological assay and histological examination. The role that the thyroid gland plays in controlling the metabolic rate makes changes of size and activity of this gland of considerable importance. Testosterone produced no significant effects on heart weight, liver weight, or small intestine length under conditions of these trials.

Masculinity

In this trial with beef cattle, the development of masculine sexual behavior of both heifers and steers following testosterone treatment further indicates the prominent role played by male hormones on this trait. Other manifestations of masculinity which were very prominent in the testosterone-treated animals included partial penis erection of steer calves, the deep, coarse voice characteristic of intact males, development of prominent musculature, and discoloration of the hair coat.

The intense development of these various masculine characteristics in the testosterone-treated calves is indicative of the androgenic activity of this substance.

Summary and Conclusions

1. The weekly intramuscular injections of testosterone at the rate of 1 mg/kg body weight resulted in the following:
   - ▶ An increase in rate of gain and a decrease in feed required per unit of gain in both heifers and steers, but with heifers showing a more marked response to the testosterone.
   - ▶ Testosterone-treated heifers had a slightly lower dressing per cent, a lower per cent of fat, a higher per cent of protein, and a higher per cent of round and chuck than control heifers; while testosterone-treated steers were quite similar to control steers in these traits.
   - ▶ The thyrotropic hormone content of pituitaries from testosterone-treated calves was greater than that of control calves.
   - ▶ Testosterone-treated calves had larger thyroid and adrenal glands than control calves.
   - ▶ The gonadotropic hormone content of the anterior pituitary was decreased and corpus luteum formation was partially inhibited by testosterone treatment.
   - ▶ Calves receiving testosterone developed masculine appearance and patterns of masculine behavior which were entirely lacking in the control calves.
2. The action of testosterone in increasing average daily gain may be through the stimulation of the anterior pituitary gland to secrete more thyrotropic hormone which would stimulate the thyroid gland to secrete more thyroxine. A high level of thyroxine in turn would increase the metabolic rate, which would result in a decreased fat storage and might increase nitrogen retention. The lower caloric requirement for protein anabolism as compared with fat deposition might account for the reduction in feed required per unit of gain

and the consequent increase in average daily gain on the same food intake.

3. There was very little difference in palatability or cooking quality between meat from control and meat from testosterone-treated animals. Palatability scores and shearing tests indicated that roasts from the control and testosterone-treated heifers and steers were all quite satisfactory.

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