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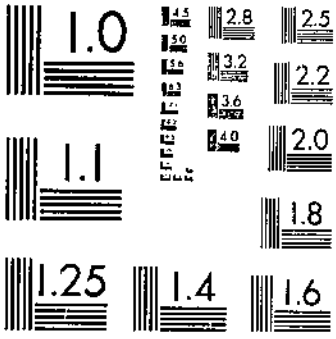

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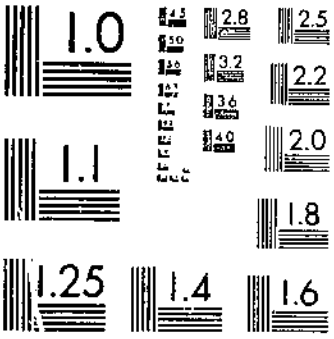

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UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Relation Between Urinary Calculi and Use of Grain Sorghum in Steer-Fattening Rations in the Southern Great Plains[1]

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INTRODUCTION

In the southern Great Plains, where grain sorghum is used extensively in fattening steers in feed lots, considerable trouble has been experienced in the formation of calculi in the bladder or other urinary passage. Large calculi sometimes become lodged in the urethra and cause death. This disorder has been reported as a rather common occurrence in the area surrounding the Big Spring Field Station, Big Spring, Tex. Experienced range cattlemen have attributed a number of losses among range steers to urinary calculi.

This condition is not associated entirely with dry-lot feeding. At the beginning of a feeding test in 1941 at the Big Spring Station, 8 calves, random selected from 56 head, were sent to Fort Worth for immediate slaughter. Varying amounts of calculi were found in the

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[2] Acknowledgment is made to the following Bureau of Animal Industry staff members: M. W. Hazen for assistance in compiling the data and I. P. Earle for assistance in planning the experiments and interpreting the data. Credit is also given to H. Schmidt, Division of Veterinary Science, and G. S. Fraps, Division of Chemistry, Texas Agricultural Experiment Station, for assistance in planning and conducting the work.

bladders of 7 of the 8 head, indicating that the condition exists among range steers that have not been fed sorghum in dry lot. Numerous experiments [3] at Big Spring, however, have indicated that the calculi disorder is aggravated by the feeding of grain sorghum.

Davidson [4] reported urinary calculi to be the most important deficiency disease in cattle in southwestern Saskatchewan, Canada. Although his investigations indicate that lack of phosphorus is partly the cause of the malady, he states that it is undoubtedly the result of multiple deficiency. According to Davidson, during a normal season in southwestern Saskatchewan the grass ripens and dries out early in July, becoming deficient in phosphorus, vitamins A and D, and protein. Under these conditions urinary calculi trouble makes its appearance in October, reaches its peak in November and December, and then gradually disappears. Incidence of calculi is slight if heavy rainfall occurs during the latter part of the summer and causes a growth of green forage. This investigator reported that the feeding of bonemeal and green cured alfalfa hay during the latter part of the dry summer season practically eliminates calculi trouble in Saskatchewan.

Preliminary tests were conducted at the Big Spring Field Station from 1939 to 1943 to determine the effect of various methods of feeding on urinary calculi. These tests indicated that feeding about 0.17 pound of magnesium carbonate per head daily along with milo grain, cottonseed meal, and sumac silage to fattening steers significantly increased the amount of urinary calculi. The addition of vitamin A or carotene supplement did not influence the incidence of calculi, nor did the substitution of cottonseed hulls for sumac silage have any effect. However, the feeding of milo heads caused a greatly increased calculi formation. Furthermore, it was found that the incidence of calculi varied considerably from year to year with the same ration. In view of these findings and the importance of the problem to the cattle industry of the region, the experiments reported in this bulletin were designed to determine the effect of urinary calculi on beef production and also to find methods of controlling the disorder.

The experiments here reported were begun late in the fall of 1942 and continued for three successive years. They were conducted cooperatively at the Big Spring Field Station, Big Spring, Tex., by the Bureaus of Animal Industry and Plant Industry, Soils, and Agri-

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[3] BLACK, W. H., JONES, J. M., and KEATING, F. E. COMPARISON OF VARIOUS FORMS OF MILO GRAIN FOR FATTENING STEERS IN THE SOUTHERN GREAT PLAINS. U. S. Dept. Agr. Tech. Bul. 581, 16 pp., illus. 1937.

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JONES, J. M., BLACK, W. H., and KEATING, F. E. SORGO SILAGE, SORGO FODDER AND COTTONSEED HULLS AS ROUGHAGES IN RATIONS FOR FATTENING CALVES. Tex. Agr. Expt. Sta. Bul. 363, 36 pp., illus. 1927.

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[4] DAVIDSON, W. B. NUTRITIONAL DEFICIENCY DISEASES, THEIR SOURCES AND EFFECTS. Reprint of paper presented before the annual meeting of the Saskatchewan Veterinary Association at Saskatoon, Saskatchewan, October 6, 1944. Canad. Jour. Compar. Med. 9: 155-162.

cultural Engineering of the United States Department of Agriculture, and the Texas Agricultural Experiment Station.

WEATHER CONDITIONS DURING THE EXPERIMENTS

The temperatures and precipitation at the Big Spring Field Station during the experiments are shown in table 1. Mean temperature ranged from 26° F. in January 1943 to 92° in May 1945, and this range was less than that found in studies made at the same station in previous experiments. Temperatures for similar periods during each of the 3 years of the present experiments were rather uniform. Accordingly, any differences in the results of the experiments, one year with another, could hardly be attributed to differences in temperatures. Although there was considerable variation in the rainfall between years for definite periods, it was not so excessive in any instance as to interfere with the conduct of the experiments.

TABLE 1.—*Temperatures and precipitation at the Big Spring Field Station, Big Spring, Tex., during the experiments*

Month	1942–43			1943–44			1944–45		
	Mean temperatures		Precipitation	Mean temperatures		Precipitation	Mean temperatures		Precipitation
	Maximum	Minimum		Maximum	Minimum		Maximum	Minimum	
	°F.	*°F.*	*Inches*	*°F.*	*°F.*	*Inches*	*°F.*	*°F.*	*Inches*
November	72	39	0.08	67	35	1.17	63	40	2.70
December	59	31	2.81	53	29	2.76	53	29	1.36
January	57	26	.20	58	29	1.05	59	30	.85
February	66	31	.02	60	37	2.62	61	34	.20
March	67	35	.86	68	38	.68	73	44	1.94
April	84	51	.25	81	44	.14	78	46	.00
May	83	57	4.41	89	50	2.00	92	58	.68
Total			8.66			10.72			7.82

EXPERIMENTAL PROCEDURE

Early in November of each year, 48 head of range-bred steer calves born during the spring of that year were selected from the herds at the Sonora and Barnhart, Tex., Ranch Experiment Stations in west-central Texas for use in the experiments. The steers averaged Good to Choice as feeders and were of strictly beef type breeding (fig. 1). They averaged about 437 pounds in weight the first year, 495 the second, and 460 the third. A preliminary period of about 10 days to 3 weeks was given the steers to become accustomed to the feeds and the new environment. They were allotted to 6 groups, as nearly alike as possible with respect to weight, type, conformation, and feeder grade.

As concentrates, all the groups were fed some form of milo or corn, together with cottonseed meal; and as roughage, sumac sorgo silage. To study the effect on the incidence of calculi in the urethra, also, all groups were fed a daily ration of pulverized limestone in varying amounts or bonemeal. In the ration for group 2, ground shelled corn was substituted for milo. Group 6 was fed ground milo heads instead

of milo grain. Group 5 was given cottonseed hulls in place of silage in the first experiment but the cottonseed hulls were discontinued in later experiments, since no apparent benefit was derived. A small quantity of alfalfa leaf meal was fed to group 5, also, to supply approximately the same amount of carotene that was supplied to the other groups by the silage.

FIGURE 1.—Type of feeder steers used in the experiments.

Except for the first period, the grain and cottonseed meal were fed in the ratio of approximately 6 to 1. All groups were allowed as much of the mixture as they desired after getting on full feed.

Silage was kept as constant as possible between groups. In the last 2 years, however, the silage for group 6 was so reduced that about the same amount of bulk was provided in the rations for each group. The silage was reduced on the basis of 3 pounds for each pound of pomace in the milo heads. The cottonseed hulls were fed to group 5 at the average rate of 5.5 pounds per head daily, ranging from about 8 pounds for the first period to about 4 pounds for the last.

The concentrates were thoroughly mixed and then spread over and mixed with the roughage, which was placed in the feed troughs first. The mineral (limestone or bonemeal) was then added and thoroughly mixed with the combined feeds in the trough. Common salt was kept in separate containers and was always before the cattle. The cattle were fed at approximately 8 a. m. and 5 p. m. each day. Any feed refused was removed previous to the next feeding and its weight was deducted from the weight of the feed fed. The steers were fed under shelter. Each group had a total area of about 1,500 square feet. About half of the area was under shed.

Individual weights of steers were taken on three successive days at the beginning and end of each experiment and on 1 day at 28-day intervals throughout each experiment. Weighings were begun

promptly at 1 p. m. and continued without interruption until they were completed. At the end of each experiment the steers were shipped to Fort Worth, Tex., a distance of approximately 275 miles, and slaughtered. The carcasses were graded after being chilled 24 hours. At the time of slaughter the urinary bladders were removed and the calculi therein filtered from the urine. The calculi were taken immediately to the Texas Agricultural Experiment Station, where they were dried and weighed.

RESULTS OF EXPERIMENTS

1942–43 Experiment

The average daily rations and gains per head by periods in the first experiment are given in table 2. With few exceptions all groups consumed essentially the same quantities of feeds within a given period, and the average rations for the entire period for all groups were almost identical. Group 6 consumed an average daily ration of 13.35 pounds of ground milo heads as compared with 11.33 pounds of ground milo grain consumed by the other groups. On a threshed grain basis, the quantities of grain would be essentially the same.

Table 2.—*Average daily rations and gains per steer by periods, 1942–43*

Group No.	Feed and gain [1]	28-day period No.— 1	2	3	4	5	6	7 [2]	Average for 182 days
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	Ground milo grain	4.79	8.43	10.88	12.93	14.49	15.00	14.04	11.39
	Cottonseed meal	1.02	1.41	1.81	2.16	2.41	2.59	2.34	1.92
	Sumac silage	18.91	16.68	13.89	12.04	12.18	12.00	11.29	14.1[illegible]
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	1.51	2.10	2.31	2.97	2.33	2.61	.99	2.29
2	Ground shelled corn	5.88	8.93	10.53	12.94	14.49	14.70	13.71	11.29
	Cottonseed meal	1.04	1.41	1.75	2.16	2.41	2.46	2.29	1.91
	Sumac silage	19.32	16.68	13.71	12.04	12.18	12.00	11.29	14.18
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	1.75	2.25	2.71	2.85	2.73	2.49	1.36	2.37
3	Ground milo grain	4.88	8.80	10.85	12.93	14.49	15.00	14.04	11.38
	Cottonseed meal	1.04	1.40	1.81	2.16	2.41	2.59	2.34	1.92
	Sumac silage	19.32	16.60	13.86	12.04	12.19	12.00	11.29	14.20
	Limestone	.12	.12	.12	.12	.12	.12	.12	.12
	Average daily gain	1.26	2.21	2.73	2.78	2.66	2.59	1.71	2.32
4	Ground milo grain	4.88	8.93	10.49	12.93	14.14	14.92	14.04	11.32
	Cottonseed meal	1.04	1.41	1.75	2.16	2.41	2.49	2.34	1.91
	Sumac silage	19.32	16.68	13.50	12.04	12.16	11.93	11.29	14.13
	Bonemeal	.27	.37	.46	.48	.51	.54	.43	.41
	Average daily gain	1.54	2.29	2.12	2.72	2.42	2.53	1.17	2.20
5	Ground milo grain	4.82	8.93	10.58	12.93	14.96	15.00	14.04	11.26
	Cottonseed meal	1.03	1.41	1.76	2.16	2.33	2.59	2.31	1.90
	Cottonseed hulls	8.33	7.17	5.00	4.67	4.30	4.25	4.09	5.50
	Alfalfa leaf meal	.33	.27	.21	.29	.33	.34	.32	.30
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	1.08	2.18	1.92	3.07	2.17	2.54	2.27	2.27
6	Ground milo heads	4.88	8.85	10.87	13.72	19.27	20.03	18.79	13.[illegible]
	Cottonseed meal	1.01	1.40	1.82	2.17	2.12	2.59	2.36	1.97
	Sumac silage	18.32	16.16	13.88	12.72	12.21	12.00	11.12	14.02
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	1.56	2.76	1.90	2.77	2.61	1.96	2.51	2.10

[1] Formulated common salt was fed free choice to all groups.
[2] This period had 11 days only.

Group 5 consumed an average of 5.50 pounds of cottonseed hulls per day, which seemingly was about equal to the 14 pounds of sumac silage consumed by the other groups, as measured by gains in weight. Consumption of concentrates gradually increased through the first six 28-day periods, or 168 days. During the last 14 days, or from 168 to 182 days, however, the average ration of concentrates decreased, indicating that the steers were reaching a rather high degree of finish at the end of 168 days. The roughage, on the other hand, showed a gradual decrease as the test progressed.

The average daily gains for the steers in all groups reached their maximum in the fourth period. For the most part, the rate of gain was rather consistent for all groups throughout the test. Groups 1, 2, 3, and 4, however, showed a noticeable decrease in gains during the last 14 days.

The average gains, amount of calculi in the bladders, feed consumption, and carcass grades for the steers in the first experiment are given in table 3. The gain was greatest in group 2, which received ground shelled corn in place of ground milo, and smallest in group 6, fed ground milo heads. The average amount of calculi in the bladders was smallest in the group receiving corn and largest in the one receiving milo heads, indicating a close relationship between the kind of grain fed and the amount of calculi in the bladders. The average gains in each group were highly satisfactory and were not materially affected

TABLE 3.—*Summary of results of the first experiment, Nov. 11, 1942, to May 12, 1943 (182 days)*

Item		Group 1 (fed ground milo grain, 0.06 pound limestone)	Group 2 (fed ground shelled corn, 0.06 pound limestone)	Group 3 (fed ground milo grain, 0.12 pound limestone)	Group 4 (fed ground milo grain, 0.44 pound bonemeal)	Group 5 (fed ground milo grain, cottonseed hulls, alfalfa leaf meal, 0.06 pound limestone)	Group 6 (fed ground milo heads, 0.06 pound limestone)
Steers	number	7	8	8	8	8	7[1]
Average initial weight	pounds	500	499	497	494	496	496
Average final weight	do	901	923	920	899	905	860
Average gain	do	401	433	423	400	409	383
Average daily gain	do	2.20	2.38	2.32	2.20	2.25	2.10
Average amount of calculi in bladders	grams	1.01	.05	1.45	.22	1.44	4.35
Average feed consumed per 100 pounds of gain:							
Grain	pounds	517	475	490	515	501	534
Cottonseed meal	do	87	80	83	87	85	93
Sorgo silage or hulls	do	612	596	614	613	215	669
Alfalfa leaf meal	do					14	
Efficiency[2]	do	17.45	18.80	18.37	17.17	17.32	15.15
Carcass grade[3]	score	12.30	12.00	12.50	13.00	11.75	11.67

[1] One steer was removed from the experiment owing to chronic bloating and its records were not included in the results.

[2] Two steers were removed in January on account of calculi, and their records, other than those for calculi, were not included in the results.

[3] Pounds of steer gain per 100 pounds of digestible nutrients consumed. Digestibility factors used: Milo grain, 79.9; milo heads, 77.4; shelled corn, 80.6; cottonseed meal, 73.13; sumac silage, 15.1; cottonseed hulls, 43.7; alfalfa leaf meal, 57.4.

[4] Grade scores: Choice, 8-12, inclusive; Good, 14-18, inclusive; Commercial, 20-24, inclusive; and Utility, 26-30, inclusive.

by the amount of urinary calculi in the bladders. The feeding of 0.12 pound of limestone per head daily slightly increased the incidence of calculi over that resulting from the feeding of 0.06 pound. The amount of urinary calculi in the group fed bonemeal instead of limestone was relatively low. The feeding of 5.5 pounds of cottonseed hulls with 0.3 pound of alfalfa leaf meal, in place of about 14 pounds of sumac silage, seemingly did not affect the calculi picture.

Two steers suffering from calculi formation in the urinary tract were removed from the group fed milo heads after being on feed approximately 2 months. When slaughtered, they were found to have a comparatively small amount of calculi in the bladder but rather large calculi were lodged in the urethra.

In efficiency of feed utilization, the groups fed milo grain and shelled corn had considerable advantage over the group fed milo heads. The last-mentioned group had the least desirable carcasses of any of the groups, but there was no material difference among any of the carcasses. In view of the fact that two steers in the group fed milo heads had to be removed from the experiment owing to calculi trouble, this group appeared to be the least satisfactory one.

1943–44 Experiment

The average daily rations and gains per head by periods in the second experiment are given in table 4. The average rations by periods were essentially the same in all groups and slightly less than those for the previous year. The steers used in 1943–44 averaged about 58 pounds less at the beginning of the test than those of the first year, consequently, on a weight basis there was little difference in the daily rations between years. For groups 3 and 6, fed milo grain with 0.12 pound of limestone and milo heads with 0.06 pound of limestone, respectively, the consumption of concentrates increased rather gradually through the first five periods. The other groups showed a further increase in the sixth period. There was a gradual reduction in roughage consumption from period to period but it was essentially the same for all groups. As already indicated, the silage was fed at a lower level to group 6 because of the additional roughage contained in the milo heads fed to this group.

The rate of gain reached its maximum in the third period for three of the groups and in the fourth period for the remaining ones. The gains, however, were consistent throughout the test, and there was no marked difference between any of the groups for the first 168 days. In the last 14 days the group 5 steers, fed no mineral other than salt, gained less than a half pound per head daily. The group 2 steers, fed shelled corn, and the group 3 steers, fed milo grain with 0.12 pound of limestone, also showed a noticeable decrease in rate of gain during the last 14 days.

The average gains, amount of calculi in the bladders, feed consumption, and carcass grades of the steers in the second experiment are given in table 5. The average gains of all groups were highly satisfactory. As in the previous test, there did not seem to be a close correlation between rate of gain and amount of urinary calculi, but there appeared to be a close relationship between the kind of grain fed and the amount of calculi formed. Again the group fed milo

TABLE 4.—*Average daily rations and gains per steer by periods, 1943–44*

Group No.	Feed and gain [1]	28-day period No. — 1	2	3	4	5	6	[2] 7	Average for 182 days
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	Ground milo grain	4.33	8.03	10.70	12.59	14.10	14.43	12.19	10.81
	Cottonseed meal	1.42	1.32	1.78	2.10	2.35	2.40	2.03	1.91
	Sumac sorgo silage	19.79	17.14	14.65	13.95	12.27	11.93	10.40	14.44
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.32	1.95	2.74	2.84	2.64	2.23	1.70	2.40
2	Ground shelled corn	4.33	8.10	10.59	12.61	13.57	14.05	12.07	10.66
	Cottonseed meal	1.42	1.32	1.78	2.10	2.26	2.35	2.00	1.88
	Sumac sorgo silage	19.79	17.35	14.48	12.82	12.23	11.93	10.41	14.43
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.32	2.49	2.42	2.71	2.46	2.20	1.29	2.34
3	Ground milo grain	4.33	8.10	10.70	12.47	13.99	13.78	12.01	10.67
	Cottonseed meal	1.42	1.32	1.78	2.10	2.33	2.29	2.00	1.88
	Sumac sorgo silage	19.79	17.36	14.65	12.89	12.27	11.93	10.41	14.47
	Limestone	.12	.12	.12	.12	.12	.12	.12	.12
	Average daily gain	2.19	2.48	2.52	2.88	2.79	2.40	1.24	2.44
4	Ground milo grain	4.33	8.10	10.70	12.61	14.07	14.31	12.82	10.85
	Cottonseed meal	1.42	1.32	1.78	2.10	2.35	2.38	2.13	1.91
	Sumac sorgo silage	19.79	17.36	14.65	12.83	12.23	11.93	10.41	14.46
	Bonemeal	.27	.37	.46	.48	.54	.54	.43	.44
	Average daily gain	1.95	2.41	3.10	2.47	2.96	2.32	1.51	2.46
5	Ground milo grain	4.33	7.95	10.34	12.61	14.10	14.64	13.14	10.85
	Cottonseed meal	1.42	1.32	1.77	2.09	2.35	2.44	2.18	1.92
	Sumac sorgo silage	19.79	16.98	14.17	12.83	12.23	11.90	10.41	14.32
	Average daily gain	2.37	1.06	2.72	2.38	2.40	2.76	.41	2.27
6	Ground milo heads	5.08	10.28	14.07	15.47	17.53	16.91	15.18	13.51
	Cottonseed meal	1.42	1.32	1.76	1.95	2.20	2.11	1.90	1.80
	Sumac sorgo silage	17.12	15.00	11.43	9.03	8.09	7.18	5.92	10.90
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.34	1.80	2.92	2.52	2.45	2.43	1.49	2.45

[1] Granulated common salt was fed free choice to all groups.
[2] This period had 14 days only.

TABLE 5.—*Summary of results of the second experiment, Nov. 3, 1943, to May 3, 1944 (182 days)*

Item	Group 1 (fed ground milo grain, 0.06 pound limestone)	Group 2 (fed ground shelled corn, 0.06 pound limestone)	Group 3 (fed ground milo grain, 0.12 pound limestone)	Group 4 (fed ground milo grain, 0.44 pound bonemeal)	Group 5 (fed ground milo grain, no mineral but common salt)	Group 6 (fed ground milo heads, 0.06 pound limestone)
Steers ... number	[1] 7	8	[1] 7	8	8	8
Average initial weight ... pounds	440	434	435	438	435	441
Average final weight ... do	877	860	879	885	849	869
Average gain ... do	437	426	444	447	414	428
Average daily gain ... do	2.40	2.34	2.44	2.46	2.27	2.35
Average amount of calculi in bladders ... grams	4.553	.192	1.160	.925	.680	12.65
Average feed consumed per 100 pounds of gain:						
Grain ... pounds	450	455	437	442	477	575
Cottonseed meal ... do	79	81	77	78	85	77
Sorgo silage ... do	602	617	593	589	630	463
Efficiency [2] ... do	19.64	19.24	20.20	20.06	18.61	17.51
Carcass grade [3] ... score	12.00	12.25	12.00	12.50	11.50	12.75

[1] One steer died in January and its records were not included in the results.
[2] See footnote 3, table 3.
[3] See footnote 4, table 3.

heads had the greatest amount of calculi and the corn-fed group the least, but both groups had considerably more calculi than those in the 1942–43 test. Group 5, fed no mineral other than salt, although making only slightly less gain than the other groups, had a comparatively small amount of urinary calculi. In contrast with the results of the 1942–43 test, the group receiving 0.12 pound of limestone per head daily, group 3, had considerably less urinary calculi than the groups receiving 0.06 pound, with one exception—group 2. In the 1943–44 experiment, it was not necessary to remove any steers because of calculi trouble. Two steers died late in January as a result of malignant edema.

In efficiency of feed utilization, there was little difference between the groups. However, group 5, fed no mineral other than common salt, and group 6, fed milo heads, required the most feed per 100 pounds of gain, and accordingly were less efficient in producing gains. There were no significant differences in carcass grades between the several groups, as all were within the low Choice grade.

1944–45 Experiment

The average daily rations and gains per head by periods in the third experiment are given in table 6. At the beginning of the test the steers were intermediate in weight to those used in the previous tests. All groups consumed slightly more feed in the first and third periods than those used in the two preceding years. However, all except group 5 consumed slightly less for the entire period of 182 days. For four of the groups, the consumption of concentrates increased gradually through the sixth period. Groups 1 and 3, fed ground milo grain with 0.06 and 0.12 pound of limestone, respectively, reached their maximum consumption of concentrates in the fifth period. Except for group 6, the consumption of silage was slightly greater than during the two preceding tests. It gradually decreased from about 24 pounds per head daily during the first period to about 11 pounds at the end of the test.

Groups 1 and 2, fed milo grain and shelled corn, respectively, with 0.06 pound of limestone, and group 4, fed milo grain with bonemeal, reached their maximum rate of gain in the third period, whereas other groups had their maximum gain in the fourth or fifth period. There were noticeable decreases in the rate during the second period for all groups and for most of the groups during the last 14 days. The gains as a whole were similar to those of the first year, but slightly less than those of the second year.

The average gains, amount of calculi in the bladders, feed consumption, and carcass grades of the steers in the third experiment are given in table 7. Again the gains in all groups were satisfactory and the differences between groups were of little importance. As in the first two experiments there appeared to be no correlation between gains and the amount of calculi in the bladders; furthermore, group 6, fed milo heads and 0.06 pound of limestone, had the most calculi in the bladders and made the least gain. Group 3, fed milo grain and 0.12 pound of limestone, made essentially the same gain but had less than one-fifth as much calculi. Group 1, fed milo grain and 0.06 pound of limestone, made 0.1 pound greater daily gain than group 3 but,

TABLE 6.—*Average daily rations and gains per steer by periods, 1944–45*

Group No.	Feed and gain [1]	28-day period No.— 1	2	3	4	5	6	7 [2]	Average for 182 days
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	Ground milo grain	5.14	8.04	11.30	12.15	13.01	12.75	12.20	10.54
	Cottonseed meal	1.50	1.36	1.88	2.02	2.17	2.12	2.03	1.86
	Sumac silage	23.91	18.85	16.07	14.12	12.70	11.88	11.18	15.95
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.33	1.84	2.74	2.46	2.42	2.20	1.31	2.26
2	Ground shelled corn	5.12	7.95	11.11	11.93	12.83	13.00	11.48	10.11
	Cottonseed meal	1.50	1.35	1.85	1.99	2.14	2.17	1.91	1.84
	Sumac silage	23.90	18.53	16.62	14.12	12.54	12.00	10.74	15.86
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.98	2.02	2.88	2.37	2.59	1.85	1.40	2.37
3	Ground milo grain	5.14	7.74	11.21	11.63	13.42	12.34	11.40	10.34
	Cottonseed meal	1.50	1.32	1.86	1.93	2.23	2.06	1.90	1.82
	Sumac silage	23.98	17.95	16.50	13.58	12.03	11.92	11.39	15.79
	Limestone	.12	.12	.12	.12	.12	.12	.12	.12
	Average daily gain	2.54	1.62	2.60	2.11	2.68	1.92	1.13	2.16
4	Ground milo grain	5.14	7.69	11.39	12.28	13.00	14.33	12.68	10.78
	Cottonseed meal	1.50	1.27	1.88	2.05	2.17	2.38	2.11	1.89
	Sumac silage	23.98	18.34	16.69	13.06	12.32	11.03	11.18	15.82
	Bonemeal	.27	.37	.46	.48	.48	.48	.48	.43
	Average daily gain	2.90	1.79	2.64	2.63	2.50	2.00	.99	2.30
5	Ground milo grain	5.14	7.94	11.19	12.52	13.81	14.71	13.25	11.07
	Cottonseed meal	1.50	1.31	1.86	2.09	2.30	2.45	2.26	1.94
	Sumac silage	23.98	18.71	16.52	14.12	12.79	12.00	11.18	15.96
	Average daily gain	2.57	1.64	2.58	2.58	2.59	2.34	.52	2.24
6	Ground milo heads	6.57	10.54	14.43	15.26	15.95	16.44	14.50	13.30
	Cottonseed meal	1.50	1.33	1.82	1.91	2.00	2.06	1.81	1.77
	Sumac silage	19.08	11.78	10.40	9.56	8.72	8.00	7.57	10.97
	Limestone	.06	.06	.06	.06	.06	.06	.06	.06
	Average daily gain	2.14	1.96	2.47	2.63	2.10	2.00	1.02	2.14

[1] Granulated common salt was fed free choice to all groups.
[2] This period had 14 days only.

TABLE 7.—*Summary of results of the third experiment, Nov. 1, 1944, to May 2, 1945 (182 days)*

Item		Group 1 (fed ground milo grain, 0.06 pound limestone)	Group 2 (fed ground shelled corn, 0.06 pound limestone)	Group 3 (fed ground milo grain, 0.12 pound limestone)	Group 4 (fed ground milo grain, 0.44 pound bonemeal)	Group 5 (fed ground milo grain, no mineral but common salt)	Group 6 (fed ground milo heads, 0.06 pound limestone)
Steers	number	8	8	[1] 7	8	8	8
Average initial weight	pounds	463	460	466	457	463	459
Average final weight	do	874	892	850	876	861	848
Average gain	do	411	432	393	419	398	389
Average daily gain	do	2.26	2.37	2.16	2.30	2.21	2.14
Average amount of calculi in bladders	grams	2.963	.038	.826	.153	.354	4.560
Average feed consumed per 100 pounds of gain:							
Grain	pounds	467	439	479	468	494	622
Cottonseed meal	do	82	78	85	82	87	83
Sorgo silage	do	706	668	731	687	712	513
Efficiency [2]	do	18.50	19.00	17.97	18.51	17.62	16.09
Carcass grade [3]	score	11.50	11.75	12.57	10.75	12.50	12.00

[1] One steer died in January and its records were not included in the results.
[2] See footnote 3, table 3.
[3] See footnote 4, table 3.

on the other hand, had three and one-half times as much calculi. Group 4, fed milo grain and bonemeal, made practically the same gain as group 1 but had considerably less calculi. Group 5, fed no mineral other than salt, made about average gain but was considerably below the average in amount of calculi. One steer in this group evidently had been suffering from calculi trouble as its carcass, although grading Choice so far as finish was concerned, was condemned because of uremic poisoning. In group 4 also, one steer showed symptoms of calculi trouble toward the close of the test. The group fed corn was the most efficient as it produced the most gain from a given unit of feed. The group fed milo heads was the least efficient as in the two preceding tests.

There was essentially no difference in the carcass grades of the various groups as all averaged within the Choice grade. Group 4, which received bonemeal, had, on the average, slightly the highest finish. Figure 2 shows the group 5 steers at the end of the test. The condition of these steers is typical of that of the other groups.

FIGURE 2.—Group 5 steers (fed no mineral other than common salt) at the end of the 1944–45 experiment.

AVERAGE RESULTS OF THE THREE EXPERIMENTS

It was evident each year that the kind of grain fed had a closer relationship to the incidence of calculi than did the kind of mineral supplement fed. In 2 of the 3 years, the steers fed shelled corn (group 2) and the low limestone level made the greatest average gain and in all 3 years had the least calculi in the bladders (table 8). On the other hand, the steers in group 6, fed ground milo heads, made the least gain in 2 years, and each year had the greatest amount of calculi in their bladders. The difference in average gains between groups 2 and 6 for the 3-year period was significant ($p<0.05$).[4]

[4] SNEDECOR, G. W. STATISTICAL METHODS APPLIED TO EXPERIMENTS IN AGRICULTURE AND BIOLOGY. Ed. 3, 442 pp., illus. Ames, Iowa, 1940.

TABLE 8.—*Amount of calculi in bladder and total gain of individual steers in each of the six groups for the three experiments*

Group No.	Rations used [1]	1942–43 experiment [2]			1943–44 experiment [3]			1944–45 experiment [4]		
		Steer No.	Amount of calculi	Total gain	Steer No.	Amount of calculi	Total gain	Steer No.	Amount of calculi	Total gain
			Grams	*Lb.*		*Grams*	*Lb.*		*Grams*	*Lb.*
1	Ground milo grain, cottonseed meal, sorgo silage, and 0.06 pound limestone	8	1.160	346	6	0.05	488	1	0.340	470
		20	.030	398	12	.27	493	3	1.015	461
		17	.525	422	15	11.20	401	4	.157	346
		34	.065	414	16	8.74	457	24	.128	469
		31	3.220	402	29	4.62	414	29	.045	354
		26	0	392	36	1.79	445	32	10.415	350
		47	2.055	438	42	5.20	385	47	.060	426
		....	....	....	....	....	....	53	2.502	418
	Average	....	1.006	402	....	4.553	437	....	2.063	412
2	Same as for group 1 except ground shelled corn instead of milo	13	0	475	2	1.20	437	6	.008	474
		10	0	436	10	.04	461	7	0	470
		7	0	421	23	0	404	13	.095	464
		27	0	459	26	0	489	15	.025	385
		33	0	435	27	.180	410	25	.093	385
		36	0	427	30	0	431	34	.015	470
		38	.345	400	31	0	355	48	.100	420
		5	.050	398	34	.12	385	49	.050	303
	Average	....	.040	432	....	.192	425	....	.038	432
3	Same as for group 1 except 0.12 pound limestone	15	.125	368	17	.03	573	9	2.775	405
		1	.770	368	19	.03	338	10	.520	459
		10	2.050	446	28	.65	428	16	.025	455
		40	.800	481	32	1.00	435	21	.045	368
		30	0	424	33	1.75	489	31	1.148	303
		42	.400	458	45	.37	470	33	.074	323
		45	6.370	430	50	4.20	378	37	1.188	390
		12	1.100	410	....	....	....	....	....	....
	Average	....	1.452	423	....	1.16	444	....	.826	393
4	Same as for group 1 except 0.42–0.44 pound bonemeal instead of limestone	3	0	438	18	1.85	151	11	1.330	365
		14	.085	337	21	5.20	475	19	.000	410
		23	1.000	377	22	0	423	20	.040	422
		50	0	365	24	.10	420	26	0	448
		44	0	391	25	0	466	35	.080	407
		48	0	434	38	.25	434	39	0	393
		39	.050	438	39	0	421	41	0	434
		16	0	417	46	0	478	45	.010	405
	Average	....	.216	400	....	.925	447	....	.183	410
5	Same as for group 1 except no mineral other than salt in last 2 tests: cottonseed hulls and alfalfa leaf meal fed in place of silage in first test	21	0	347	48	.15	409	12	2.122	401
		9	.475	380	3	1.61	423	17	.048	357
		4	4.160	391	4	0	357	18	.122	391
		25	1.650	442	8	.63	394	30	.091	422
		49	2.170	413	13	.06	446	36	.429	360
		28	2.385	500	20	0	469	43	0	409
		37	0	383	40	2.85	390	46	.050	476
		6	.050	406	41	.10	428	52	.030	350
	Average	....	1.430	409	....	.68	414	....	.351	408
6	Same as for group 1 except ground milo heads instead of milo grain	11	0	346	1	.11	388	2	.110	395
		2	0.350	364	5	37.73	387	5	2.730	347
		32	0	414	11	3.60	386	8	.150	401
		40	14.710	415	35	.08	395	11	1.560	410
		41	.975	406	37	5.60	578	23	12.600	396
		21	1.070	360	43	7.27	434	27	5.385	392
		....	....	....	44	13.90	431	28	.652	446
		....	....	....	47	32.85	419	42	13.160	326
	Average	....	4.351	383	....	12.651	428	....	4.800	389

[1] Common salt was fed ad libitum to all groups.

[2] One steer in group 1 was removed from experiment at the close of test because of chronic bloating; his records were considered to be seriously affected by this condition. Two in group 6 were slaughtered on January 20 and February 13, respectively, because of calculi in the urethra. Results from these three animals were not included in averages.

[3] One steer in group 1 and one in group 3 died late in January from malignant edema. Their results were not included in averages.

[4] One steer in group 3 was removed from experiment on January 12 because of forage poisoning; results from this animal were not included in averages. Steer No. 11 in group 4 and steer No. 12 in group 6 showed evidence of calculi in the urethra at the end of the test; and steer No. 12 in group 5, although showing no evidence of calculi trouble before slaughter, was found, at time of slaughter, to have uremic poisoning, and its carcass was condemned.

Differences in amounts of calculi in these groups were highly significant. Group 4 steers, fed ground milo grain and bonemeal in place of limestone, ranked next to group 2, fed shelled corn in average gain and low calculi content for the 3-year period.

In the first year, six of eight steers in group 2 had no calculi in their bladders; in the second year four of eight steers were free from calculi; and in the third year one of eight steers had none. In the 3 years only one steer in group 2, fed shelled corn, had as much as 1 gram of calculi in the bladder. This group, therefore, was practically free from calculi each year. It would appear that replacing milo grain with shelled corn controlled the calculi formation to such an extent that the feed-lot performance was not affected adversely by the presence of calculi in the urinary system. Even though the calculi could be largely controlled by feeding corn in place of milo, the problem was to prevent or control the formation of calculi when milo was fed as the latter grain is the predominating carbohydrate concentrate in the region.

In group 4, as indicated above, the feeding of bonemeal at a rather high level tended to reduce the incidence of calculi, as compared with the results obtained with groups 1, 3, 5, and 6. In the first year five of eight steers had no calculi; in the second year, four of eight; and in the last year three of eight. The differences in gains between groups 4 and 6 were not statistically significant, but differences in amounts of calculi were highly significant ($p. < 0.01$). Differences between other groups in these respects were not significant.

The feeding of cottonseed hulls in place of silage, together with a small quantity of alfalfa leaf meal to supply about the same amount of carotene as would be contained in the silage (group 5 in the first year's experiment) seemingly did not influence the formation of calculi in the bladder. The use of no mineral other than salt (group 5 during the last 2 years), as compared with a low level of limestone, likewise had little effect on the amount of calculi. In group 5 there were two steers with no calculi in the 1943–44 test and one steer with no calculi in the last year. The average amount of calculi in the bladder per steer in group 5 over the 2-year period was 0.515 gm., which was similar to the 3-year average of 0.441 gram for group 4, fed bonemeal.

In 2 of the 3 years group 2 fed shelled corn was the most efficient, as it produced the most gain for a given unit of feed. This group also averaged slightly higher in this respect for the 3-year period, but this increased efficiency over that of the various groups fed ground milo grain was relatively unimportant. The steers fed milo heads were, to a considerable extent, the least efficient in their production of steer gains. The difference was statistically significant. These factors further indicate that although the rate of gain was not materially affected by the amounts of calculi in the bladders, there may be a relationship between the incidence of calculi and the efficiency of feed utilization. Group 2, fed shelled corn, for instance, had the greatest efficiency and the least calculi over the 3-year period, whereas group 6, fed milo heads, had the least efficiency and the most calculi.

The average carcass grade for all groups was low Choice, indicating that the carcass grade was not affected by the incidence of calculi.

SUMMARY AND CONCLUSIONS

Experiments made to study the effect of urinary calculi on beef production and methods of controlling the disorder in steers on fattening rations were conducted for 3 years at the Big Spring Field Station, Big Spring, Tex. The work was carried on cooperatively by the Bureaus of Animal Industry and Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture and the Texas Agricultural Experiment Station. Each experiment was begun early in November and extended over a period of 182 days. Six groups consisting of eight head each of Good to Choice grade steer calves were selected for each experiment. As concentrates they were fed some form of milo or corn, together with cottonseed meal; as roughage, sumac sorgo silage. The following variations in feeding were studied to determine their effect on the incidence of calculi: Including in the ration pulverized limestone in varying amounts or bonemeal; in group 2, substituting ground shelled corn for milo; in group 6, feeding ground milo heads instead of ground milo grain. In group 5, cottonseed hulls and a small quantity of alfalfa leaf meal were used in place of silage in the first year. The roughage was kept as constant as possible between groups in all tests. For the most part, the grain and cottonseed meal were fed in the ratio of approximately 6 to 1, but all groups were fed as much as the steers desired after getting on full feed.

The results of these experiments indicate that calculi formation in the bladders of the steers was closely related to the feeding of milo grain and to a lesser extent to a lack of phosphorus in the ration. The tests indicated that calculi could be controlled to a considerable degree and prevented in many cases by feeding corn as the carbohydrate concentrate in a sumac-silage and cottonseed-meal ration for fattening steers, and also by supplying additional phosphorus in the form of bonemeal.

Although calculi were definitely associated with the feeding of milo, it was evident that their incidence was influenced by the form in which the milo was fed. Each year the amounts of calculi in the bladders of the steers fed ground milo heads were consistently greater than in those fed ground milo grain.

Over the 3-year period, a high percentage of the steers fed approximately 0.43 pound of bonemeal per head daily were free from calculi in their bladders.

Although the formation of calculi was not significantly influenced by the calcium level in the ration, there was a tendency toward a smaller amount of calculi in steers fed 0.12 pound of limestone per head daily than in those fed 0.06 pound.

The results of these experiments, although not conclusive, indicated that the formation of urinary calculi in steers being fattened on grain sorghums may be controlled to a considerable extent by using the threshed grain rather than the heads, and by supplementing the ration with phosphorus.

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