ABSTRACT OF THESIS

ALFALFA HAY SUPPLEMENT AS COMPARED TO FISH LIVER OIL IN THE VITAMIN A NUTRITION OF EASTERN COLORADO BEEF CATTLE

Submitted by

Marvin E. Kniese

In partial fulfillment of the requirements

for the Degree of Master of Science

Colorado A and M College

Fort Collins, Colorado

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ABSTRACT

In order to study the comparative values of alfalfa hay and fish liver oil as vitamin A supplements, thirty-eight steer calves divided into four groups, were fed common dry land rations throughout a wintering and fattening phase, separated by a summer range interval during which time the steers grazed together in one pasture. Three of the lots received a cane ration while the fourth lot was wintered on range. Two of the cane fed lots were given a vitamin A supplement, one receiving fish liver oil and the other a small quantity of alfalfa hay to provide carotene equivalent in vitamin A value to the fish liver oil supplement. Individual, one-day weights were taken monthly, and two-day weighings were made at the beginning and conclusion of each phase of the experiment. Samples of all feeds including range grass were analyzed for dry matter, nitrogen, and carotenoids. Blood serum was analyzed for carotene, vitamin A, calcium and phosphorus.

TABLE I. ALLOTTING AND FEEDING PLAN - AKRON STEERS (1945-7)

Lot No.	I	II	III	IV
No. of Animals	10	10	10	8 [1]
Av. In. Wt.	418.75	418.50	420.83	432.50
Winter Ration	Chopped Cane Soy Bean Meal Mineral Mix [2] Salt [3]	Chopped Cane Soy Bean Meal Mineral Mix Salt Vit. A Oil	Chopped Cane Soy Bean Meal Mineral Mix Salt Alfalfa Hay [4]	Soy Bean Meal Mineral Mix Salt Native Pasture
Summer Ration	Native dry land pasture and salt (all steers together)			
Fattening Ration	Ground Barley Ground Coes Chopped Cane Soy Bean Meal Mineral Mix [2] Salt [3]	Ground Barley Ground Coes Chopped Cane Soy Bean Meal Mineral Mix Salt Vit. A Oil	Ground Barley Ground Coes Chopped Cane Soy Bean Meal Mineral Mix Salt Alfalfa Hay [4]	Ground Barley Ground Coes Chopped Cane Soy Bean Meal Mineral Mix Salt

1. Only 8 animals on winter pasture because fire reduced pasture area prior to beginning of experiment.
2. 2 parts limestone, 2 parts steamed bone meal, and 1 part salt self fed to all lots.
3. Salt self fed to all lots.
4. Fed as a supplement to supply carotene equivalent to vitamin A in oil fed to lot II. Chopped cane and soy bean meal reduced to equalize dry matter and protein intake.

Within the limitations of criteria such as weight gains, blood serum and liver carotene and vitamin A, and absence of deficiency symptoms, it may be concluded from this investigation that common dry land rations provided for adequate vitamin A nutrition in beef steers. Alfalfa hay as a vitamin A supplement was equal to, and in some instances, more effective than fish liver oil in the maintenance of blood serum carotene and vitamin A levels. Furthermore, alfalfa hay produced a better general appearance and appetite during wintering and fattening than did the oil supplement.

While fresh green grass and cereal grains each increased strikingly, the ratio of serum vitamin A to serum carotene, generally an inverse relationship between this ratio and serum carotene level was observed. The establishment of serum vitamin A level always lagged behind that for serum carotene with changing levels of carotene consumption. Depression of serum carotene and calcium levels was associated with increasing serum vitamin A, especially when the level of serum vitamin A was relatively high.

Greater gains during winter growth were reflected in smaller gains during following summer growth, and vice versa, but with respect to overall gain or final slaughter value, no significant differences appeared between lots or outcome groups.

Extremely low serum phosphorus levels indicated that summer range was deficient in phosphorus.

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In partial fulfillment of the requirements

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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

October 20 1947

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Marvin E. Kniese

ENTITLED ALFALFA HAY SUPPLEMENT AS COMPARED TO FISH LIVER OIL IN THE VITAMIN A NUTRITION OF EASTERN COLORADO BEEF CATTLE.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

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Permission to publish this thesis or any part of it must be obtained from the Dean of the Graduate School.

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INTRODUCTION

The research reported in this thesis was undertaken to secure information pertinent to two important questions confronting the Colorado cattle producer, namely: (1) Is it necessary to supplement common dryland beef steer rations with vitamin A?; and (2) Should vitamin A be supplied in the beef steer ration in the form of carotene in alfalfa hay supplement, or, per se, from fish liver oil concentrate? The investigation was carried out with Hereford steers wintered as calves, pastured during the summer, and fattened as yearlings the following winter.

In certain years vitamin A deficiency has been observed in cattle in Colorado. Such deficiency has appeared more frequently in the Eastern plains section of the state, which husbands sixty per cent of the cattle population (57) and produces feed of low provitamin A content (60). General lack of thrift, eye and respiratory disorders, calf diarrhea, poor reproductive performance, and occasional classical vitamin A deficiency symptoms as described by Schmidt (51), Jones, et al, (33), and Barron (1) have been reported. Unfortunately, only a small part of the alfalfa hay, commonly recognized as a rich source of vitamin A, which is produced on farms in adjacent areas, reaches the plains cattle region where it may be often needed to supplement winter rations.

REVIEW OF THE LITERATURE

Considerable information concerning the vitamin A requirement of cattle is now available. Most of the pertinent literature, however, relates to minimum vitamin A requirements determined after depletion of vitamin A reserves. Results applicable to supplementing standard dry land rations for cattle during wintering and fattening have not been reported for this area.

Schmidt (51), and Dickson and Jones (13) observed vitamin A deficiency symptoms after 116 days in steer calves fed a slightly modified fattening ration. Jones and co-workers (33) demonstrated early stage night blindness at 45 days in steer calves receiving a fattening ration devoid of vitamin A. Yearling beef steers being fattened on dried beet pulp, molasses, barley, and cottonseed meal in California (21) were found to develop acute vitamin A deficiency syndrome in 225 days, and the vitamin A reserves were practically exhausted at 282 days. Later the California investigators (22) published data showing the minimum carotene requirement for cattle to be 26 to 33 micrograms per kilogram of body weight daily. In subsequent trials (23), (24) the minimum carotene requirement was confirmed and the minimum vitamin A requirement was set at 5.1 to 6.3 micrograms per kilogram live weight per day. These workers also observed that carotene from alfalfa meal was equal to carotene in oil for cattle (24), but state (23) that the optimum level far exceeds the minimum requirement. Jones and co-workers (32) recommended a minimum consumption of 1500 micrograms of carotene per

100 lbs. live weight per day, but later (31) found advanced vitamin A deficiency symptoms in calves and early symptoms in yearlings after 196 days on a ration allowing 2000 micrograms of carotene per 100 pounds daily, derived from alfalfa leaf meal, forage sorghum silage, or grain sorghum silage. These investigators reported that steers on a fattening ration were unable to consume enough grain sorghum silage to meet minimal carotene requirements, after the silage had been stored a few months. Riggs (49) found that a daily intake of 1000 micrograms of carotene per hundred weight daily lengthened by only 15 days the period before deficiency symptoms occurred.

Halverson, Hostetler, Foster, and Sherwood (26) indicated that 43 to 55 International units of vitamin A per kilogram body weight daily is the minimum safe intake for cattle. Nylund and With (46) recommended 38-80 micrograms of carotene per kilogram body weight as a minimum for warm blooded animals. Moore, Berry, and Sykes (42) suggested a minimum intake of 66 micrograms of carotene per kilogram for dairy calves, while Nelson (45), working with the same group, found beef calves to have slightly but significantly higher plasma vitamin A and carotene at similar ages and levels of intake. Lewis and Wilson (39) published data recommended 250 U.S.P. units of vitamin A per kilogram of live weight as an optimum daily intake for dairy calves, while Hilton, Wilbur, and Hague (30) stated that a dairy cow producing milk of high vitamin A potency should receive 200,000 International units of vitamin A daily.

A new field of research in vitamin A nutrition was introduced by Moore (43) in 1940 in a report on synergistic action of vitamins

A and E. In 1941 Davies and Moore (12) confirmed earlier observations, and later Harris, Kaley, and Hickman (27) published convincing data showing that carotene intake levels inadequate for normal growth in rats became adequate when mixed tocopherols were added to the diet. Guggenheim (20) reported similar results with rats during the same year.

PROCEDURE

Purebred Hereford steers purchased from the Ft. Lewis branch of Colorado A and M College were allotted as uniformly as possible with respect to weight, type, condition, and color, and were fed in groups as shown in Table I.

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3. Salt self fed to all lots.
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All lots were fed twice daily during wintering and fattening except the pasture group which was fed protein supplement only once daily during the wintering phase. All feeds offered and refused were weighed daily. Feed samples taken every 28 days during wintering and fattening and four times during summer grazing were analyzed

for dry matter, total nitrogen and total carotenoids. Carotenoids were determined according to the method described by Peterson (47), and the Kjeldahl method was used in determining nitrogen. A sample of blood was taken from each steer at approximately two month intervals. Serum carotenoids and vitamin A were determined colorimetrically according to the Carr-Price method as modified by Dan and Evelyn (11). A factor was applied in computation of vitamin A to correct for blue color developed by carotene (5). The method of Bodansky and Fay (4) was used for determining serum calcium, and serum phosphorus was measured by the Harrow (28) modification of the Briggs method (8). Liver samples obtained from all steers at time of slaughter were analyzed for carotene and vitamin A by the method of Gallup and Hoefer (16).

Each steer was weighed on two consecutive days at the beginning and end of the wintering phase, at the end of summer grazing, and at the end of the experiment. Individual single day weights were taken each month.

The data were analyzed according to the procedure described by Snedecor (54). Since the animals were allotted according to three type of outcome groups, variation between these outcome groups was accounted for. Data for wintering, summer, fattening, and total gain, dressing percentage, blood serum carotene, vitamin A, and phosphorus for the final blood samples in each phase, blood serum calcium for each sampling period, and liver carotene and vitamin A were analyzed. Values pertaining to steer number 40, Lot IV, which died, and steer number 21, which was operated upon to relieve calculus, were

disregarded. The .05 level of probability was used as a criterion for determining the significance of differences.

RESULTS AND DISCUSSION

Relationship of Blood Serum Carotene and Vitamin A to Carotene and Vitamin A Equivalent Intake*

Blood serum carotene of lot III animals, as shown by analysis of variance (appendix Table 14), was significantly higher than in the other lots at the end of the wintering and fattening phases. Gross inspection of the data also indicated a higher level of serum carotene in this group at all sampling dates during both phases. The lot wintered on pasture had the lowest serum carotene of any group on March 6, 1946, the last sampling date prior to the appearance of spring grass. During fattening the pasture lot maintained higher serum carotene levels than did lots I and II which received approximately the same levels of carotene intake, indicating an increased ability to convert carotene from plant sources to serum carotene. This may be due to a greater depletion of reserves during the previous winter. Average serum carotene levels were lower for the winter pasture lot during the summer although the difference was not significant after 190 days on pasture. There was no apparent difference in serum carotene between lots I and II at any of the sampling dates.

Mean serum vitamin A levels showed wide differences on but two sampling dates. On March 6, 1946, during wintering, the higher vitamin A serum levels in the supplemented lots (II and III) are

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* Vitamin A equivalent intake calculated as 3.5 micrograms carotene equivalent to 1 International unit vitamin A.

TABLE II. RELATIONSHIP OF BLOOD SERUM CAROTENE AND VITAMIN A TO CAROTENE AND VITAMIN A EQUIVALENT[a] INTAKE (AKRON STEERS 1946-7)

		CAROTENE			VITAMIN A		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Date	Lot	Intake (mcgms/100 lbs. body wt.)	Blood Serum (mcgms/100 ml.)	Ratio Col.4/Col.3	Equiv. Intake (I.U./100 lbs. body wt.)	Blood Serum (I.U./100 ml.)	Ratio Col.7/Col.6
1/9/46	I	5,279	67.58	.0128	1,508	110.14	.0730
	II	5,238	72.00	.0137	6,431	93.24	.0145
	III	20,615	123.90	.0061	5,890	100.04	.0170
	IV	(3,946)[b]	102.34	.0259	1,927	90.69	.0805
3/6/46	I	5,350	31.92	.0060	1,529	117.31	.0767
	II	5,279	24.99	.0047	4,906	206.41	.0421
	III	14,152	78.58	.0056	4,043	209.99	.0519
	IV	(4,950)	20.16	.0041	1,414	66.52	.0470
5/6/46	I	3,374	25.32	.0075	964	93.20	.0967
	II	3,426	23.00	.0067	3,895	99.98	.0345
	III	7,894	84.97*	.0176	2,255	127.64	.0566
	IV	(16,956)	440.86*	.0260	4,845	165.76	.0342
7/12/46	I	(82,566)[c]	775.75	.0094	23,590	316.35	.0134
	II	(82,566)	759.25	.0092	23,590	313.56	.0133
	III	(82,566)	730.00	.0088	23,590	215.20[d]	.0091
	IV	(82,566)	628.75	.0076	23,590	132.12[e]	.0056
9/11/46	I	(98,902)	389.50	.0039	28,258	249.77	.0088
	II	(98,902)	377.00	.0038	28,258	235.73	.0083
	III	(98,902)	357.50	.0036	28,258	235.17	.0083
	IV	(98,902)	329.64	.0033	28,258	253.04	.0090

TABLE II. (CONTINUED) RELATIONSHIP OF BLOOD SERUM CAROTENE AND VITAMIN A TO CAROTENE AND VITAMIN A EQUIVALENT[a] INTAKE (AKRON STEERS 1946-7)

		CAROTENE			VITAMIN A		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Date	Lot	Intake (mcgms/100 lbs. body wt.)	Blood Serum (mcgms/100 ml.)	Ratio Col.4/Col.3	Equiv. Intake (I.U./100 lbs. body wt.)	Blood Serum (I.U./100 ml.)	Ratio Col.7/Col.6
11/12/46	I	(50,230)	273.90	.0055	14,366	289.16	.0201
	II	(50,230)	299.40	.0060	14,366	249.77	.0174
	III	(50,230)	278.56	.0055	14,366	256.00	.0178
	IV	(50,230)	254.57	.0051	14,366	282.87	.0197
1/8/47	I	13,017	25.71	.0020	3,719	156.15	.0420
	II	13,012	21.72	.0017	27,415	134.36	.0049
	III	14,468	34.80	.0024	4,134	178.38	.0431
	IV	11,800	31.89	.0027	3,371	129.30	.0384
3/5/47	I	2,374	55.11	.0232	678	164.43	.2425
	II	2,383	44.77	.0188	1,459	174.08	.1193
	III	4,229	71.93	.0170	1,208	183.88	.1522
	IV	2,450	47.44	.0194	700	171.91	.2456
5/14/47	I	3,115	30.90	.0099	890	140.13	.1574
	II	3,147	28.33	.0090	1,448	171.70*	.1185
	III	4,842	64.53*	.0133	1,383	165.21*	.1195
	IV	3,888	59.57*	.0153	1,111	139.03	.1251

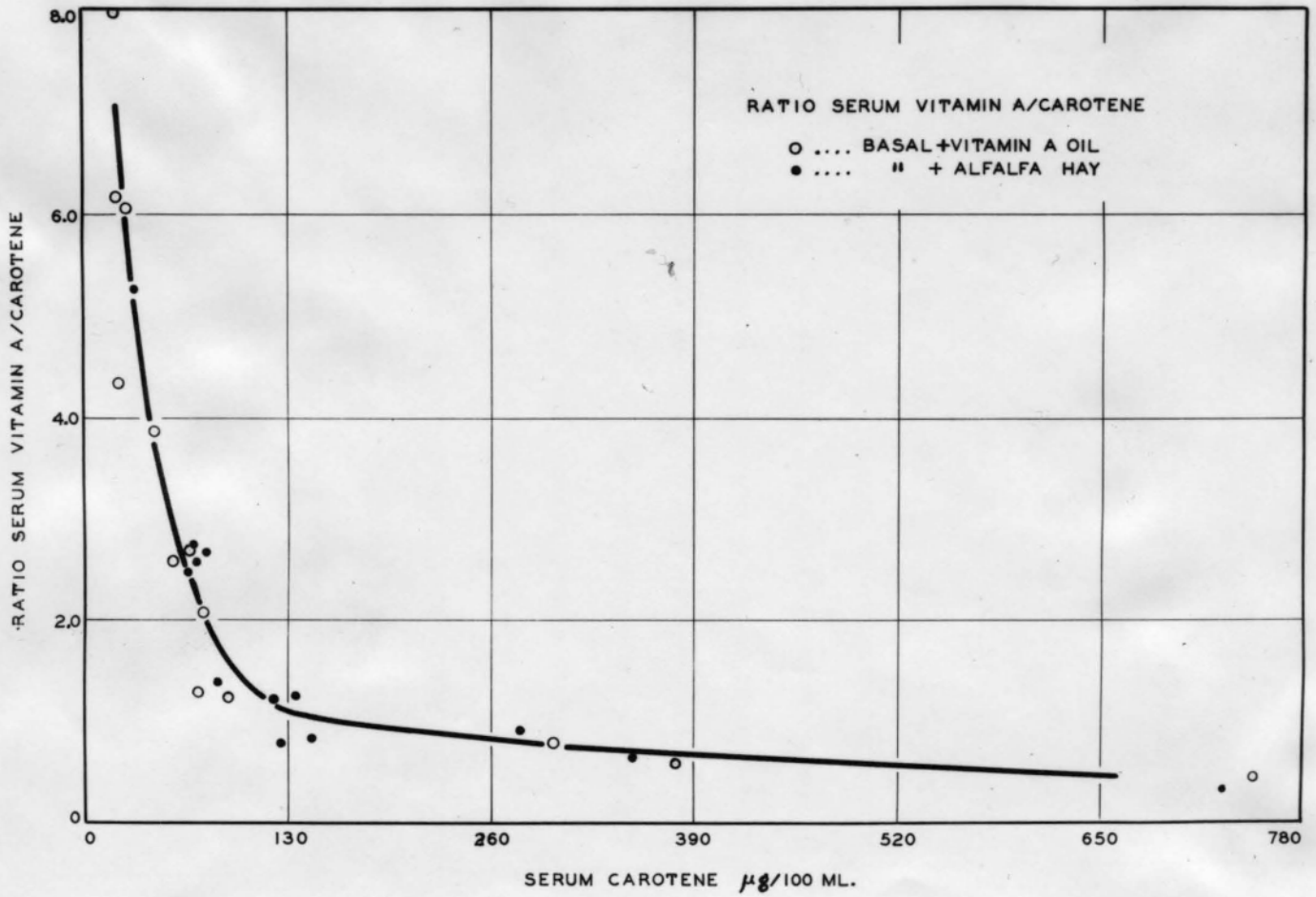
* Averages differ significantly from Lot I.

a. Calculated 3.5 micrograms equivalent to 1 International unit vitamin A.
b. Total dry matter intake assumed equivalent to Lot I.
c. Assumed dry matter intake from Ill. Agric. Expt. Sta. Bull. 454 (18).
d. Average for 3 steers.
e. Average for 2 steers.

apparent (Table II), and at the close of the fattening phase these same lots did show a significantly higher serum vitamin A level (Appendix Table 15a). The differences disappeared at the close of the wintering phase indicating inadequate vitamin A equivalent intake to meet requirements, while during fattening the data indicate lower requirements, greater storage, or less rapid depletion of vitamin A reserves. Due to a misunderstanding lot II received several times calculated vitamin A oil intake for a short time during beginning of fattening, but this was not reflected in higher serum vitamin A values two months later. It is interesting to note the relatively higher serum vitamin A levels for all lots during the fattening period as compared to those of similar dates during the previous wintering period. Table II and Figure I indicate that the highest ratios of serum vitamin A to carotene were manifested in the fattening period when the ration contained cereal grains and the tocopherol intake was probably appreciable. Differences as a whole between outcome groups regarding blood serum vitamin A values at the end of wintering and fattening phases were significant, but the differences in averages between outcome groups within treatments are not consistent.

A decline in efficiency of metabolism of carotene and vitamin A with increasing levels of intake is shown in Table II and Figure I. While absolute blood levels are higher at high intake levels, the values for serum carotene and vitamin A are relatively lower the greater the consumption of carotene or vitamin A equivalent. Also the ratio of serum vitamin A to serum carotene varies inversely with

Figure I. Ratio of Serum Vitamin A to Serum Carotene for Vitamin A Oil and Alfalfa Supplemented Lots - (Steers 1945-7; Heifers, Wintering Period 1946-7)



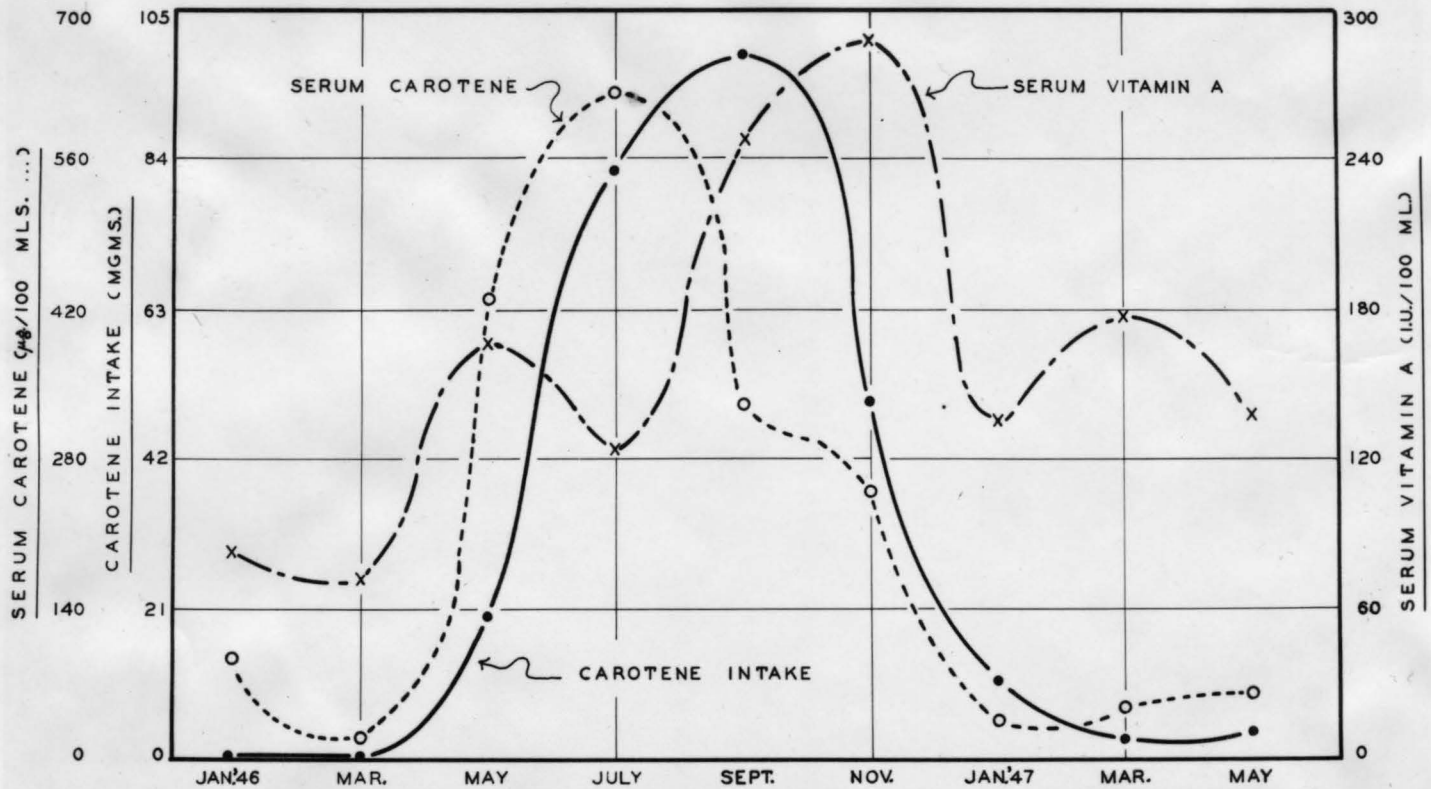
carotene level.

The relationship of blood serum carotene and vitamin A to carotene intake for animals wintered on pasture and receiving no vitamin supplement is illustrated in Figure II. Three important points are graphically represented, namely: (1) the relatively greater effect of early grass as compared to other carotene sources on the serum carotene and vitamin A levels, (2) the apparent lag in establishment of serum vitamin A levels with respect to serum carotene levels, and (3) the relatively great enhancement of serum vitamin A by early spring grass and cereal grains.

Observations on Livers at Time of Slaughter

Liver carotene values show significantly higher levels for the alfalfa supplemented and winter pasture groups. Such storage by the winter pasture steers reflects a more efficient use of carotene from low carotene feeds, already noted in previous discussion, and further validating the serum carotene values. Higher liver vitamin A values observed for lots II and III indicate greater storage than occurred in lot I. The fact that vitamin A appeared in the livers of all lots showed that the vitamin A equivalent intake was adequate to provide for some storage, and that the animals were apparently not subjected to sub-minimal levels of consumption, at least for intervals well within the limits of the depletion period. The effect of the larger amounts of vitamin A oil during early fattening upon the liver vitamin A values are not known.

Figure II. Carotene Consumption, Serum Carotene and Vitamin A for Steers Wintered on Native Pasture, and Receiving No Vitamin Supplement.



SERUM CAROTENE AND VITAMIN A OF HEREFORD STEERS - SHOWING EFFECT OF WINTER RANGE, SUMMER RANGE, AND FATTENING.

TABLE III. LIVER CAROTENE AND VITAMIN A CONTENT, AND CONDEMNATIONS

	Lot I	Lot II	Lot III	Lot IV
Carotene (Mcgms/gram fresh liver)	1.085	0.920	1.526*	1.506*
Vitamin A (I.U./gram fresh liver)	5.918	9.642*	13.241*	10.881*
No. of livers condemned[1/]	4[2/]	1[3/]	0	0

* Averages differ significantly from lot I.
1. U. S. Government inspection
2. 2 abscesses, 1 healed abscess, and 1 telangiectasis
3. "Sawdust."

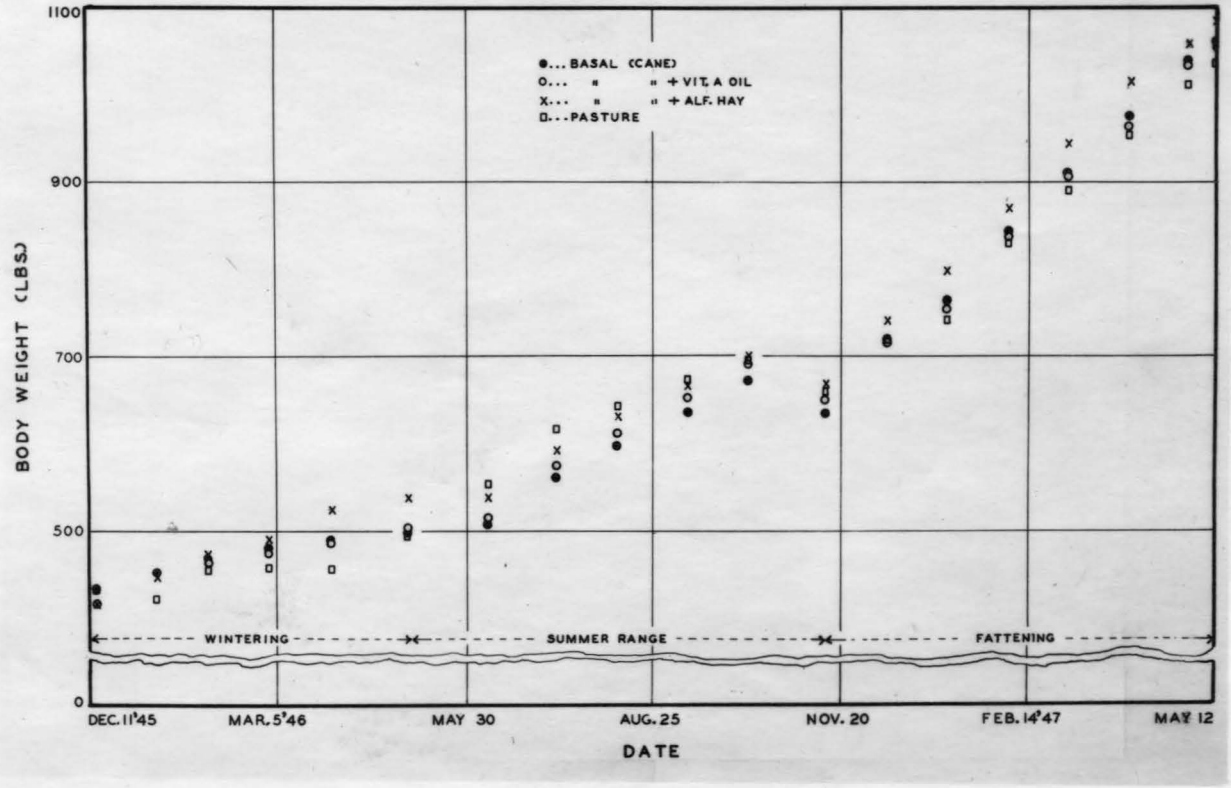
General Appearance

Steer calves receiving a small amount of alfalfa hay in the winter ration had better appetites, were more vigorous and thrifty, and produced hair with more bloom during the latter part of the winter than did animals in any of the other three groups. The animals on native winter pasture generally exhibited a rough hair coat, but at the end of the wintering phase their general appearance was better than that of calves in the two cane fed groups to which no alfalfa hay was added. Significant differences in general health and appearance between the lots were not apparent at the end of summer grazing when all lots were appraised at the same value.

Weight Gains

Average weights of each lot of steers are shown for monthly intervals in Figure III. The greater gains of the alfalfa fed group during wintering and of the winter pasture fed group during the summer grazing period were significant when compared to the basal cane fed lot. No significant difference was observed with respect

Figure III. Average Weights of Steers by Lots.



to total overall gains or to gains during fattening between groups. However, the accelerated growth of the winter pasture lot in the early part of the summer grazing period, as well as the gains shown during early fattening by the alfalfa supplemented group are worthy of mention. Differences as a whole between outcome groups within treatments were significant for fattening gain and seemed to favor the larger steers in type group one, but this observation did not hold true in all lots.

TABLE IV. WEIGHT GAINS PER UNIT DRY MATTER AND PROTEIN INTAKE
(Gain in pounds per 100 pounds intake)

	Lot I	Lot II	Lot III	Lot IV
		Wintering		
Dry Matter	5.73	5.71	7.64	(4.73)[1]
Protein	64.26	64.08	80.22	52.96
		Summer Range		
Dry Matter	(4.93)[2]	(5.38)	(4.30)	(5.57)
Protein	53.88	58.71	47.02	60.97
		Fattening		
Dry Matter	9.51	9.75	10.37	9.87
Protein	95.10	92.76	91.40	90.17

1. Dry matter consumption assumed to be equal to that for lot I.
2. Calculated on basis of dry matter consumption shown for steers on pasture taken from Ill. Agric. Expt. Sta. Bull. 454 (18).

Weight gains per unit of dry matter and protein intake (Table IV) vary directly with rates of gain during the three phases. These data, however, clearly illustrate the greater rate of gain associated with maximum feed intake during fattening and the effect of allowing steers to graze too long on a given allotment. It must be noted that weight losses the last month on summer pasture (Figure III) may have been

due partially to lice and a severe snow storm during the first week of November. These losses reflect upon the efficiency of gain for the entire period as shown in Table IV.

Rank of lots according to slaughter value on foot and later as to carcass value was not uniform, but all steers were sold on the Denver market at the same price per hundred weight, and analysis of variance applied to dressing percentages showed no differences between lots. Similar uniformity was also evident with respect to individual slaughter and carcass grades shown in Appendix Table 1. Steers in the alfalfa supplemented group presented the appearance of having longer legs than shown by animals in the other lots. When the carcasses were split following slaughter it was observed that the bone in the alfalfa fed lot was quite hard and flint-like. In cross section the bone showed at the periphery a thin, hard, layer which lacked opacity, similar to bones observed often in older animals. Bones from the other three lots exhibited a softer, milky white peripheral layer.

TABLE V. SLAUGHTER AND CARCASS OBSERVATIONS

Lot	Slaughter[1] Rank	Selling Price/Cwt.	Carcass[2] Rank	Dressing Percent
I	2	$24.75	1	61.57
II	1	24.75	3	61.41
III	3	24.75	2	61.95
IV	4	24.75	4	60.56

1. Ranked by Mr. Warren Monfort, Greeley, Colorado and Mr. A. W. Avery, Eaton, Colorado, prominent cattle feeders.
2. U. S. Government grades.

Cost of Gains

Table VI indicates that the least expensive gain was made by steers receiving alfalfa during the winter growth period. Reversal in the cost of gain was evident in the subsequent summer grazing period, tending to equalize between lots the total cost per unit gain. During fattening, the pasture fed lot showed the least economy of gain, but considering the wide variations in rate of gain observed between steers, differences between lots with respect to cost of total gain appeared not to be significant.

TABLE VI. COST PER 100 POUNDS GAIN

Period	Lot I	Lot II	Lot III	Lot IV
Wintering	$13.54	$14.00	$12.08	$15.72
Summer Range	6.85	6.17	7.46	5.94
Fattening	22.68	22.08	22.12	23.81
Overall	18.19	17.38	17.65	18.79

Other Observations

Moderate general infestation by lice was evident in all groups at the time these animals were moved from summer pasture to the fattening lots. Severe infestation was apparent on some steers as indicated by the appearance of eggs on all parts of the body, being so numerous on the brisket, neck, and face that white hair presented a dirty yellow appearance. Eleven of the thirty-eight steers exhibited infestation to this degree. Of these, two were in lot I, three in lot II, two in lot III, and four of the eight animals in lot IV. Unfortunately, accurate observations were not made at this time. While the infestation appeared to be general, it was believed that the

winter pasture group was most seriously affected. Severe weather and inability to contract sprayers prevented correction of this condition until late winter, but with one exception the hair color improved after steers were placed on fattening rations. Steer number 24 in lot IV became so weak even on maximum fattening ration that a blood transfusion was administered on December 26, 1946. Although the steer recovered rapidly, heavier infestation by lice in lot IV prevailed until the steers were sprayed with Rotenone and Lethane on March 24, 1947. Practically all lice and eggs were destroyed. Steer number 40, lot IV, developed pulmonary edema and died, probably as a result of the spraying.

On April 17, 1947, steer number 21, of lot III, exhibited symptoms diagnosed as urinary calculi. Following surgical correction of the condition the animal appeared to respond with normal weight gain, and no discrimination was made by the buyers at the time of purchase on the Denver market or by the inspectors at slaughter.

On a windy day, February 6, 1946, when much dust and sand was being blown through the lots, the eyes of all animals except the vitamin A oil supplemented lot, lacrimated badly. The area immediately under the eyes was caked with a thick layer of mud extending to the lower jaw bone.

Blood Serum Calcium and Phosphorus

Low serum calcium was noted for the two supplemented groups at the last two wintering sample dates, and for the pasture group on

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Note: The diagnoses, transfusion, and surgery were performed by Dr. LeRoy Johnson and Dr. Rue Jensen of the Veterinary Staff, Colorado A and M College.

March 6, 1946. Explanation of the differences appears to depend on some factor other than consumption or serum levels of carotene or vitamin A. Significant differences observed between outcome groups as a whole are not consistent with the differences observed between outcome groups between lots. These variations may be associated somewhat with degree of fattening. A sharp increase in serum calcium late in fattening suggests increased demand for calcium in fat deposition (61).

TABLE VII. BLOOD SERUM CALCIUM AND PHOSPHORUS
Mgms/100 ml.

Date	Lot I		Lot II		Lot III		Lot IV	
	Ca.	P.	Ca.	P.	Ca.	P.	Ca.	P.
1/9/46	7.80	16.63	7.39	17.04	7.82	16.32	7.78	15.35
3/6/46	7.55	16.56	6.60*	17.12	6.31*	18.28	6.32*	18.06
5/6/46	7.13	10.78	6.54*	11.21	6.49*	10.92	7.24	9.67
7/12/46	7.34	4.35	7.49	4.36	7.82*	4.13	8.12*	3.96
9/11/46	6.86	5.48	7.31*	6.05	7.35*	5.66	7.39	5.27
11/12/46	9.56	3.40	9.31	3.48	9.09	3.29	8.71	3.20
1/8/47	8.35	8.14	7.90	7.92	7.66†	7.81	7.19*	7.75
3/5/47	8.32	7.86	7.96	8.02	8.19	7.82	7.89	7.95
5/14/47	10.04	10.12	11.42	11.06	11.82	10.89	11.38	8.11

* Averages differ significantly from lot I.
† Significant at 90% level.

Analysis of variance studies of the levels at the close of each phase, and gross inspection of individual data (Table 6) with one exception, indicate no differences with respect to blood serum phosphorus between lots or outcome groups. At the close of the experiment lot IV exhibited lower serum phosphorus levels than did the other groups. This may be attributed somewhat to stage of fattening, while

the differences between outcome groups within treatments must be attributed entirely to chance. Abnormally high serum phosphorus levels on the first two sampling dates may be due to physiological age, sex, past nutritional history, and consumption of relatively large amounts of mineral mixture after arrival at the station. The sharp increase in serum phosphorus during early fattening following very low levels while on summer pasture, appears to support this explanation. The very low serum phosphorus levels at termination of summer grazing indicate a need for phosphorus supplementation on native summer pasture.

Inspection of the calcium and phosphorus levels indicates a low serum Ca:P ratio in young animals. The ratio changed from approximately 1:3 through 2:1 to 1:1 during the course of these experiments. It is believed that the extreme reversal of the Ca:P ratio during summer grazing was the result of an accelerated growth rate together with lack of phosphorus.

SUMMARY AND CONCLUSIONS

In order to study the comparative values of alfalfa hay and fish liver oil as vitamin A supplements, thirty-eight steer calves divided into four groups, were fed common dry land rations consisting of cane, protein supplement, barley, and grain sorghum throughout a wintering and fattening phase, separated by a summer range interval during which time the steers grazed together in one pasture. Three of the lots received a cane ration while the fourth lot was wintered on range. Two of the cane fed lots were given a vitamin A supplement, one receiving fish liver oil and the other a small quantity of alfalfa hay to provide carotene equivalent in vitamin A value to the fish liver oil supplement. Individual, one-day weights were taken monthly, and two-day weighings were made at the beginning and conclusion of each phase of the experiment. Samples of all feeds including range grass were analyzed for dry matter, nitrogen, and carotenoids. Blood serum was analyzed for carotene, vitamin A, calcium and phosphorus.

Within the limitations of criteria such as weight gains, blood serum and liver carotene and vitamin A, and absence of deficiency symptoms, it may be concluded from this investigation that common dry land rations including cane, protein supplement, barley, and grain sorghum provided for adequate vitamin A nutrition in beef steers. Alfalfa hay as a vitamin A supplement was equal to, and in some instances, more effective than fish liver oil in the maintenance of blood serum carotene and vitamin A levels. Furthermore, alfalfa hay produced a better general appearance and appetite during wintering

and fattening than did the oil supplement.

While fresh green grass and cereal grains each increased strikingly the ratio of serum vitamin A to serum carotene, generally an inverse relationship between this ratio and serum carotene level was observed. The establishment of serum vitamin A level always lagged behind that for serum carotene with changing levels of carotene consumption. Depression of serum carotene and calcium levels was associated with increasing serum vitamin A, especially when the level of serum vitamin A was relatively high.

Greater gains during winter growth were reflected in smaller gains during following summer growth, and vice versa, but with respect to overall gain or final slaughter value, no significant differences appeared between lots or outcome groups.

Extremely low serum phosphorus levels indicated that summer range was deficient in phosphorus.

APPENDIX TABLES

TABLE 1. INITIAL AND FINAL WEIGHTS AND GRADES
DRESSING % AND CUTTING COMMENTS (AKRON STEERS 1945-7)

Lot	Steer #	Initial weight	Initial[1/] grade	Condition[2/]	Color[3/]	Final wt.	Slaughter grade	Carcass grade	Dressing %	Cutting[4/] Comments
I	4	550.0	1	2	L	1202.5	G ∔	Ch	61.97	V.G.
	6	502.5	1	1	L	1225.0	G ∔	Ch	63.90	V.G.
	16	390.0	2	2	L	975.0	Ch-	Ch	60.75	Good
	94	367.5	2	3	L	1022.5	Ch-	G ∔	60.31	Good[5/]
	43	470.0	2	2	M	1077.5	G ∔	G ∔	60.91	Good
	25	417.5	2	2	D	972.5	G	G	65.35	Good
	26	435.0	2	2	M	1080.0	Ch-	Ch	60.51	Good
	32	305.0	3	4	L	935.0	G	G ∔	58.43	Good[6/]
	45	400.0	3	3	M	1027.5	G ∔	G ∔	61.03	Good[7/]
	36	350.0	3	3	M	1045.0	G	G ∔	62.53	Good
II	962	512.5	1	1	M	1152.5	G ∔	Ch	60.39	V.G.
	10	482.5	1	2	L	1062.5	G	G ∔	61.80	Fair
	11	435.0	2	2	L	1132.5	G ∔	Ch	62.31	V.G.
	44	440.0	2	2	L	1082.5	Ch-	Ch	59.67	V.N.
	123	392.5	2	2	M	1032.5	G ∔	G	60.42	Poor
	122	447.5	2	3	L	1127.5	G ∔	Ch	61.33	V.G.
	28	487.5	2	2	M	1132.5	G	G ∔	61.86	Fair
	29	347.5	3	3	M	890.0	G	G	63.14	Fair
	35	347.5	3	3	M	950.0	G	G	61.32	Poor
	39	292.5	3	4	L	1005.0	G ∔	G ∔	61.88	V.N.

TABLE 1. (CONTINUED) INITIAL AND FINAL WEIGHTS AND GRADES
DRESSING % AND CUTTING COMMENTS (AKRON STEERS 1945-7)

Lot	Steer #	Initial weight	Initial grade[1]	Condition[2]	Color[3]	Final wt.	Slaughter grade	Carcass grade	Dressing %	Cutting[4] Comments
III	7	515.0	1	2	L	1340.0	Ch	Ch	62.06	Good
	8	497.5	1	2	D	1140.0	G	G +	60.50	Good
	93	472.5	2	1	M	1220.0	G +	Ch	61.98	V.G.
	92	412.5	2	3	M	1100.0	G	Ch	62.31	V.G.
	20	465.0	2	3	M	1135.0	G	G +	62.49	Good
	21*	437.5	2	2	L	1022.5	G	G +	63.22	Good
	96	392.5	2	3	M	1047.5	G	G +	60.99	Good
	91	345.0	3	2	L	870.0	G -	G	63.59	Fair[8]
	33	365.0	3	2	L	1000.0	G +	G +	61.09	Good
	90	322.5	3	3	L	925.0	G -	G +	62.51	Good
IV	1	492.5	1	1	L	1122.5	G +	Ch	57.80	Good
	9	465.0	1	1	M	1085.0	G +	Ch	62.33	Good
	12	420.0	2	2	L	1052.5	G +	G +	60.44	Fair
	17	417.5	2	2	M	905.0	G	G	61.09	Fair
	24	497.5	2	2	M	1047.5	G	G +	59.39	Good[9]
	30	392.5	3	3	M	1095.0	G +	Ch	63.21	Good
	698	342.5	3	3	M	895.0	G	G	59.64	Poor
	40*	340.0	3	3	L	Died	---	---	-----	----

* Not calculated in averages

1. 1 - Choice, 2 - Good, 3 - Medium
2. 1 - Excellent, 2 - Good, 3 - Fair, 4 - Poor
3. L - Light, M - Medium, D - Dark
4. V.N. - Very nice, V.G. - Very good
5. Smooth eye
6. Small eye
7. Light covering
8. Off color
9. No marbling

TABLE 2a. STEER WEIGHTS - WINTERING PHASE (1945-6)

Lot	Steer #	12/11-12	1/9	2/6	3/6	4/3	5/6-7	Total Gain
I	4	550.0	595	605	620	625	602.5	52.5
	6	502.5	550	555	575	575	600.0	97.5
	16	390.0	425	450	460	460	465.0	75.0
	94	367.5	405	415	415	430	455.0	87.5
	43	470.0	490	505	510	520	517.5	47.5
	25	417.5	430	460	465	485	500.0	82.5
	26	435.0	475	490	515	525	555.0	120.0
	32	305.0	345	360	380	390	400.0	95.0
	45	400.0	425	450	450	460	485.0	85.0
	36	350.0	395	415	425	440	460.0	110.0
II	962	512.5	560	550	570	570	595.0	82.5
	10	482.5	515	525	535	525	552.5	70.0
	11	435.0	465	480	470	510	522.5	87.5
	44	440.0	470	465	465	490	507.5	67.5
	123	392.5	430	465	480	495	505.0	112.5
	122	447.5	480	480	515	515	542.5	95.0
	28	487.5	510	530	540	550	562.5	75.0
	29	347.5	370	380	390	385	405.0	57.5
	35	347.5	395	420	415	445	452.0	102.5
III	7	515.0	555	580	605	650	662.5	147.5
	8	497.5	515	565	565	595	602.5	105.0
	93	472.5	520	560	580	630	637.5	165.0
	92	412.5	455	485	490	545	552.5	140.0
	20	465.0	485	520	525	555	565.0	100.0
	21	437.5	475	500	510	530	542.5	105.0
	96	392.5	420	450	470	505	527.5	135.0
	91	345.0	370	380	400	435	432.5	87.5
	33	365.0	390	400	420	440	442.5	77.5
	90	322.5	355	380	395	440	445.0	122.5
IV	1	492.5	475	505	500	500	555.0	62.5
	9	465.0	460	490	495	490	537.5	72.5
	12	420.0	410	450	455	455	510.0	90.0
	17	417.5	390	425	425	425	467.5	50.0
	24	497.5	470	505	515	520	550.0	52.5
	30	392.5	380	405	425	420	477.5	85.0
	698	342.5	355	380	390	390	422.5	80.0
	40	340.0	335	350	345	345	382.5	42.5

TABLE 2b. STEER GAINS - SUMMER GRAZING (1946)

Lot	Steer #	5/8	6/12	7/12	8/9	9/11	10/11	11/7	11/13	Total Gain
I	4	584	588	652	668	718	736	682	696.0	93.5
	6	564	602	686	724	762	794	764	759.0	159.0
	16	440	478	518	562	590	612	584	577.0	112.0
	94	434	474	522	558	592	632	604	577.0	122.0
	43	492	520	590	602	658	684	648	647.0	129.5
	25	472	500	572	618	632	678	640	618.0	118.0
	26	540	540	588	638	658	708	694	690.0	135.0
	32	384	426	478	522	562	592	578	560.0	160.0
	45	452	478	526	560	606	656	608	609.0	124.0
	36	430	464	498	554	606	644	618	621.5	161.5
II	962	562	584	642	696	722	750	710	717.0	122.0
	10	526	554	630	658	712	752	714	696.0	143.5
	11	496	534	582	630	668	694	668	668.0	145.5
	44	480	488	554	588	644	674	636	635.0	127.5
	123	486	528	584	628	678	704	650	673.0	168.0
	122	520	566	610	654	696	732	712	709.5	167.0
	28	546	574	622	678	692	744	700	668.0	105.5
	29	388	412	480	524	556	604	560	562.5	157.5
	35	422	454	510	544	576	620	604	579.0	129.0
	39	374	416	494	538	582	608	580	576.0	193.5
III	7	620	632	696	758	792	814	788	779.0	116.5
	8	570	598	654	692	738	766	722	717.0	114.5
	93	632	624	676	724	742	778	750	758.5	121.0
	92	534	544	612	644	686	740	694	688.0	135.5
	20	534	560	614	672	684	722	688	675.0	110.0
	21	520	574	632	658	702	730	696	686.0	143.5
	96	500	528	576	600	626	652	626	619.5	92.0
	91	406	436	498	526	546	604	562	548.0	115.5
	33	426	462	490	534	566	600	578	570.0	127.5
	90	420	446	512	546	580	622	600	598.0	153.0
IV	1	538	592	652	678	696	734	700	700.5	145.5
	9	510	582	646	678	700	738	744	713.0	175.5
	12	482	544	624	656	688	710	684	668.0	158.0
	17	444	500	564	558	616	628	592	682.0	114.5
	24	520	600	652	666	704	728	680	679.0	129.0
	30	450	534	586	624	672	684	688	666.0	188.5
	698	394	476	524	556	582	596	590	573.0	150.5
	40	358	432	468	488	506	524	512	510.0	127.5

TABLE 2c. STEER WEIGHTS - FATTENING (1946-7)

Lot	Steer #	11/13	12/11	1/8	2/5	3/5	4/2	4/30	5/15	Total Gain
I	4	696.0	795	850	945	1040	1105	Total	1202.5	506.5
	6	759.0	830	910	990	1070	1135	Lot	1225.0	466.0
	16	577.0	655	700	785	825	895	Weights	975.0	398.0
	94	577.0	660	745	825	890	945	Only	1022.5	445.5
	43	647.0	720	765	845	900	990		1077.5	430.5
	25	618.0	675	740	785	865	915		972.5	354.5
	26	690.0	770	805	860	940	995		1080.0	390.0
	32	560.0	625	655	740	780	845		935.0	375.0
	45	609.0	675	720	810	860	930		1027.5	418.5
	36	621.5	700	735	830	910	965		1045.0	423.5
II	962	717.0	755	800	900	970	1040		1152.5	435.5
	10	696.0	760	785	875	940	980		1062.5	366.5
	11	668.0	720	800	880	965	1045		1132.5	464.5
	44	635.0	710	775	835	900	985		1082.5	447.5
	123	673.0	730	730	815	875	940		1032.5	359.5
	122	709.5	760	800	900	985	1030		1127.5	418.0
	28	668.0	785	830	910	995	1035		1132.5	464.5
	29	562.5	595	625	685	765	790		890.0	327.5
	35	579.0	625	665	725	800	860		950.0	371.0
	39	576.0	640	690	780	845	920		1005.0	429.0
III	7	779.0	895	955	1060	1175	1255		1340.0	561.0
	8	717.0	790	875	905	1000	1080		1140.0	423.0
	93	758.5	835	895	995	1050	1115		1220.0	461.5
	92	688.0	760	805	880	940	1025		1100.0	412.0
	20	675.0	785	845	915	1000	1060		1135.0	460.0
	21	686.0	770	820	905	970	1045		1022.5	336.5
	96	619.5	685	755	840	920	990		1047.5	428.0
	91	548.0	595	630	675	750	790		870.0	322.0
	33	570.0	630	705	780	840	900		1000.0	430.0
	90	598.0	655	705	765	795	875		925.0	327.0
IV	1	700.5	750	835	920	970	1060		1122.5	422.0
	9	713.0	785	830	890	965	1000		1085.0	372.0
	12	668.0	750	785	850	915	985		1052.5	384.5
	17	682.0	610	630	720	780	840		905.0	323.0
	24	679.0	700	680	795	880	960		1047.5	368.5
	30	666.0	740	750	880	915	1000		1095.0	429.0
	698	573.0	625	625	690	750	800		895.0	322.0
	40	510.0	570	610	685	730	Died		------	-----

TABLE 3. FEED COSTS - AKRON STEERS (1945-7)

	LOT I		LOT II		LOT III		LOT IV	
Wintering (146 days)								
Chopped Cane	10.58 T	$ 79.35	10.58 T	$ 79.35	9.50 T	$ 71.25	----	-----
Soy Bean Oil Meal	1,099#	34.61	1,102#	34.73	805#	25.36	879#	$ 26.79
Alfalfa Hay	------	-----	------	-----	1.88 T	47.00	----	------
Fish Oil	------	-----	1,890c.c.	2.02	-----	-----	----	-----
Pasture	------	-----	------	-----	-----	-----	5 mo.	60.00
Mineral Mixture	40#	.85	40#	.85	30#	.64	20#	.43
Salt	60#	.60	90#	.90	80#	.80	40#	.40
TOTAL		115.41		117.55		145.05		88.52
Av./hd.		11.54		11.76		14.50		11.06
Summer (190 days)								
Pasture	6 mo.	90.00	6 mo.	90.00	6 mo.	90.00	6 mo.	72.00
Av./hd.		9.00		9.00		9.00		9.00
Fattening (186 days)								
Ground Coes	14,804#	421.91	13,715#	390.88	14,281#	407.01	9,950#	283.58
Ground Barley	14,085#	373.25	12,996#	344.39	13,570#	359.60	9,494#	251.59
Chopped Cane	10.44 T	78.30	10.39 T	77.92	9.61 T	72.09	8.48 T	63.60
Soy Bean Oil Meal	1,370#	78.78	1,362#	78.34	912#	52.47	1,050#	60.36
Alfalfa Hay	------	------	------	------	1.84 T	46.00	-----	------
Fish Oil	------	------	2,268c.c.	7.11	------	------	-----	------
Mineral Mixture	70#	1.49	100#	2.13	80#	1.70	80#	1.70
Salt	60#	.60	100#	1.00	90#	.90	70#	.70
TOTAL		954.33		901.47		939.77		661.83
Av./hd		95.43		90.15		93.98		89.15[1/]
GRAND TOTAL		1159.74		1109.32		1174.92		822.35
Av./hd		115.97		110.93		117.49		112.08[1/]

1/ Steer number 40 (Lot IV) died 24 March 1947.

Feed cost/unit	1945-6	1946-7		1945-6	1945-7		1945-7
Chopped Cane (Ton)	$ 7.50	$ 7.50	Fish Oil (Lb.)	$ .54	1.62	Pasture (Mo.)	$1.50
Alfalfa Hay (Ton)	25.00	25.00	Mineral Mixture (Cwt)	2.13	2.13	G.Coes (Cwt)	2.85
SBOM (Cwt)	3.15	5.75	Salt (Cwt)	1.00	1.00	G.Barley (Cwt)	2.65

TABLE 4. BLOOD SERUM CAROTENE - (1946-7)
Mcgms/100 ml.

Lot	Steer No.	1/9	3/6	5/6	7/12	9/11	11/12	1/8	3/5	5/14
I	4	67.0	46.1	23.0	697.5	315.0	213.0	20.1	49.5	51.0
	6	86.3	24.0	24.0	847.5	402.5	258.0	22.2	48.0	33.0
	16	70.2	55.2	19.5	790.0	432.5	318.0	24.0	69.0	42.0
	94	50.1	19.7	24.5	787.5	407.5	264.0	21.0	48.9	19.5
	43	66.6	15.8	21.5	905.0	407.5	261.0	21.0	60.0	21.0
	25	79.8	35.0	20.0	605.0	282.5	237.0	16.8	54.0	21.0
	26	57.8	37.4	29.0	682.5	430.0	324.0	45.0	57.0	42.0
	32	42.9	42.7	30.5	682.5	430.0	300.0	21.0	63.0	30.0
	45	63.6	23.0	30.0	892.5	370.0	204.0	27.0	41.7	18.0
	36	91.4	20.2	31.2	867.5	417.5	360.0	39.0	60.0	31.5
II	962	73.1	33.1	28.0	762.5	342.5	345.0	7.5	41.1	30.0
	10	88.8	----	18.5	517.5	332.5	243.0	0.0	----	----
	11	----	15.8	18.5	662.5	357.5	276.0	37.5	39.9	34.5
	44	100.8	21.6	24.0	980.0	422.5	369.0	37.5	51.0	24.0
	123	89.7	27.6	29.5	915.0	422.5	339.0	31.2	48.9	30.0
	122	56.6	----	17.5	610.0	392.5	234.0	0.0	48.9	31.5
	28	----	38.6	17.0	782.5	395.0	315.0	42.0	51.0	33.0
	29	46.4	15.6	18.5	682.5	302.5	276.0	24.0	36.6	21.0
	35	56.3	18.2	20.0	847.5	367.5	351.0	0.0	36.6	16.5
	39	64.3	29.3	38.5	832.5	435.0	246.0	37.5	48.9	34.5
III	7	150.1	106.0	98.8	967.5	400.0	312.0	50.1	100.8	45.0
	8	109.4	40.3	48.5	547.5	307.5	204.0	63.0	60.0	67.5
	93	95.0	64.3	79.0	742.5	377.5	339.0	20.4	78.0	57.0
	92	144.0	91.9	92.5	520.0	345.0	237.0	20.4	48.0	70.5
	20	102.7	94.8	79.5	575.0	242.5	228.0	19.5	78.0	55.5
	21	136.0	85.9	83.5	727.5	350.0	282.0	24.0	67.8	69.0
	96	128.6	80.6	62.5	755.0	345.0	273.0	27.0	99.0	69.0
	31	126.5	111.6	100.2	817.5	397.5	276.0	42.0	52.8	55.5
	33	122.4	52.8	87.5	692.5	385.0	258.0	48.6	78.0	72.0
	90	136.3	64.8	116.2	952.5	417.5	381.0	22.2	52.8	88.8
IV	1	144.2	----	356.0	682.5	330.0	300.0	18.6	49.5	63.0
	9	128.7	26.4	565.0	625.0	335.0	246.0	24.6	66.0	57.0
	12	204.5	19.0	587.5	872.5	407.5	363.0	27.0	69.0	117.0
	17	96.3	19.2	520.0	-----	397.5	288.0	41.1	35.1	54.0
	24	43.2	19.2	337.5	575.0	265.0	156.0	30.0	45.0	54.0
	30	60.9	16.6	352.5	462.5	272.5	177.0	48.9	30.0	39.0
	698	38.6	20.6	367.5	555.0	300.0	252.0	33.0	37.5	33.0
	40	54.8	24.5	352.5	605.0	262.5	213.0	50.4	34.1	Died

TABLE 5. BLOOD SERUM VITAMIN A - (1946-7)
I.U./100 ml.

Lot	Steer No.	1/9	3/6	5/6	7/12	9/11	11/12	1/8	3/5	5/14
I	4	96.3	253.8	116.2	270.5	248.2	281.5	182.0	206.6	149.7
	6	98.7	-----	104.0	346.6	284.0	229.2	195.8	175.4	150.0
	16	116.7	80.6	94.2	266.8	217.0	249.5	-----	127.2	146.1
	94	117.1	112.6	91.2	482.2	235.6	280.5	102.7	153.5	156.3
	43	65.7	95.5	66.8	213.6	252.7	263.0	174.5	150.9	134.4
	25	105.7	114.5	92.5	221.8	247.0	377.3	151.3	181.1	110.4
	26	141.6	138.9	94.5	304.8	294.2	428.5	-----	-----	146.1
	32	136.5	82.6	86.0	212.2	235.8	238.0	135.8	186.2	166.5
	45	86.7	95.8	91.8	430.2	250.3	239.7	173.0	126.6	123.9
	36	139.3	81.6	94.8	414.7	233.1	304.2	134.1	172.4	117.9
II	962	106.8	187.4	115.0	262.4	239.5	190.8	-----	191.3	195.0
	10	80.4	-----	110.8	301.6	272.6	296.9	-----	-----	-----
	11	-----	221.0	94.5	395.7	237.9	277.5	134.7	191.6	156.9
	44	95.5	231.4	99.8	356.8	237.2	221.4	177.8	214.0	169.2
	123	120.1	208.0	107.5	319.0	262.0	268.5	85.9	146.4	151.5
	122	84.6	-----	82.0	251.1	239.1	191.2	-----	181.7	201.9
	28	-----	188.5	80.2	273.8	210.6	207.3	127.9	149.4	139.5
	29	89.3	232.6	106.2	283.5	197.0	205.5	145.1	163.7	162.9
	35	78.4	193.0	96.8	360.5	203.9	338.5	-----	175.1	183.0
	39	90.9	189.4	107.0	331.2	257.4	280.2	134.7	153.6	185.4
III	7	109.0	172.8	117.0	95.9	267.5	415.4	206.5	237.5	188.1
	8	104.1	114.4	131.0	292.1	249.9	227.1	203.4	122.1	206.7
	93	110.2	138.2	147.0	257.6	252.3	239.9	-----	200.0	182.7
	92	151.0	292.0	110.2	-----	203.8	214.8	-----	182.6	122.7
	20	98.2	257.7	123.8	-----	184.2	217.2	-----	200.0	155.1
	21	89.1	277.2	122.8	-----	230.7	305.3	-----	223.9	148.8
	96	71.4	226.9	122.8	-----	222.6	189.2	173.2	185.9	123.3
	91	74.9	243.5	137.2	-----	254.9	328.9	140.8	145.5	201.6
	33	86.3	200.5	152.2	-----	218.2	253.0	168.0	207.2	147.6
	90	95.2	243.8	107.5	-----	263.2	218.5	-----	174.2	161.1
IV	1	105.1	-----	226.2	-----	294.1	249.2	97.5	160.4	70.8
	9	91.0	-----	153.5	-----	234.2	231.9	94.5	208.1	118.2
	12	178.5	85.3	192.5	-----	252.7	317.8	184.2	202.0	223.2
	17	72.2	35.9	142.5	-----	266.4	387.6	-----	164.0	166.2
	24	72.0	71.5	125.8	-----	223.0	238.5	141.0	161.6	184.2
	30	59.8	59.9	160.6	166.1	258.2	192.9	-----	122.1	81.6
	698	56.2	80.1	159.2	98.1	242.7	362.2	-----	185.0	129.0
	40	114.2	95.7	163.0	121.4	223.5	329.1	172.5	217.4	-----

TABLE 6. BLOOD SERUM CALCIUM - (1946-7)
Mgms/100 ml.

Lot	Steer No.	1/9	3/6	5/6	7/12	9/11	11/12	1/8	3/5	5/14
I	4	8.21	----	7.10	7.85	6.85	9.25	9.81	7.40	7.24
	6	6.84	7.84	7.10	6.70	6.70	9.65	8.35	7.55	10.48
	16	7.38	7.64	7.01	7.15	6.85	9.25	8.68	8.10	10.76
	94	7.26	6.93	7.06	7.20	6.70	9.85	9.08	9.30	9.68
	43	7.02	7.32	7.39	7.90	6.50	9.80	7.94	8.80	9.53
	25	6.96	7.64	6.41	6.50	7.15	8.60	7.64	8.90	13.72
	26	7.94	7.32	7.36	8.15	6.75	9.65	8.96	----	10.04
	32	10.82	7.56	6.94	7.50	6.60	9.25	8.96	8.40	10.32
	45	7.75	8.11	7.58	7.25	7.35	11.10	7.04	7.40	8.86
	36	-----	----	7.34	7.20	7.10	9.25	7.02	9.05	9.72
II	962	9.94	6.48	6.81	6.85	8.30	9.85	7.62	8.10	10.38
	10	5.56	----	6.51	7.50	8.00	9.75	7.47	----	-----
	11	-----	6.60	6.61	6.70	7.50	10.10	8.35	7.45	13.09
	44	9.40	6.30	6.75	7.25	7.10	9.35	7.47	8.15	9.58
	123	-----	6.62	6.42	7.50	7.50	6.60	7.70	7.85	9.54
	122	6.84	----	4.85	8.00	6.65	8.95	----	7.70	13.98
	28	-----	6.46	6.94	7.80	7.35	9.85	8.12	8.15	11.90
	29	-----	6.38	6.92	7.20	7.40	10.60	7.64	8.45	10.02
	35	5.99	6.54	6.95	7.90	7.00	9.10	8.25	8.00	10.49
	39	6.62	7.40	6.68	7.20	6.30	8.95	8.52	7.75	13.84
III	7	7.90	6.73	5.11	7.95	7.20	9.75	9.00	8.10	10.61
	8	7.90	6.86	5.40	8.20	7.35	8.60	8.08	8.25	15.74
	93	7.57	6.79	5.83	7.75	8.20	9.10	7.32	8.20	11.94
	92	8.39	5.51	6.31	8.30	7.25	8.60	----	8.30	10.87
	20	8.21	5.99	6.74	7.70	7.60	8.50	7.12	7.50	10.29
	21	8.06	6.26	6.63	7.25	8.20	9.15	7.27	7.85	11.48
	96	6.69	5.98	7.04	7.35	8.00	8.90	8.10	8.25	11.00
	91	8.21	6.96	7.22	7.60	6.80	9.85	7.60	8.30	10.48
	33	7.51	----	7.65	7.45	6.65	9.00	8.50	8.25	12.63
	90	7.96	5.65	7.10	8.10	7.10	9.50	5.53	8.55	12.82
IV	1	7.94	----	7.12	8.65	7.35	8.50	6.94	7.95	10.30
	9	7.75	6.30	7.28	7.95	8.50	8.65	6.79	----	11.04
	12	7.60	5.80	7.42	7.60	7.40	8.80	7.34	7.70	12.26
	17	7.96	6.38	7.40	----	6.75	8.15	8.05	7.40	13.54
	24	----	6.76	6.84	7.40	6.80	11.40	6.99	7.45	8.96
	30	7.90	6.30	7.53	8.65	7.20	7.70	----	8.30	11.48
	698	7.54	6.40	7.06	8.45	7.75	7.75	7.02	8.55	12.08
	40	7.69	5.83	8.08	8.10	7.45	8.40	7.17	7.85	-----

TABLE 7. BLOOD SERUM PHOSPHORUS - (1946-7)
Mgms/100 ml.

Lot	Steer No.	1/9	3/6	5/6	7/12	9/11	11/12	1/8	3/5	5/14
I	4	15.84	16.65	10.40	5.15	4.20	2.96	9.60	8.75	9.35
	6	16.36	15.40	10.18	3.95	5.65	3.58	7.35	8.15	10.90
	16	19.24	18.95	8.05	4.90	6.05	4.04	7.35	7.80	10.60
	94	16.80	14.75	9.26	4.80	6.05	2.40	7.50	7.30	9.65
	43	15.76	14.45	11.86	3.85	5.50	2.40	7.15	6.40	9.80
	25	17.56	19.20	11.50	4.45	4.20	2.98	8.35	7.40	11.10
	26	15.72	16.40	11.80	3.65	5.00	3.60	7.80	----	8.80
	32	16.56	16.15	10.04	3.90	5.40	3.70	8.40	7.90	9.20
	45	13.04	17.15	12.60	4.35	5.95	4.20	8.60	8.75	10.75
	36	19.40	16.55	12.08	4.50	6.85	4.16	9.35	8.25	11.10
II	962	15.84	17.00	10.68	4.00	5.55	3.62	6.15	8.00	9.35
	10	18.08	-----	10.26	5.45	6.20	3.62	6.90	----	-----
	11	-----	16.85	11.94	4.40	5.65	3.60	9.75	7.80	10.90
	44	16.24	13.05	11.30	4.40	5.30	3.12	6.05	8.00	10.75
	123	-----	18.30	11.66	4.00	6.65	3.88	8.85	7.30	11.10
	122	16.08	-----	10.43	3.95	4.80	3.62	8.75	7.30	14.50
	28	18.72	17.40	11.62	3.90	3.85	3.02	8.25	8.40	9.80
	29	16.24	19.70	11.16	5.00	6.50	3.40	7.90	8.40	9.65
	35	15.48	18.40	11.02	4.20	4.05	3.04	7.90	7.90	11.40
	39	19.60	16.15	12.00	4.35	6.05	3.84	8.70	9.10	12.05
III	7	13.56	19.85	9.06	3.95	5.45	3.20	7.50	7.40	9.35
	8	15.40	20.30	12.18	3.95	5.05	2.90	7.80	8.00	10.75
	93	16.08	15.50	12.22	4.50	6.55	3.94	5.85	7.80	10.90
	92	17.04	15.30	9.17	3.85	5.85	3.54	7.65	8.50	15.20
	20	16.48	20.90	10.71	4.80	4.80	2.42	8.25	8.75	13.15
	21	15.48	-----	9.84	4.50	5.30	2.30	8.25	8.15	9.80
	96	17.84	17.45	11.55	3.90	5.95	3.50	8.20	7.65	11.10
	91	17.12	18.45	12.18	4.35	5.20	4.76	8.00	7.05	8.00
	33	16.96	-----	10.64	3.90	5.85	----	8.00	7.90	9.65
	90	16.40	18.40	10.54	4.00	6.20	2.06	9.00	7.30	9.95
IV	1	-----	-----	10.54	4.20	4.70	2.66	7.25	8.40	9.20
	9	16.48	17.05	9.24	3.65	6.25	3.24	6.95	7.80	11.10
	12	14.24	16.70	9.00	3.35	5.00	2.90	9.35	7.65	8.80
	17	16.04	15.85	9.45	----	5.65	3.24	6.90	5.85	6.25
	24	14.00	20.50	11.02	4.70	5.30	3.80	5.55	9.00	7.85
	30	16.24	19.05	9.24	4.10	4.85	3.86	9.25	8.50	6.35
	698	15.12	19.20	9.24	3.75	5.15	2.72	9.00	8.50	7.20
	40	13.48	14.95	10.60	4.30	4.75	3.90	9.85	8.40	----

TABLE 8. LIVER CAROTENE, VITAMIN A, AND CONDITION
(20 May 1947)

Lot	Steer No.	Carotene (mcgms./gram)	Vitamin A (I.U./gram)	Liver Condition
I	4	1.350	4.365	OK.
	6	1.125	5.665	OK.
	16	1.150	6.005	Abscess - Condemned
	94	0.725	4.645	Telang - Condemned
	43	1.100	9.650	OK.
	25	0.825	6.855	Abscess - Condemned
	26	1.275	7.700	OK.
	32	0.900	7.295	OK.
	45	1.200	4.860	Abscess*- Condemned
	36	1.200	2.135	OK.
II	962	1.350	8.340	OK.
	10	0.825	9.625	OK.
	11	1.125	9.295	OK.
	44	1.050	9.230	OK.
	123	0.700	9.630	OK.
	122	0.775	8.725	Saw dust- Condemned
	28	0.750	2.860	OK.
	29	0.700	11.310	OK.
	35	0.875	11.360	OK.
	39	0.950	16.045	OK.
III	7	1.885	11.825	OK.
	8	1.600	11.205	OK.
	93	1.225	13.700	OK.
	92	1.150	6.680	OK.
	20	1.300	6.770	OK.
	21	2.000	2.800	OK.
	96	2.025	11.665	OK.
	91	1.350	19.645	OK.
	33	1.650	8.780	OK.
	90	1.550	28.900	OK.
IV	1	1.950	5.595	OK.
	9	1.700	9.015	OK.
	12	2.100	23.955	OK.
	17	1.100	10.155	OK.
	24	1.950	5.170	OK.
	30	0.950	9.550	OK.
	698	1.150	13.230	OK.
	40	-----	-----	--

* Scar tissue from old abscess.

TABLE 9. FEED ANALYSIS (1945-7)

Type of Feed	Date Sample	Master Number	Percent Dry Matter	Lbs. Protein Per lb.D.M.	Mcgms Carotene Per lb.D.M.
Chopped Cane	12/21/45	1066	87.76	.0726	3,206
	2/6/46	1104	88.22	.0557	2,161
	3/6/46	1182	89.26	.0602	1,981
	4/3/46	1202	79.04	.0668	1,843
	5/7/46	1252	83.51	.0548	1,491
	11/14/46	1352	35.25	.0562	2,755
	12/12/46	1361	58.24	.0783	9,128
	12/23/46	1364	49.95	.0740	11,222
	1/8/47	1379	65.78	.0797	4,968
	2/5/47	1396	79.58	.0765	2,170
	3/5/47	1457B	80.46	.0716	3,330
	4/2/47	1500	88.66	.0828	4,788
	4/30/47	1532	94.68	.0562	586
	5/14/47	1558	93.52	.0759	4,077
Alfalfa Hay	12/21/45	1062	89.90	.1339	36,859
	12/22/45	1065	86.84	.1176	13,108
	3/6/46	1183	92.81	.1496	21,041
	4/3/46	1201	94.24	.1371	14,628
	5/7/46	1253	87.35	.1125	10,850
	11/14/46	1354	82.26	.1484	17,461
	12/12/46	1362	88.68	.1388	12,414
	12/23/46	1365	89.93	.1799	13,357
	1/8/47	1380	80.12	.1862	11,608
	2/5/47	1397	88.54	.1842	12,346
	3/5/47	1456	90.08	.1840	9,173
	4/2/47	1501	91.74	.1888	9,972
	4/30/47	1533	88.22	.2044	12,178
	5/14/47	1559	87.62	.1908	11,604
Range Grass	12/22/45	1061	90.52	.0380	517
	2/6/46	1106	80.46	.0384	0
	4/3/46	1203	88.64	.0553	5,327
	5/7/46	1254	88.40	.0837	29,247
	5/7/46	1255	79.15	.0753	29,815
	7/12/46	1348	90.79	.0870	35,975
	9/11/46	1350	90.68	.1221	42,831
	11/14/46	1355	90.46	.0504	7,958

D.M. - Dry Matter

TABLE 9. (CONTINUED) FEED ANALYSIS (1945-7)

Type of Feed	Date Sample	Master Number	Percent Dry Matter	Lbs. Protein Per lb.D.M.	Mcgms Carotene Per lb.D.M.
C. Seed Meal	12/21/45	1066	89.38	.4305	0
Soy Bean Meal	2/6/46	1107	91.44	.4789	0
	3/6/46	1181	93.04	.4755	466
	4/3/46	1204	90.83	.4647	0
	5/7/46	1251	89.76	.4740	0
C. Seed Meal	11/14/46	1351	91.21	.3881	93
Soy Bean Meal	12/12/46	1357	90.56	.4330	193
	1/8/47	1374	89.84	.4521	0
	2/5/47	1391	89.37	.4754	0
	3/5/47	1478	91.19	.4526	0
	4/2/47	1496	88.77	.4407	0
	4/30/47	1529	89.64	.4352	0
Barley	12/12/46	1359	87.20	.1170	128
	1/8/47	1375	87.38	.1103	0
	2/5/47	1393	87.22	.1124	0
	3/5/47	1479	87.55	.1210	308
	4/2/47	1497	84.06	.1285	429
	4/30/47	1530	87.08	.1137	0
Sorghum (Grain)	12/12/46	1358	86.55	.1146	163
	1/8/47	1376	86.52	.1165	0
	2/5/47	1392	86.54	.1017	0
	3/5/47	1480	86.50	.1091	0
	4/2/47	1498	86.90	.1096	0
	4/30/47	1531	87.25	.0931	0
Fish Liver Oil	12/14/45		Vitamin A - 11,550 I.U. per gram		
	1/18/46		" 10,200 I.U. " "		
	2/22/46		" 10,600 I.U. " "		
	4/3/46		" 29,050 I.U. " "		
	8/15/46		" 26,000 I.U. " "		
	8/18/47		" 31,000 I.U. " "		

D.M. - Dry Matter

TABLE 10a. TOTAL FEED CONSUMPTION - WINTERING PERIOD (1945-6)

Lot	Dates	Chopped Cane Lbs.	Protein Supplement Lbs.	Alfalfa Hay Lbs.	Vitamin A Oil ml.	Salt Lbs.	Mineral Mixture Lbs.
I	12/12-1/9	(4104.80)*	210.00	-----	-----	10.00	20.00
	1/ 9-2/6	4700.00	210.00	-----	-----	10.00	-----
	2/ 6-3/6	3985.00	210.00	-----	-----	-----	10.00
	3/ 6-4/3	3120.00	210.00	-----	-----	10.00	10.00
	4/ 3-5/7	3775.00	258.75	-----	-----	10.00	20.00
TOTAL		19684.80	1098.75	-----	-----	40.00	60.00
Av./hd./day		13.48	0.75	-----	-----	0.03	0.04
II	12/12-1/9	(4099.20)*	210.00	-----	420	10.00	20.00
	1/ 9-2/6	4700.00	210.00	-----	420	10.00	10.00
	2/ 6-3/6	3985.00	210.00	-----	420	-----	20.00
	3/ 6-4/3	3114.00	210.00	-----	420	10.00	20.00
	4/ 3-5/7	3800.00	262.50	-----	210	10.00	20.00
TOTAL		19698.20	1102.50	-----	1890	40.00	90.00
Av./hd./day		13.49	0.75	-----	1.30	0.03	0.06
III	12/12-1/9	(2660.00)*	210.00	1540.00	-----	10.00	20.00
	1/ 9-2/6	4212.50	142.50	540.00	-----	10.00	10.00
	2/ 6-3/6	3495.00	140.00	490.00	-----	-----	10.00
	3/ 6-4/3	3145.00	140.00	490.00	-----	10.00	30.00
	4/ 3-5/7	4121.50	172.50	603.75	-----	-----	10.00
TOTAL		17634.00	805.00	3663.75	-----	30.00	80.00
Av./hd./day		12.08	0.55	2.51	-----	0.02	0.05
IV	12/12-1/9	------	198.00	-----	-----	10.00	20.00
	1/ 9-2/6	------	168.00	-----	-----	-----	10.00
	2/ 6-3/6	------	168.00	-----	-----	10.00	10.00
	3/ 6-4/3	------	168.00	-----	-----	-----	-----
	4/ 3-5/7	------	207.00	-----	-----	-----	-----
TOTAL		------	879.00	-----	-----	20.00	40.00
Av./hd./day		------	0.75	-----	-----	0.02	0.03

* Assumed from cane consumption records of wintering heifers 1946-7, by the formula:

$$\frac{\text{Cane Consumption of Heifers}}{\text{Weight of Heifers}} \times \text{Weight of Steers}$$

TABLE 10b. TOTAL FEED CONSUMPTION - FATTENING (1946-7)

Lot	Dates	Ground Coes Lbs.	Ground Barley Lbs.	Protein Supplement Lbs.	Chopped Cane Lbs.	Chopped Alfalfa Hay-Lbs.	Vitamin A Oil ml.	Salt Lbs.	Mineral Mixture Lbs.
I	11/13-12/11	263.75	268.75	192.50	7,010.00	-----	-----	20.00	20.00
	12/11- 1/8	1,707.50	1,707.50	210.00	4,185.00	-----	-----	10.00	-----
	1/ 8- 2/5	2,225.00	2,225.00	206.25	2,062.52	-----	-----	10.00	10.00
	2/ 5- 3/5	2,684.00	2,684.00	210.00	2,100.00	-----	-----	10.00	20.00
	3/ 5- 4/2	2,852.00	2,852.00	210.00	2,100.00	-----	-----	10.00	10.00
	4/ 2- 5/17	5,072.00	4,348.00	341.25	3,412.50	-----	-----	-----	10.00
	TOTAL	14,804.75	14,085.75	1,370.00	20,870.00	-----	-----	60.00	70.00
	Av./hd./day	7.96	7.56	0.74	11.22	-----	-----	0.03	0.04
II	11/13-12/11	263.75	268.75	192.50	7,010.00	-----	1,620	20.00	20.00
	12/11- 1/8	1,667.50	1,667.50	206.25	4,147.50	-----	370	20.00	-----
	1/ 8- 2/5	2,173.50	2,173.50	202.50	2,025.00	-----	70	10.00	10.00
	2/ 5- 3/5	2,666.00	2,666.00	210.00	2,100.00	-----	64	20.00	30.00
	3/ 5- 4/2	2,872.50	2,872.50	210.00	2,100.00	-----	56	10.00	30.00
	4/ 2- 5/17	5,073.00	4,348.00	341.25	3,412.50	-----	88	20.00	10.00
	TOTAL	13,715.25	12,996.25	1,362.50	20,795.00	-----	2,268	100.00	100.00
	Av./hd./day	7.37	6.99	0.73	11.18	-----	1.22	0.05	0.05

TABLE 10b. (CONTINUED) TOTAL FEED CONSUMPTION - FATTENING (1946-7)

Lot	Dates	Ground Coes Lbs.	Ground Barley Lbs.	Protein Supplement Lbs.	Chopped Cane Lbs.	Chopped Alfalfa Hay-Lbs.	Vitamin A Oil ml.	Salt Lbs.	Mineral Mixture Lbs.
III	11/13-12/11	263.75	268.75	127.50	6,470.00	540.00	-----	20.00	20.00
	12/11- 1/8	1,707.50	1,707.50	140.00	3,625.00	560.00	-----	10.00	-----
	1/ 8- 2/5	2,212.50	2,212.50	137.50	1,512.50	550.00	-----	10.00	10.00
	2/ 5- 3/5	2,486.50	2,486.50	140.00	2,100.00	560.00	-----	20.00	20.00
	3/ 5- 4/2	2,732.50	2,732.50	140.00	2,100.00	560.00	-----	10.00	20.00
	4/ 2- 5/17	4,878.50	4,162.50	227.50	3,412.50	910.00	-----	20.00	10.00
	TOTAL	14,281.25	13,570.25	912.50	19,220.00	3,680.00	-----	90.00	80.00
	Av./hd./day	7.68	7.30	0.49	10.33	1.98	-----	0.05	0.04
IV	11/13-12/11	211.00	215.00	154.00	5,648.00	-----	-----	20.00	20.00
	12/11- 1/8	1,067.00	1,067.00	168.00	2,550.00	-----	-----	10.00	-----
	1/ 8- 2/5	1,593.00	1,593.00	168.00	1,680.00	-----	-----	10.00	20.00
	2/ 5- 3/5	1,928.00	1,928.00	168.00	2,128.00	-----	-----	10.00	20.00
	3/ 5- 4/2	1,921.50	1,921.50	155.92	1,971.25	-----	-----	10.00	10.00
	4/ 2- 5/17	3,229.50	2,769.50	235.80	2,992.50	-----	-----	10.00	10.00
	TOTAL	9,950.00	9,494.00	1,049.72	16,969.75	-----	-----	70.00	80.00
	Av./hd./day	6.94	6.62	0.80	11.83	-----	-----	0.05	0.06

TABLE 11a. TOTAL DRY MATTER, PROTEIN, AND CAROTENE INTAKE
WINTERING PERIOD (1945-6)

Lot	Dates	Total D.M. Intake Lbs.	Av./hd/day Lbs.	Total Protein Intake Lbs.	Av./hd/day Lbs.	Total Carotene Intake Mcgms.	Av./hd/day Mcgms.	Total Vit. A I.U.	Av./hd/day I.U.
I	12/12-1/9	2,496	8.91	234.4	0.837	6,189,304	22,105	------	-----
	1/ 9-2/6	3,291	11.75	285.5	1.020	8,323,084	29,725	------	-----
	2/ 6-3/6	2,959	10.57	253.0	0.904	5,771,517	20,613	------	-----
	3/ 6-4/3	2,818	10.06	257.4	0.919	5,063,969	18,086	------	-----
	4/ 3-5/7	3,302	9.71	296.4	0.872	5,114,356	15,042	------	-----
TOTAL		14,866	10.18	1,326.7	0.909	30,462,230	20,865	------	-----
II	12/12-1/9	2,477	8.85	233.2	0.833	6,138,308	21,923	4,410,000	15,750
	1/ 9-2/6	3,224	11.51	281.2	1.004	8,143,256	29,083	4,410,000	15,750
	2/ 6-3/6	2,872	10.26	247.9	0.885	5,591,340	19,854	4,410,000	15,750
	3/ 6-4/3	2,813	10.05	257.1	0.918	5,054,409	18,051	4,410,000	15,750
	4/ 3-5/7	3,326	9.78	299.1	0.880	5,149,363	15,145	4,252,500	12,507
TOTAL		14,712	10.08	1,318.5	0.903	30,076,676	20,600	21,892,500	14,995
III	12/12-1/9	2,306	8.24	301.5	1.077	24,288,634	86,754	------	-----
	1/ 9-2/6	3,266	11.66	298.3	1.065	21,361,944	72,721	------	-----
	2/ 6-3/6	2,839	10.14	256.3	0.915	17,677,987	63,136	------	-----
	3/ 6-4/3	3,233	11.55	294.3	1.051	13,251,227	47,326	------	-----
	4/ 3-5/7	4,054	11.92	345.4	1.016	12,505,422	36,781	------	-----
TOTAL		15,698	10.75	1,495.8	1.025	89,145,214	61,058	------	-----
IV	12/12--- -5/7	Native Pasture (actual quantities unknown).							

TABLE 11b. TOTAL DRY MATTER, PROTEIN, AND CAROTENE INTAKE
FATTENING PERIOD (1946-7)

Lot	Dates	Total D.M. Intake Lbs.	Av./hd/day Lbs.	Total Protein Intake Lbs.	Av./hd/day Lbs.	Total Carotene Intake Mcgms.	Av./hd/day Mcgms.	Total Vit. A I.U.	Av./hd/day I.U.
I	11/13-12/11	3,914	13.98	381.96	1.364	30,004,597	107,159	------	-----
	12/11- 1/ 8	5,500	19.64	603.24	2.154	21,787,194	77,811	------	-----
	1/ 8- 2/ 5	5,551	19.82	638.94	2.281	5,754,661	20,552	------	-----
	2/ 5- 3/ 5	6,537	23.35	743.28	2.655	5,434,730	19,410	------	-----
	3/ 5- 4/ 2	6,885	24.59	797.45	2.848	8,111,727	28,970	------	-----
	4/ 2- 5/17	11,628	25.27	1,260.17	2.740	14,531,141	31,589	------	-----
TOTAL		40,015	21.51	4,425.04	2.379	85,624,050	46,034	------	-----
II	11/13-12/11	3,914	13.98	381.96	1.364	30,004,597	107,159	43,740,000	156,214
	12/11- 1/ 8	5,410	19.32	593.73	2.120	21,586,913	77,096	9,990,000	35,679
	1/ 8- 2/ 5	5,431	19.40	624.94	2.232	5,651,008	20,182	1,890,000	6,750
	2/ 5- 3/ 5	6,507	23.24	739.87	2.642	5,432,420	19,402	1,728,000	6,171
	3/ 5- 4/ 2	6,920	24.71	801.55	2.863	8,118,369	28,994	1,512,000	5,400
	4/ 2- 5/17	11,628	25.27	1,260.17	2.740	14,531,141	31,589	2,376,000	5,165
TOTAL		39,810	21.40	4,402.22	2.367	85,324,443	45,873	59,097,000	31,773

TABLE 11b. (CONTINUED) TOTAL DRY MATTER, PROTEIN, AND CAROTENE INTAKE
FATTENING PERIOD (1946-7)

Lot	Dates	Total D.M. Intake Lbs.	Av./hd/day Lbs.	Total Protein Intake Lbs.	Av./hd/day Lbs.	Total Carotene Intake Mcgms.	Av./hd/day Mcgms.	Total Vit. A I.U.	Av./hd/day I.U.
III	11/13-12/11	4,065	14.52	404.34	1.444	34,567,260	123,454	------	-----
	12/11- 1/ 8	5,612	20.04	634.94	2.268	25,111,620	89,684	------	-----
	1/ 8- 2/ 5	5,532	19.76	662.51	2.366	9,776,853	34,917	------	-----
	2/ 5- 3/ 5	6,630	23.68	766.67	2.738	10,788,242	38,529	------	-----
	3/ 5- 4/ 2	7,124	25.44	839.89	2.999	12,946,377	46,237	------	-----
	4/ 2- 5/17	10,010	21.76	1,340.33	2.914	23,989,786	52,152	------	-----
TOTAL		40,973	22.03	4,648.72	2.499	117,210,138	63,016	------	-----
IV	11/13-12/11	3,150	14.06	307.04	1.372	24,171,705	107,909	------	-----
	12/11- 1/ 8	3,434	15.33	389.12	1.737	13,287,894	59,321	------	-----
	1/ 8- 2/ 5	4,141	18.49	477.64	2.132	4,687,419	20,926	------	-----
	2/ 5- 3/ 5	5,208	23.25	578.10	2.581	5,402,550	19,295	------	-----
	3/ 5- 4/ 2	5,122	24.05	579.27	2.720	7,374,834	34,624	------	-----
	4/ 2- 5/17	8,241	25.59	870.22	2.703	12,617,266	39,184	------	-----
TOTAL		29,236	20.39	3,201.39	2.232	67,541,668	47,100	------	-----

TABLE 12a. VARIANCE ANALYSIS - TOTAL WINTER GAINS (1945-7)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	27,020.14		
Between treatments	3	11,369.16	3,789.72	7.792**
Within treatments	32	15,650.98		
Between Outcome groups	8	3,977.96	497.24	1.022
Within Outcome groups	24	11,673.02	486.38	

TABLE 12b. VARIANCE ANALYSIS - TOTAL SUMMER GAINS (1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	22,049.08		
Between treatments	3	5,041.70	1,671.56	3.179**
Within treatments	32	17,034.38		
Between Outcome groups	8	4,413.28	551.66	1.049
Within Outcome groups	24	12,621.10	525.88	

TABLE 12c. VARIANCE ANALYSIS - TOTAL FATTENING GAINS (1946-7)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	103,527.31		
Between treatments	3	12,046.22	4,015.41	1.924
Within treatments	32	91,481.09		
Between Outcome groups	8	41,379.85	5,172.48	2.478**
Within Outcome groups	24	50,101.24	2,087.55	

TABLE 12d. VARIANCE ANALYSIS - TOTAL GAINS (1945-7)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	156,297.75		
Between treatments	3	19,901.69	6,633.90	1.876
Within treatments	32	136,396.06		
Between Outcome groups	8	51,522.10	6,440.26	1,821
Within Outcome groups	24	84,873.96	3,536.42	

TABLE 13. VARIANCE ANALYSIS - DRESSING PERCENT
(May 20, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	79.62		
Between treatments	3	7.93	2.64	1.060
Within treatments	32	71.69		
Between Outcome groups	8	11.98	1.50	Less than 1
Within Outcome groups	24	58.71	2.49	

TABLE 14a. VARIANCE ANALYSIS - SERUM CAROTENE
(May 6, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	993,648.56		
Between treatments	3	915,405.77	305,135.26	108.376**
Within treatments	32	88,242.79		
Between Outcome groups	8	20,670.11	2,583.76	Less than 1
Within Outcome groups	24	67,572.68	2,815.53	

TABLE 14b. VARIANCE ANALYSIS - SERUM CAROTENE
(Nov. 12, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	110,732.75		
Between treatments	3	8,587.74	2,862.58	Less than 1
Within treatments	32	102,145.01		
Between Outcome groups	8	8,945.12	1,118.14	
Within Outcome groups	24	93,199.89	3,883.33	

TABLE 14c. VARIANCE ANALYSIS - SERUM CAROTENE
(May 14, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	16,695.96		
Between treatments	3	9,403,37	3,134.46	12.110**
Within treatments	31	7,292.59		
Between Outcome groups	8	2,539.60	317.45	1.236
Within Outcome groups	23	5,752.99	258.83	

TABLE 15a. VARIANCE ANALYSIS - SERUM VITAMIN A
(May 6, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	37,530.25		
Between treatments	3	1,782.69	594.23	1.741
Within treatments	32	35,647.56		
Between Outcome groups	8	27,554.27	3,444.28	10.089**
Within Outcome groups	24	8,193.29	341.39	

TABLE 15b. VARIANCE ANALYSIS - SERUM VITAMIN A
(Nov. 12, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	146,654.57		
Between treatments	3	11,456.14	3,818.71	1.014
Within treatments	32	135,198.43		
Between Outcome groups	8	44,827.11	5,603.38	1.488
Within Outcome groups	24	90,371.32	3,765.47	

TABLE 15c. VARIANCE ANALYSIS - SERUM VITAMIN A
(May 14, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	40,107.20		
Between treatments	3	6,817.60	2,272.53	3.426**
Within treatments	31	33,289.60		
Between Outcome groups	8	18,031.15	2,253.89	3.397**
Within Outcome groups	23	15,258.45	663.41	

TABLE 16a. VARIANCE ANALYSIS - SERUM CALCIUM
(Jan. 9, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	29	31.82		
Between treatments	3	.81	.270	Less than 1
Within treatments	26	31.01		
Between Outcome groups	8	9.51	1.189	Less than 1
Within Outcome groups	18	21.50	1.194	

TABLE 16b. VARIANCE ANALYSIS - SERUM CALCIUM
(Mar. 6, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	29	12.50		
Between treatments	3	7.90	2.633	13.714**
Within treatments	26	4.60		
Between Outcome groups	8	1.14	.142	Less than 1
Within Outcome groups	18	3.46	.192	

TABLE 16c. VARIANCE ANALYSIS - SERUM CALCIUM
(May 6, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	14.88		
Between treatments	3	4.02	1.340	51.538**
Within treatments	32	10.46		
Between Outcome groups	8	9.83	1.170	45.000**
Within Outcome groups	24	.63	0.026	

TABLE 16d. VARIANCE ANALYSIS - SERUM CALCIUM
(July 12, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	8.82		
Between treatments	3	2.78	.926	4.837**
Within treatments	31	6.04		
Between Outcome groups	8	1.67	.209	1.100
Within Outcome groups	23	4.37	.196	

TABLE 16e. VARIANCE ANALYSIS - SERUM CALCIUM
(Sept. 11, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	9.80		
Between treatments	3	1.77	.590	5.086**
Within treatments	32	8.03		
Between Outcome groups	8	5.24	.655	5.646**
Within Outcome groups	24	2.75	.116	

TABLE 16f. VARIANCE ANALYSIS - SERUM CALCIUM
(Nov. 12, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	29.42		
Between treatments	3	3.26	1.087	1.300
Within treatments	32	26.16		
Between Outcome groups	8	6.09	.761	Less than 1
Within Outcome groups	24	20.07	.836	

TABLE 16g. VARIANCE ANALYSIS - SERUM CALCIUM
(Jan. 8, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	32	23.29		
Between treatments	3	5.42	1.807	3.094**
Within treatments	29	17.87		
Between Outcome groups	8	5.60	.700	1.198
Within Outcome groups	21	12.27	.584	

TABLE 16h. VARIANCE ANALYSIS - SERUM CALCIUM
(Mar. 5, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	32	7.81		
Between treatments	3	.96	.320	2.013
Within treatments	29	6.85		
Between Outcome groups	8	3.51	.439	2.761**
Within Outcome groups	21	3.34	.159	

TABLE 16i. VARIANCE ANALYSIS - SERUM CALCIUM
(May 14, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	105.09		
Between treatments	3	17.47	5.823	1.838
Within treatments	31	87.62		
Between Outcome groups	8	14.78	1.848	Less than 1
Within Outcome groups	23	72.84	3.167	

TABLE 17a. VARIANCE ANALYSIS - SERUM PHOSPHORUS
(May 6, 1946)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	35	48.11		
Between treatments	3	9.98	3.330	2.362
Within treatments	32	38.13		
Between Outcome groups	8	4.34	0.540	Less than 1
Within Outcome groups	24	33.79	1.410	

TABLE 17b. VARIANCE ANALYSIS - SERUM PHOSPHORUS
(Nov. 12, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	12.96		
Between treatments	3	.37	.123	Less than 1
Within treatments	31	12.59		
Between Outcome groups	8	2.12	.265	Less than 1
Within Outcome groups	23	10.47	.455	

TABLE 17c. VARIANCE ANALYSIS - SERUM PHOSPHORUS
(May 14, 1947)

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	34	122.75		
Between treatments	3	41.59	13.860	7.357
Within treatments	31	81.16		
Between Outcome groups	8	37.83	4.728	2.510
Within Outcome groups	23	43.33	1.884	

TABLE 18. VARIANCE ANALYSIS - LIVER CAROTENE

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	71	11.54		
Between treatments	3	5.41	1.803	20.488**
Within treatments	68	6.13		
Between Outcome groups	8	1.10	0.137	1.557
Within Outcome groups	60	5.03	0.088	

TABLE 19. VARIANCE ANALYSIS - LIVER VITAMIN A

Variance Due to:	Degrees of Freedom	Sum of Squares	Mean Squares	Observed F
Totals	71	2,252.89		
Between treatments	3	531.29	177.10	8.863**
Within treatments	68	1,721.60		
Between Outcome groups	8	522.53	65.32	3.269**
Within Outcome groups	60	1,199.07	19.98	

BIBLIOGRAPHY

1. Barron, N. S. 1940. Vitamin A in Relation to Diseases of Farm Animals. Vet. Record, 54:29-39.

2. Basu, N. M. 1941. Storage of Vitamin A in the Liver Under Different Conditions of Protein and Carbohydrate Intake. Sci. and Culture, 6:672-673.

3. Benhan, S. H. 1944. Antimony Trichloride Method for Determination of Vitamin A. Canadian Jour. Research, 22B, 21-31.

4. Bodansky, M. and M. Fay. 1944. Laboratory Manual of Physiological Chemistry. Ed.4. 281pp. New York, John Wiley & Sons, Inc.

5. Boyer, P. D., P. H. Phillips and J. K. Smith. 1944. Separation of Carotene from Vitamin A for the Determination of Vitamin A in Blood Plasma. Jour. Biol. Chem., 152:445-452.

6. Brown, W. 1945. Studies on the Carotenoids and Vitamin A Levels in Cattle. I. Seasonal Changes of the Carotenoid and Vitamin A Levels and Normal Carotenoid - Vitamin A Ratio of the Blood. Jour. Nutr., 29:61-71.

7. Brown, W. 1945. Studies on the Carotenoid and Vitamin A Levels in Cattle. II. Carotenoids and Vitamin A in the Liver, Their Ratio, and Their Relationship to Blood Levels. Jour. Nutr., 29:73-79.

8. Briggs, A. P. 1922. A Modification of the Bell-Doisy Phosphate Method. Jour. Biol. Chem., 53:13.

9. Brody, S. 1945. Bioenergetics and Growth. 1023pp. New York, Reinhold Publishing Corporation.

10. Converse, H. T. and E. B. Meigs. 1939. The Vitamin A Requirements for Normal Growth in Young Dairy Calves. Am. Soc. An. Prod. Proc., 32:67-72.

11. Dan, W. J. and K. A. Evelyn. 1938. Determination of Vitamin A with the Photoelectric Colorimeter. Biochem. Jour., 32:1008.

12. Davies, A. W. and T. Moore. 1941. Interaction of Vitamin A and E. Nature, 147:794-796.

13. Dickson, R. E. and J. H. Jones. 1935. Vitamin A in the Cattle Wintering Ration in Texas. Texas Agric. Expt. Sta. Ann. Report, 48:200-201.

14. Eekelen, A. M., A. Emmerie, H. W. Julius and L. K. Wolf. 1932. The Reaction of Carr-Price as a Test for Vitamin A. Soc. Acad. Sci. Amsterdam Proc., 35:1347-1359.

15. Frey, P. R. and R. Jensen, 1946. Depletion of Hepatic Reserves of Vitamin A and Carotene in Cattle. Jour. Nutr. 32:133-141.

16. Gallup, W. D. and J. A. Hoefer. 1946. Determination of Vitamin A in the Liver. Indus. and Eng. Chem., Anal. Ed., 18:288.

17. Gallup, W. D. and A. H. Kuhlman. 1941. Carotene Content in the Blood Plasma of Dairy Cattle in Relation to Vitamin A Deficiency. Okla. Acad. Sci. Proc., 21:89-92.

18. Garrigus. W. P. and H. P. Rusk. 1939. Some Effects of the Species and Stage of Maturity of Plants on the Forage Consumption of Grazing Steers of Various Weights. Ill. Agric. Expt. Sta. Bull., 454:441-508.

19. Gray, E. L., K. Morgareidge and J. D. Cauley. 1940. Intestinal Absorbtion of Vitamin A in Normal Rat. Jour. Nutr., 20:67-74.

20. Guggenheim, A. K. 1944. The Biological Value of Carotene from Various Sources and the Effect of Vitamin E on the Utilization of Carotene and Vitamin A. Biochem. Jour., 38:260-264.

21. Guilbert, H. R. and G. H. Hart. 1934. Storage of Vitamin A in Cattle. Jour. Nutr., 8:25-44.

22. Guilbert, H. R. and G. H. Hart. 1935. Minimum Vitamin A Requirements with Particular Reference to Cattle. Jour. Nutr., 10:409-427.

23. Guilbert, H. R., C. E. Howell and G. H. Hart. 1940. Minimum Vitamin A and Carotene Requirements of Mammalian Species Jour. Nutr., 19:91-103.

24. Guilbert, H. R., R. F. Miller and E. H. Hughes. 1937. The Minimum Vitamin A and Carotene Requirements of Cattle, Sheep, and Swine. Jour. Nutr., 113:543-564.

25. Hague, S. M., R. J. Westfall, J. W. Wilbur, and J. H. Hilton. 1944. The Vitamin A Requirements of Dairy Cows for the Production of Butterfat of High Vitamin A Value. III. Availibility of Carotene in Dehydrated Alfalfa Hay as Compared with Carotene in Oil. Jour. Dairy Sci., 27:63-66.

26. Halveson, J. O., E. H. Hostetler, J. E. Foster and F. W. Sherwood 1939. Soy Bean Hay, Alfalfa Hay and Yellow Corn as a Vitamin A Supplement to Cottonseed Meal for Growing Cattle. Jour. Nutr., 18:285-296.

27. Harris, P. L., M. W. Kaley and K. C. D. Hickman. 1944. Co-vitamin Studies. II. The Sparing Action of Natural Tocopherol Concentrates on Carotene. Jour. Biol. Chem. 152:313-20.

28. Harrow, B. 1942. Laboratory Manual of Biochemistry. Philadelphia, W. B. Saunders Co.

29. Hart, G. H. and H. R. Guilbert. 1933. Vitamin A Deficiency as Related to Reproduction in Range Cattle. Calif. Agri. Expt. Sta. Bull., 560:3-30.

30. Hilton, J. H., J. W. Wilbur and S. M. Hague. 1944. The Vitamin A Requirements of Dairy Cows for Production of Butterfat of High Vitamin A Value. II. Vitamin A per se. Jour. Dairy Sci., 27:57-62.

31. Hoefer, J. A. and W. D. Gallup. 1947. The Comparative Value of a Carotene Concentrate, Alfalfa Meal, and a Fish Liver Oil in Maintaining the Vitamin A Content of the Blood and Liver of Fattening Lambs. Jour. of An. Sci., 6:325-332.

32. Jones, R. H., J. M. Jones, G. S. Fraps, A. R. Kemmerer, R. E. Dickson, C. F. Fisher and N. R. Ellis. 1944. Sorghum Silages and Dehydrated Alfalfa Leaf Meal as Sources of Carotene in Beef Cattle Fattening Rations. Texas Agri. Expt. Sta. Bull., 659:27pp.

33. Jones, R. H., H. Schmidt, R. E. Dickson, G. S. Fraps, J. M. Jones J. K. Riggs, A. R. Kemmerer, P. E. Howe, W. H. Black, N. R. Ellis and P. T. Marion. 1943. Vitamin A Studies in Fattening Feeder Calves and Yearlings. Texas Agri. Expt. Sta. Bull., 630:52pp.

34. Kaser, M. and J. A. Stekol. 1943. A Critical Study of Carr-Price Reaction for the Determination of B-Carotene and Vitamin A in Biological Materials. Jour. Lab. and Clin. Med., 28:904; Abstracted in Chem. Abs., 38:5860 (1944).

35. Kehar, N. D. 1940. Serum Protein Fractions of Normal and Vitamin A, Calcium, and Phosphorus Deficient Cattle. India Jour. Vet. Sci., 10:223-228.

36. Kemmerer, A. R., J. F. Fudge and G. S. Fraps. 1942. Carotene Content of Texas Range Forages. Am. Soc. Agron. Jour., 34:851-855.

37. Koehn, C. J. and W. C. Sherman. 1940. The Determination of Vitamin A and Carotene with the Photoelectric Colorimeter. Jour. Biol. Chem., 132:527-538.

38. Kuhlman, A. H. and W. D. Gallup. 1941. Carotene (Provitamin A) Requirements of Dairy Cattle for Reproduction. Soc. An. Prod. Proc., 33:67-73.

39. Lewis, J. M. and L. T. Wilson. 1945. Vitamin A Requirements in Calves. Jour. Nutr., 30:467-475.

40. Mellanby, E. 1947. Vitamin A and Bone Growth. The Reversibility of Vitamin A Deficiency Changes. Jour. Physiol., 105:382-399.

41. Meunier, P. and Y. Raoul. 1943. Comparison of Determination of Vitamin A by Carr-Price Reaction and Ultra-Violet Spectrography. Soc. Chem. Biol. Bull., 25:173-183; Abstracted in Chem. Abs., 38:2980 (1944).

42. Moore, L. A., M. H. Berry and J. F. Sykes. 1943. Carotene Requirements for the Maintenance of a Normal Spinal Fluid Pressure in Dairy Calves. Jour. Nutr., 26:649-658.

43. Moore. T. 1940. The Effect of Vitamin E Deficiency on the Vitamin A Reserves of the Rat. Biochem. Jour., 34:1321-1328.

44. Moore, T. and J. E. Payne. 1942. The Vitamin A Content of Livers of Cattle, Sheep and Pigs. Biochem. Jour., 36:34-36.

45. Nelson, H. F., L. A. Moore, R. E. Harwood and G. E. Branaman. 1944. Vitamin A and Carotene of the Blood Plasma of Beef and Dairy Calves from Birth to Four Months of Age. Mich. Agri. Expt. Sta. Qrtly. Bull., 26; No. I:1-4.

46. Nylund, C. E. and T. K. With. 1942. The Vitamin A Requirements of Warm Blooded Animals and Man. Vitamine U. Hormone, 2:7-20, 125-142; Abstracted in Chem. Abs., 38:2368 (1944).

47. Peterson, W. J. 1941. Recent Developments in Methods for Determining Carotene. Indus. and Eng. Chem., Anal. Ed., 13:212-216.

48. Peterson, W. J., J. S. Hughes and H. F. Freeman. 1937. Determination of Carotene in Forage. Indus. and Eng. Chem., Anal. Ed., 9:71.

49. Riggs, J. K. 1940. Length of Time Required for Depletion of Vitamin A Reserves in Range Cattle. Jour. Nutr., 20:441-500.

50. Schmidt, H. 1935. Mineral Requirements of Cattle in the Red Beds Region of Texas. Texas Agri. Expt. Sta., Ann. Report, 48:19-20.

51. Schmidt, H. 1941. Vitamin A Deficiencies in Ruminants. Am. Jour. Vet. Research, 2:373-379.

52. Sen, K. C. and G. H. Sharma. 1936. Vitamin A Reserves in the Liver of Some Farm Animals. India Jour. Vet. Sci., 6:128-140; Abstracted in Chem. Abs., 30:8330 (1934).

53. Sherman, W. C. 1941. Effect of Certain Fats and Unsaturated Fatty Acids on the Utilization of Carotene. Jour. Nutr., 22:153-165.

54. Snedecor, G. W. 1940. Statistical Methods. Ed.3, 485pp., The Iowa State Collegiate Press, Ames, Iowa.

55. Sutton, T. S. and P. A. Soldner. 1945. Seasonal Variations of the Blood Plasma Carotene and Vitamin A of Adult Dairy Cattle. Jour. Dairy Sci., 28:859-867.

56. Treichler, R., A. R. Kemmerer and G. S. Fraps. 1942. Utilization of Carotene and Vitamin A in Rats. Jour. Nutr., 24:57-64.

57. U. S. Census Bureau. 1945. U. S. Census of Agriculture, Vol. I, Part 29.

58. Wall, M. E. and S. J. Kelley. 1943. Determination of B-Carotene in Plant Tissue. Food Research, 8:143.

59. Ward, R. E., S. I. Bechdel and N. B. Guerrant. 1945. Carotene and Vitamin A in the Nutrition of Dairy Cattle. Jour. Dairy Sci., 28:859-867.

60. Washburn, L. E., W. E. Connell and S. S. Wheeler. 1946. Do Vitamin A Supplements Need be Added to Beef Cattle Feeds in Colorado? Colorado A and M News, 1, No. 6:6.

61. Wilkes, R. P. 1943. Altering the Calcium-Phosphorus Ratio for Fattening Steers. 57pp. Thesis, M.S. Degree, Colorado A and M College Library.