COLOR OF BEEF FAT

AS INFLUENCED BY PASTURE

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By

LANIER COOKE HOWELL

Bachelor of Science

Clemson Agricultural and Mechanical College

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APPROVED BY:

Lowell E. Walters
Chairman, Thesis Committee

Member of the Thesis Committee

A. E. Darlow
Head of the Department

O. C. McIlrath
Dean of the Graduate School

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INTRODUCTION

Consumers associate the yellow color of beef fat with aged animals, dairy cattle, or with grass fed cattle which frequently lack the finish of grain fed cattle; therefore, a prejudice against the yellow color of beef fat prevails.

Yellow fat contains considerable quantities of carotene, which is one of the yellow pigments found in green plant tissues. This pigment is a precursor of vitamin A which is essential for normal growth and reproduction in cattle.

The amount of carotene deposited in the fat of cattle is conditioned by the carotene content of the feed eaten and by the age and breeding of the animal. Of these factors, the carotene content of the feed is the most important.

There are two ways by which some of the lower prices received for beef carcasses containing yellow fat may be overcome: (1) The production of white fat, and (2) Education of the consumer.

STATEMENT OF THE PROBLEM

This experiment was designed to study the influence of pasture and dry lot feeding on: (1) the color of fat, (2) the carotene content of fat, (3) the carotene and vitamin A content of liver, (4) the carotene and vitamin A content of blood plasma and (5) the tenderness of the meat of beef steers.

REVIEW OF LITERATURE

Guilbert (1936) states that the color of the fat is not a reliable index of the quality and palatability of the meat, and the popular discrimination against yellow fat of beef is not entirely warranted.

Snapp (1941) states that cattle fattened exclusively on pasture produced carcasses that were low in fat content. These carcasses containing a greater amount of yellow fat usually graded no better than medium, and their meat possessed inferior eating qualities because of lack of finish. Cattle full fed grain on pasture compared favorably with dry lot cattle of similar finish with the exception that the color of the fat was a more pronounced yellow where pasture was included. From these experiments, it appeared that supplementing pasture with grain produced carcasses of higher grades because of more finish and less yellow fat color. For the same reasons, cattle from dry lot feeding surpassed in carcass grade those in which part of the feed consisted of pasture.

Hankins (1941) reports that two groups of 20 beef type steers, grading low good as feeders, were fed 173 days in each year of a three year experiment. Group one was fed on blue grass pasture with block salt. Group two was fed in dry lot on a ration consisting of corn, cottonseed meal, mixed hay, and salt. The feed consumption of the latter group was so controlled as to maintain approximately the same degree of finish throughout the feeding period as group one. Dressing percentages, carcass grades, and palatability failed to show differences attributable to the differenees in feed. The fat of the grass

fattened animals was more yellow and contained more carotene as well as vitamin A when measured by both spectrophotometric and biological assay methods.

Bull (1937) reports the following results from an experiment using 60 choice yearling Hereford heifers fed corn and cottonseed meal on four different kinds of pasture from May 4 to September 28:

Lot I	Lot II	Lot III	Lot IV
Alfalfa	Brome Grass	Alfalfa and Bluegrass	Bluegrass
1 Creamy	4 Creamy	2 Slightly Yellow	1 Creamy
7 Slightly Yellow	4 Slightly Yellow	6 Yellow	6 Slightly Yellow
1 Yellow	1 Yellow		1 Yellow

Bull makes the following statement:

> It appears probable that an explanation of the unusual amount of yellow beef during the fall and winter of 1934-35 was the residual effect of pasturing cattle upon the luxuriant fall pasture before they were put into the feed lot.

Nobles (1937) reported the following results using three year old steers:

Lot I Grass only, 142 days.

Lot II Grass supplemented with corn and cottonseed meal, 142 days.

Lot III Grass only, 142 days. Followed by grain and mixed hay in dry lot approximately 60 days as an average.

Results obtained on the color of fat shows that Lot I contained the most red, least white, and was intermediate in proportion of yellow. Lot II had the least yellow and the most white, and was inter-

mediate in proportion of red. Lot III contained the least red, the most yellow, and was intermediate in proportion of white.

Wilson (1937) conducted an experiment in which two-year-old-steers, grading low good and good, were fed in three tests:

Lot I — Grass alone, 135 days.

Lot II — Grass 56 days, followed by grass and grain supplement for the remaining period of 79 days.

Lot III — Grass and grain supplement for entire feeding period of 135 days.

Lot IV — Grass as in Lot I, followed by grass and grain supplement for 56 days.

Lot V — Grass as in Lot I, followed by grain and hay in dry lot for 56 days.

The fat from steers in Lots IV and V were lighter than that of Lots I, II and III or contained less yellow color. There were no significant differences obtained in palatability of the 9-10-11-rib roasts from the five lots of steers.

Maynard (1937) fed three lots of Hereford steers with initial weights of approximately 650 pounds for 128 days as follows:

Lot I — Alfalfa hay with ground barley and corn.

Lot II — Alfalfa pasture with ground barlye and corn.

Lot III — Pasture with ground barley and corn.

In this experiment the external fat of the steers fed hay contained 6 percent more yellow pigment than did the fat from the pasture fed steers. Differences in palatability factors among the three lots were relatively small.

Mackintosh (1930) conducted an experiment over a period of three years using three and four year old range bred Hereford steers. During

1926, the cattle were grazed together on bluestem grass from May 1 to August 5. At this time, the steers were divided into three lots and handled as follows:

Lot I Continued on bluestem grass.

Lot II Continued on bluestem grass and corn.

Lot III Continued on bluestem grass and cottonseed cake.

During 1927 and 1928, all the cattle were pastured on bluestem grass with no supplement. During 1929, the cattle were handled in the following manner:

Lot I Full fed ground shelled corn and bluestem grass hay in dry lot.

Lot II Full fed ground shelled corn on bluestem grass pasture.

Lot III Pastured on bluestem grass without supplement.

Mackintosh makes the following statement about the above experiment:

> The fat on the 'grass carcasses' was 'pinkish white' and considered desirable. Color readings indicated that the fat of the dry lot cattle contained the most white and least yellow; of the grass cattle, those receiving supplementary feeds on grass had fewer yellow units than those on grass alone.

Guilbert (1936) states that the principal, well established, scientific facts relative to the color of fat in beef may be briefly summarized as follows:

> "1. Yellow color is caused by the deposition of carotene, the precursor of vitamin A. Traces of xanthophyll and other related pigments may be present, but their contribution to the color of beef fat is insignificant. The degree of yellow color is directly proportional to the carotene content of the fat. This carotene is a source of vitamin A for human nutrition.
>
> 2. Carotene is biologically derived from plants.
>
> 3. The deposition of carotene in the fat is dependent upon

(a) the carotene content of the feed,
(b) hereditary limitations in storage, and
(c) storage as affected by the age of the animal."

Kleiner (1945) states that vitamin A is available to the human either in the form of the vitamin or in the form of a precursor, one of a series of carotinoid pigments, commonly called carotenes. The carotenes form part of the pigments of many green and yellow vegetables, and the conversion of carotene to vitamin A takes place in the body of the animal. The carotinoids are not all equally potent in their ability to form vitamin A. Beta-carotene is a symmetrical compound, and each half of the compound is convertible into a molecule of vitamin A; therefore, of the carotinoids, beta-carotene is the most effective in vitamin A formation. Alpha-carotene, gamma-carotene, and cryptoxanthine are other carotinoids which lead to the formation of vitamin A, but they contribute only half as much as beta-carotene because they are not symmetrical compounds.

Howell (1940) states that after absorption, the pro-vitamin is hydrolized, in the presence of the intracellular enzyme carotenase, in the liver of the animal. Each half of the beta-carotene molecule takes on both the H and OH of a molecule of water to produce a molecule of vitamin A.

Thompson (1947) fed beta-carotene to vitamin A depleted rats and found vitamin A in the intestinal wall and contents after 30 minutes. When he conducted a similar experiment with pigs, he found vitamin A in the intestinal wall, intestinal contents, and mesenteric lymphatics within a short time. Sexton (1946) obtained results which support the work by Thompson. This recent work indicates that the liver

may not be the only place in the animal body that carotene is converted to vitamin A.

Maynard (1947) reports that both vitamin A and carotene can be stored in the animal body. In those species in which the conversion is only partial, a large storage of carotene occurs on diets rich in the pigment.

Braun (1945) and Hubbs (1946) have demonstrated that the plasma content of carotene and vitamin A does not give an absolute measure of the storage of these substances in the animal's body.

Guilbert and Hart (1935) determined the total storage of vitamin A and carotene in the liver and body fat of cows ranging in age from 2 to 18 years which had access to green feed throughout life. They estimated the total of carotene and vitamin A to be .6 to .7 grams in young animals and up to 3.6 grams in aged cows. In the liver, the storage was in the form of vitamin A; but in the fat, carotene predominated. Sixty-seven to ninety-three percent of the total storage was in the liver. In vitamin A depleted animals, twenty-nine micrograms of carotene daily cured night blindness, but this level resulted in no storage of the vitamin. They further stated that vitamin A requirements are proportional to the body weight, and in cattle the minimum required carotene intake is between 26—33 micrograms per kilogram of live weight.

They also state that carotene in the adipose tissue may be withdrawn during vitamin A deprivation. They conducted an experiment in which the steers slaughtered at the beginning of the experiment carried considerable pigment, but when similar steers were placed on

a carotene deficient ration for 282 days and slaughtered, the body fat was white. The steers, on the same carotene deficient ration, contained creamy yellow fat at the end of a 60 to 120 day feeding period.

Kuhlman and Kellup (1942) (1942) (1941) have set forth minimum requirements for carotene intake in Jersey cattle for normal conception, reproduction and lactation as follows:

Conception - 20-39 mcg./lb. of body weight.

Reproduction - 40-45 mcg./lb. of body weight.

Lactation - 40-45 mcg./lb. of body weight.

Jones (1940) fed Hereford calves a vitamin A deficient ration until night blindness occurred. He then fed carotene at levels ranging from 800-2500 micrograms per hundred pounds of body weight daily for a fattening period of 140 days. Feeding carotene within this range produced highly desirable carcasses with white fat. No significantly increased gains resulted from feeding carotene above the level of 1,000 micrograms per hundred pounds of body weight daily.

Campbell (1943) reported that pasture-fed Virginia cattle contained 103.9 micrograms of carotene per hundred grams of fat. Dry-lot animals had a carotene content of 30.5 micrograms per hundred grams of fat. From these results, he concluded that carotene intake of cattle is a controlling factor in the vitamin A content of edible beef cuts, including both fat and lean.

Hickman (1946) advanced the following hypothesis:

> That the rate of depletion of the body reserve of a vitamin is directly proportional to the total reserve of that particular vitamin in the body; and when an animal is subjected to vitamin therapy, it should be possible to calculate a period of half adjustment.

As shown in the table below, Frey and Jensen (1947) have recently completed some work, with steers, which gives Hickman's hypothesis considerable foundation.

Days in Feed Lot	Vit. A Reserve mcg. Vit. A/gram of liver	Drop in 40 days (percent)
0	51.4	---
40	24.2	47
80	11.1	46
120	5.2	47
160	2.2	42

Frey (1946) conducted an experiment using 140 Hereford steers approximately 18 months of age which had been on native grass pasture in Colorado since the previous spring and placed in the feed lot on November 9, 1944. Twenty-two animals were slaughtered at the beginning of the experiment, and the remaining steers were divided into two dietary groups; one group received a fattening ration and the other group received a maintenance ration. The steers slaughtered at the beginning of the experiment contained 51.4 mcg. of vitamin A and 5.31 mcg. of carotene per gram of liver. After 166 days on the fattening ration, the group of steers contained 1.9 mcg. of vitamin A and 1.8 mcg. of carotene per gram of liver. This was 3.7 percent of the initial hepatic reserve of vitamin A, and 33.9 percent of the initial hepatic reserve of carotene. After 166 days on a maintenance ration,

the steers contained 9.4 mcg. of vitamin A and 3.77 mcg. of carotene per gram of liver. This was 18.3 percent of the initial hepatic reserve of vitamin A, and 71.0 percent of the initial hepatic reserve of carotene.

Guilbert and Hart (1934) concluded that over 200 days elapsed before the livers of animals, which had previously received feeds rich in carotene, were completely depleted of vitamin A and its precursors.

METHOD OF PROCEDURE

Twenty-two two-year-old Hereford steers were wintered on native grass pasture, cottonseed cake, salt, and a standard 1-1-1 mineral mixture composed of equal parts of salt, bone meal, and ground limestone. They were divided into four uniform lots of five head each at the beginning of the 1945 grazing period. The two remaining steers were slaughtered at this time, and fat and liver samples were obtained. The 1946 and 1947 trials were conducted in the same manner, and twenty-four two-year-old Hereford steers were used. Four steers were slaughtered at the beginning of the 1946 and 1947 grazing season. The fat and liver samples obtained at this time were analysed by the Agricultural Research Chemistry Department. The fat samples were analysed for carotene content using the method developed by Gallup (1945), and the liver samples were analysed for carotene and vitamin A content using the method developed by Gallup (1946).

The rations given below were fed to the different lots each year during the three year period: Lot I was full fed a ration of ground shelled corn, cottonseed cake, prairie hay, salt and a standard 1-1-1 mineral mixture for 110 days. Lot II remained on native grass pasture supplemented with salt and a 1-1-1 mineral mixture for 110 days. Lot III was full fed the same ration as Lot I for 165 days. Lot IV remained on native grass pasture for 110 days and then were full fed the same ration as Lot I for 55 days.

Individual weights and blood samples were obtained from each animal at monthly intervals. The blood was analysed for carotene and

vitamin A content using the method developed by Kimble (1939). From the monthly weights, the total gain and the average daily gain were calculated.

Lots I and II were slaughtered during the latter part of August, and Lots III and IV were slaughtered during the latter part of October. At the time of slaughter carcass grades, Munsell fat color readings, fat samples and liver samples were obtained. The carcass grades were given a code as follows: choice 3, good 2, and commercial 1. The fat samples were analysed for carotene content, and the liver samples were analysed for carotene and vitamin A content.

Feed records were kept for each lot and the total gain, average daily gain, total feed consumed, pounds of feed consumed per head daily, and pounds of feed per hundred pounds of gain were calculated. The analysis of variance applied to all data in this experiment is outlined by Snedecor (1946).

At the end of the 1947 trial a standing rib roast, 10-11-12-ribs, was obtained from each carcass, and allowed to age for 31 days at a temperature of 34° - 36° F. These roasts were cooked in an oven temperature of 325° F. until they reached an internal temperature of 170° F. A core of cooked meat, approximately 2.27 cm. in diameter, was taken from the eye muscle of each roast and a mechanical shearing test was conducted.

RESULTS AND DISCUSSION

The steers slaughtered at the beginning of the experiment contained an average of 360.0 mcg. of carotene per 100 gm. of fat, 939.3 mcg. of carotene and 22.5 mcg. of vitamin A per 100 ml. of blood plasma, and 1,032.1 mcg. of carotene and 7,185.9 mcg. of vitamin A per 100 grams of liver, as shown in Table I.

The average blood plasma carotene and vitamin A content of 10 dry lot steers and 10 pasture steers, taken at monthly intervals during the three period, are shown in Table II.

From Graph I, it can be observed that the average plasma content of the 10 pasture steers was 783.5 mcg. per 100 ml. of plasma for the month of April. The plasma carotene of this group showed a slight increase to an average of 865.1 mcg. for the month of May. From the latter part of May, these steers showed a very marked decline to an average of 663.4 mcg. during the latter part of June, and 513.6 mcg. at the end of July. The average carotene per 100 ml. of plasma was 484.3 mcg. at the end of August. Near the end of August, 5 of the steers on pasture were slaughtered, and the remaining 5 steers were placed in dry lot for an average of 55 days. The steers placed in dry lot showed a very marked decrease in carotene per 100 ml. of plasma, averaging 101.5 mcg. at the end of September. During October, these steers showed a slight decrease to an average of 90.5 mcg. of carotene per 100 ml. of plasma.

The above results add support to the theory that the carotene content of the blood is directly dependent upon the carotene intake of

TABLE I.

DATA OBTAINED FROM STEERS SLAUGHTERED AT THE BEGINNING OF EACH GRAZING SEASON

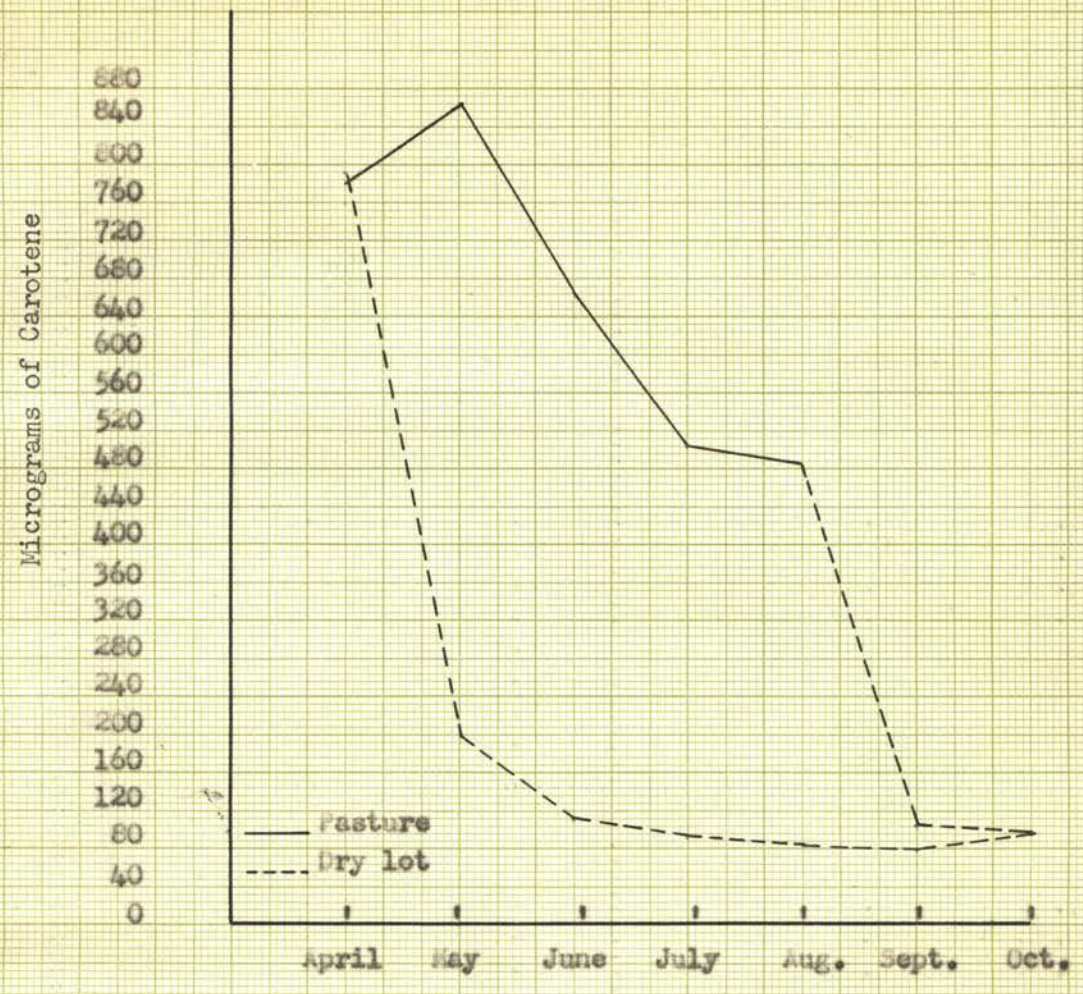
Date	No. of Animals	Carotene in Micrograms Per:			Vit. A in Micrograms Per:	
		100 ml. of Plasma	100 gm. of Fat	100 gm. of Liver	100 ml. of Plasma	100 gm. of Liver
1945	2	799.2	274.5	979.1	29.4	10,195.5
1946	4	1033.7	397.7	1226.5	30.2	7,892.6
1947	4	914.7	No Sample	864.5	17.9	4,974.7
Weighted 3 yr. Av.		939.3	360.0	1032.1	22.5	7,185.9

TABLE II.

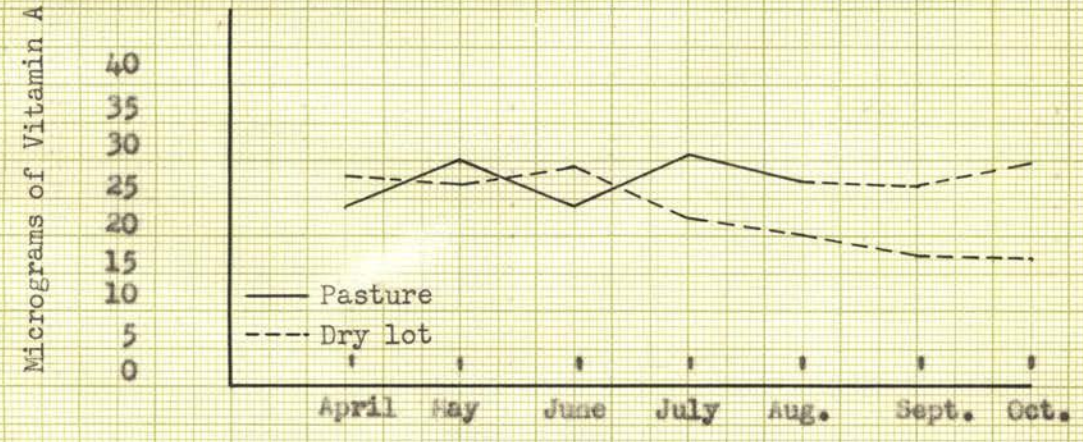
AVERAGE MICROGRAMS OF CAROTENE AND VITAMIN A PER 100 ML. OF BLOOD PLASMA

Date	Dry Lot			On Pasture		
	No. Steers	Av. Plasma Carotene mcg/100 ml.	Av. Plasma Vitamin A mcg.100 ml.	No. Steers	Av. Plasma Carotene mcg/100 ml.	Av. Plasma Vitamin A mcg/100 ml.
1945						
May 28	10	239.7	30.8	10	889.2	35.7
June 25	10	84.4	34.9	10	705.5	30.0
July 23	10	95.3	27.1	10	592.6	32.5
Aug. 16	10	99.8	22.0	10	539.9	25.6
Sept. 17	5	82.0	19.8			
	5*	125.7	25.8			
Oct. 20	5	85.3	19.0			
	5*	97.0	27.9			
1946						
April 29	10	714.0	26.7	10	732.0	23.9
May 13	10	443.2	19.4	10	860.8	28.0
June 10	10	103.2	30.0	10	670.5	29.8
July	-	-	-	-	-	-
Aug. 14	10	73.6	25.3	10	554.2	31.9
Sept. -	5	68.5	22.2			
	5*	67.5	37.5			
Oct. 23	5	71.0	18.4			
	5*	71.4	35.8			
1947						
April 29	10	367.1	29.8	10	834.9	25.2
May 27	10	304.1	12.9	10	845.3	26.5
June 30	10	145.7	22.7	10	614.3	11.7
July 28	10	85.4	18.3	10	434.6	28.6
Aug. 11	10	86.3	11.7	10	358.9	25.5
Sept. 22	5	94.1	11.3			
	5**	111.3	18.2			
Oct. 12	5	119.6	13.2			
	5**	103.2	26.2			

* Dry lot after August 20.
** Dry lot after August 26.



Graph I. Average Micrograms of Carotene per 100 ml. of Blood Plasma



Graph II. Average Micrograms of Vitamin A per 100 ml. of Blood Plasma

the animal, which in turn is dependent upon the carotene content of the feed consumed by the animal.

The 10 steers placed in dry lot during the latter part of April had an average carotene content of 790.5 mcg. per 100 ml. of plasma. After approximately one month in dry lot they had a blood level of 200.0 mcg. of carotene, or less than 1/3 of the plasma carotene content present during the preceeding month. This period was followed by a period of carotene decline, but to a much less marked degree than during the preceeding month, with the carotene averaging 111.1 mcg. during the latter part of June. The carotene declined during the month of July to an average of 90.4 mcg., a smaller decline than during June. Carotene levels continued to decline during August and September to an average value of 81.5 mcg. per 100 ml. of plasma. There was a slight unexplainable increase in carotene to an average of 91.9 mcg. per 100 ml. of plasma for the five dry lot steers during October.

The above results indicate that pasture steers placed in dry lot may be expected to show a very marked decrease in carotene during the first month. This decrease was found to be less marked during the second month.

Throughout the entire experiment, the vitamin A content of 100 ml. of plasma remained within the range of 16.8 mcg. to 30.6 mcg. regardless of the carotene content of the plasma, as shown in Graph II.

Table III contains the averages of the results from the individual lots under different systems of management, by years, for the three year period.

The steers in Lot I, II, III, and IV produced carcasses with an average grade of 1.5, 1.0, 2.8, and 2.2 respectively, for the three year period.

Attention is called to the steers in Lot I which produced carcasses of a low grade during the 1946 period. Carcasses from steers in Lot III graded high good while those from Lot IV graded average good. These results indicate that steers will produce carcasses of a similar grade when they are fed in dry lot for 165 days or allowed to graze on native pasture for 110 days and finished in dry lot for a period of 55 days.

Examination of Table III will reveal that liver carotene and vitamin A values for the 1947 trial were considerably lower than for the other two years. This may be due in part to the long dry season during the 1947 experimental period.

Steers slaughtered at the end of the experiment had an average fat pigment of 23.4, 73.5, 24.2, and 68.0 micrograms per 100 grams of fat for Lots I, II, III, IV respectively. These values were 6.5 percent for Lot I, 20.4 percent for Lot II, 6.7 percent for Lot III, and 18.8 percent for Lot IV of the average obtained from steers slaughtered at the beginning of the experiment.

Table IV (a) shows that there was no difference in fat pigment content between years; however, there was a highly significant difference due to treatments. Table IV (b) shows that most of this difference was between dry lot steers (lots I + III) and steers on pasture and steers on pasture, followed by a dry lot feeding period (lots II + IV).

Years times treatments was highly significant as showin in Table IV(a).

TABLE III.

AVERAGE CAROTENE AND VITAMIN A LEVEL IN THE BLOOD, FAT AND LIVER OF STEERS UNDER DIFFERENT SYSTEMS OF MANAGEMENT

Year	Lot	Mgt.	Days	Steers	Fat Score	Fat Pigment*	Blood Plasma		Liver		Carcass Grade
							Carotene**	Vit. A**	Carotene*	Vit. A*	
1945	1	Dry lot	112	5	1.4	18.6	107.6	22.9	227.0	2,797.0	2.0
	2	Pasture	112	5	3.2	105.6	523.0	25.4	1,057.4	6,996.4	1.0
	3	Dry lot	175	5	1.5	26.6	85.3	19.0	189.1	941.3	2.8
	4	Pasture + Dry lot	112 63	5	2.8	69.2	97.0	27.9	297.9	4,828.3	2.4
1946	1	Dry lot	106	5	3.6	25.3	71.3	27.9	254.4	2,600.0	1.0
	2	Pasture	106	5	4.8	30.5	586.8	35.8	986.0	6,797.0	1.0
	3	Dry lot	155	5	2.6	32.8	71.0	18.4	-	-	2.6
	4	Pasture + Dry lot	106 49	5	4.4	65.0	71.4	35.8	-	-	2.4
1947	1	Dry lot	112	5	2.2	26.4	84.4	14.3	174.8	344.6	1.6
	2	Pasture	112	5	4.2	84.3	318.6	23.5	632.0	3,158.4	1.0
	3	Dry lot	164	5	3.2	13.1	119.6	13.2	49.8	109.4	2.6
	4	Pasture + Dry lot	112 52	5	4.6	69.7	103.2	26.2	74.6	1,438.0	1.8

* Micrograms per 100 grams
** Micrograms per 100 ml. of plasma

TABLE IV (a).

ANALYSIS OF VARIANCE OF FAT PIGMENT FOR THE THREE YEAR PERIOD

Source of Variation	D.F.	S.S.	M.S.
Total	59	81,426.93	-
Years	2	2,766.45	1,383.2
Treatments	3	28,411.73	9,470.6**
Years X Treatments	6	19,249.77	3,208.3**
Error	48	30,998.98	645.8

TABLE IV (b).

SUMMARY OF YEARLY ANALYSIS OF VARIANCE OF FAT PIGMENT

Source of Variation		1945	1946	1947
	D.F.	M.S.	M.S.	M.S.
Total	19			
Lot I vs. Lot III	1	157.25	138.38	633.61
Lot II vs. Lot IV	1	3,321.87	2,979.07**	529.98
Lot I+III vs. Lot II+IV	1	21,002.33**	1,740.97**	17,158.08**
Error	16	1,589.42	93.69	254.29

* Significant at the 5% level.
** Significant at the 1% level.

This indicates that the results obtained under different systems of management do not follow the same pattern from year to year. Some of this variation may be attributed to the climatic differences between years.

Steers slaughtered at the end of the experiment had an average blood plasma carotene content of 87.8, 476.1, 91.9, and 90.5 micrograms per 100 ml. of blood plasma for Lots I, II, III, and IV respectively. These values were 9.3 percent for Lot I, 50.6 percent for Lot II, 9.8 percent for Lot III, and 9.6 percent for Lot IV of the average obtained from steers slaughtered at the beginning of the experiment.

There was a highly significant difference between years for the blood plasma carotene as shown in Table V (a). This difference is to be expected due to variations in weather conditions from year to year. The difference due to treatments was significant as shown in Table V (a). This difference was almost entirely due to the high plasma carotene content of the steers on pasture (Lot IV). Years times treatments was also highly significant. This indicates that the results of this experiment do not follow the same pattern from year to year due to the interaction between treatments and years.

The average plasma vitamin A values for the steers slaughtered at the end of the experiment were 21.7, 28.2, 16.9, and 29.9 micrograms per 100 ml. of blood plasma for Lots I, II, III, and IV respectively. There was a highly significant difference between years for the blood plasma vitamin A. There was also a highly significant difference due to treatments as shown in Table VI (a). Most of the difference due to treatments was obtained when the dry lot steers (Lots I + III) were

TABLE V (a)

ANALYSIS OF VARIANCE OF BLOOD PLASMA CAROTENE FOR THE THREE YEAR PERIOD

Source of variation	D.F.	S.S.	M.S.
Total	59	1,932,351.7	
Years	2	27,387.3	13,693.6**
Treatments	3	1,676,493.7	558,831.2**
Years X Treatments	6	181,415.9	30,235.9**
Error	48	47,054.8	980.3

TABLE V (b)

SUMMARY OF YEARLY ANALYSIS OF VARIANCE OF BLOOD PLASMA CAROTENE

Source of variation	D.F.	1945 M.S.	1946 M.S.	1947 M.S.
Total	19			
Lot II vs. Lots I+III+IV	1	681,493.8**	996,809.4**	175,251.7**
Lot I vs. III vs. IV	2	647.9	.3	1,551.3
Error	16	1,084.0	789.1	1,067.8

* Significant at the 5% level.
** Significant at the 1% level.

TABLE VI (a)

ANALYSIS OF VARIANCE OF BLOOD PLASMA VITAMIN A FOR THE THREE YEAR PERIOD

Source of variation	D.F.	S.S.	M.S.
Total	59	4,273.2	
Years	2	1,034.5	517.3**
Treatments	3	1,643.4	547.8**
Years X Treatments	6	234.3	39.1
Error	48	1,361.0	28.4

TABLE VI (b)

SUMMARY OF THE YEARLY ANALYSIS OF VARIANCE OF BLOOD PLASMA VITAMIN A

Source of variation	1945		1946		1947
	D.F.	M.S.	D.F.	M.S.	M.S.
Total	19		19		
Treatments	3	71.96			
Lot I vs. Lot III			1	225.6**	2.5
Lot II vs. Lot IV			1	0	18.8
Lot I+III vs. Lot II+IV			1	798.8**	616.1**
Error	16	32.71	16	21.6	30.7

* Significant at the 5% level.
** Significant at the 1% level.

compared to steers on pasture and steers on pasture followed by a dry lot feeding period (Lots II + IV), as shown in Table VI (b). Years times treatments did not produce any significant difference for plasma vitamin A. This indicates that the vitamin A content of the blood plasma in this experiment tended to follow the same pattern yearly.

The three year average quantities of carotene per 100 grams of liver obtained from steers slaughtered at the end of the experiment were 281.7 mcg. for Lot I and 891.8 mcg. for Lot II. The livers from the steers in Lot III and IV were lost for the 1946 period; therefore, the two year average of carotene per 100 grams of liver was 119.4 mcg. for Lot III and 186.3 mcg. for Lot IV. These results indicate that the steers slaughtered at the end of the period contained 21.1 percent for Lot I, 86.4 percent for Lot II, 11.5 percent for Lot III, and 18.0 percent for Lot IV of the carotene content of liver obtained from the steers slaughtered at the beginning of the experiment.

Table VII (a) contains the analysis of variance of liver carotene for the 1945 and 1947 trials. There was a highly significant difference in liver carotene between years. This could be explained on the basis of fluctuating climatic conditions. There was also a highly significant difference in liver carotene content due to treatments. Part of this difference was due to the highly significant difference obtained in liver carotene content between Lot II and Lot IV. The remainder of the difference due to treatments was obtained when the dry lot steers (Lots I + III) were compared with pasture steers and steers receiving pasture for a period followed by a period of dry lot feeding (Lots II + IV), as shown in Table VII (b). The results obtained for liver carotene content did not tend to follow the same pattern yearly as shown by the

highly significant interaction between years and treatments.

The three year average of micrograms of vitamin A per 100 grams of liver obtained from the steers slaughtered at the end of the experiment was 1,913.9 mcg. for Lot I and 5,650.6 mcg. for Lot II. Lot III and Lot IV contained an average of 525.4 mcg. and 3,133.2 mcg. respectively, per 100 grams of liver for the two year period. The steers slaughtered at the end of the experiment contained 26.6 percent for Lot I, 78.6 percent for Lot II, 7.3 percent for Lot III, and 43.6 percent for Lot IV of the micrograms of vitamin A per 100 grams of liver obtained from the steers slaughtered at the beginning of the experiment.

There was no difference in the vitamin A content of the liver between years; however, there was a highly significant difference exhibited between treatments. Most of this difference can be accounted for when the dry lot steers (Lots I +III) are compared to pasture steers and steers that had been on pasture supplemented with a dry lot feeding period (Lots II + IV), as shown in Table VIII (b).

There was no significant interaction existing between years and treatments for liver vitamin A in this experiment.

Results Obtained From Cooked Roasts

As explained in Table IX, the steers which received the dry lot ration (Lot I) and steers which received pasture for the same length of time (Lot II) had a 1.3 pound difference in the tenderometer reading. Allowing steers to remain in dry lot an additional 52 days (Lot III) longer than 112 days, reduced the tenderometer reading by 4.1 pounds.

TABLE VII (a)

ANALYSIS OF VARIANCE OF LIVER CAROTENE FOR THE TWO YEAR PERIOD (1945-47)

Source of variation	D.F.	S.S.	M.S.
Total	39	4,250,970.6	
Years	1	440,409.7	440,409.7**
Treatments	3	3,464,445.1	1,154,815.0**
Years X Treatments	3	191,181.6	63,727.2**
Error	32	154,934.2	4,841.7

TABLE VII (b)

SUMMARY OF YEARLY ANALYSIS OF VARIANCE OF LIVER CAROTENE

Source of variation	1945		1946		1947	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	19		9		19	
Treatments			1	203,732.0		
Lot I vs. Lot III					1	39,025.0*
Lot II vs. Lot IV	1	3,587.23			1	776,876.3**
Lot I+III vs. Lot II+IV	1	1,100,649.4**			1	290,272.5**
Error	16	2,815.83	8	162,720.6	16	6,867.5

* Significant at the 5% level.
** Significant at the 1% level.

TABLE VIII (a)

ANALYSIS OF VARIANCE OF LIVER VITAMIN A FOR THE TWO YEAR PERIOD (1945-47)

Source of variation	D.F.	S.S.	M.S.
Total	39	288,341,403.6	
Years	1	440,409.7	440,409.7
Treatments	3	125,781,850.8	41,927,283.6**
Years X Treatments	3	14,784,680.3	4,928,226.8
Error	32	87,581,929.7	2,736,935.3

TABLE VIII (b)

SUMMARY OF YEARLY ANALYSIS OF VARIANCE OF LIVER VIATMIN A

Source of variation	1945		1946		1947	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	19		9		19	
Treatments			1	44,028,628.0**		
Lot I vs.III	1	3,345,118.6			1	138,462.3
Lot II vs.Lot IV	1	11,752,294.5**			1	7,399,268.4*
Lot I+III vs. Lot II+IV	1	96,480,384.2			1	21,451,004.2**
Error	16	4,532,965.5	8	3,384,768.0	16	940,905.1

* Significant at the 5% level.
** Significant at the 1% level.

Placing steers in dry lot for 52 days, following 112 days on pasture (Lot IV), reduced the tenderometer reading by 4.2 pounds.

Daily Gain and Feed Required to Produce 100 Pounds of Gain.

The average daily gain of steers fed in dry lot for 110 days (Lot I) was 2.26 pounds, and they required 1,428.3 pounds of feed per 100 pounds of gain, as presented in Tables X, XI, XII. The steers receiving pasture for 110 days made an average daily gain of 2.26 pounds. These results indicate that steers on succulent pasture will gain as rapidly as steers fed in dry lot.

One half of the steers in Lot I were continued on a dry lot ration for an additional 55 days (Lot III). In this 55 day period, the steers in Lot III produced an average daily gain of 1.71 pounds, and required 1,569.7 pounds of feed per 100 pounds of gain. One half of the steers on pasture were placed in dry lot for an additional 55 days (lot IV). These steers produced an average daily gain of 1.28 pounds, and required 3,556.7 pounds of feed per 100 pounds of gain.

Steers in Lot III gained 0.43 pounds more per head daily than did steers in Lot IV, and required 44.1 percent less feed per 100 pounds of gain. The abnormally low average daily gain produced by the steers in Lot IV for the 1946 period will account for some of the difference exhibited between Lot III and Lot IV for the three year period.

The carotene content of feed samples, taken at various times during the three year period, are presented in Table XIII. This information could only be used to make predictions as to whether or not the carotene intake of the steers on pasture would be higher or

TABLE IX.

TENDEROMETER READINGS OF COOKED ROASTS FROM STEERS UNDER DIFFERENT SYSTEMS OF MANAGEMENT

Lot I Dry lot 112 days		Lot II Pasture 112 days		Lot III Dry lot 164 days		Lot IV Pasture 112 days + Dry lot 52 days	
An. No.	Lbs. reg. to shear	An. No.	Lbs. reg. to shear	An. No.	Lbs. reg. to shear	An. No.	Lbs. reg. to shear
2	23.0	1	22.5	26	15.0	34	10.9
8	13.5	48	14.6	27	10.0	25	13.5
30	16.0	56	17.4	50	16.5	70	13.1
46	14.2	65	18.5	16	15.2	94	20.0
63	20.0	72	20.0	14	9.5	83	-
Total	86.7		93.0		66.2		57.5
Av.	17.3		18.6		13.2		14.4

TABLE X

SUMMARY OF WEIGHTS, GAINS AND FEED INTAKE FOR THE 1945 PERIOD

	FIRST PHASE April 28 - August 18 1945		SECOND PHASE August 18 - October 20 1945	
Lot No.	I	II	III	IV
No. in lot	10	10	5	5
No. days in period	112	112	63	63*
Total initial wt.	7,939.00	8,036.00	5,168.00	5,000.00
Total final wt.	10,676.00	10,225.00	5,904.00	5,752.00
Total gain	2,737.00	2,267.00	736.00	752.00
Av. daily gain	2.44	1.95	2.34	2.39
Total feed in period:				
Ground corn	19,925.00		5,859.00	4,840.00
C.S.M.	1,650.00		457.00	447.00
Prairie hay	9,923.00		1,860.00	2,698.00
Total organic feed	31,498.00		8,176.00	7,985.00
Salt	53.00		10.00	15.00
Mineral	52.00		10.00	15.00
Grand Total Feed	31,603.00		8,196.00	8,015.00
Av. feed per head daily:				
Ground corn	17.80		18.60	15.40
C.S.M.	1.50		1.40	1.40
Prairie hay	8.90		5.90	8.60
Salt	.05		.03	.05
Mineral	.05		.03	.05
Total	28.20		26.00	25.30
Feed per 100 lb. gain:				
Ground corn	728.00		796.00	644.00
C.S.M.	60.00		62.00	59.00
Prairie hay	363.00		253.00	359.00
Salt	2.00		1.00	2.00
Mineral	2.00		1.00	2.00
Total	1,155.00		1,114.00	1,066.00

Grass pasture + mineral mixture and salt

* Pasture 112 days + 63 days in dry lot.

TABLE XI

SUMMARY OF WEIGHTS, GAINS AND FEED INTAKE FOR THE 1946 PERIOD

	FIRST PHASE April 29 - August 13 1946		SECOND PHASE August 13 - October 1 1946	
Lot No.	I	II	III	IV
No. in lot	10	10	5	5
No. days in period	106	106	49	49*
Total initial wt.	8,455.00	8,485.00	4,860.00	5,140.00
Total final wt.	10,155.00	10,485.00	5,135.00	5,210.00
Total gain	1,200.00	2,000.00	275.00	70.00
Av. daily gain	1.60	1.89	1.12	0.29
Total feed in period:				
Ground corn	16,261.00		4,279.00	3,500.00
C.S.M.	1,150.00		368.00	368.00
Prairie hay	8,235.00		1,089.00	1,399.00
Total organic feed	25,646.00		5,736.00	5,267.00
Salt	60.00		10.00	10.00
Mineral	50.00		10.00	10.00
Grand Total Feed	25,756.00		5,756.00	5,287.00
Av. feed per head daily:				
Ground corn	15.34		17.50	14.30
C.S.M.	1.08		1.50	1.50
Prairie hay	7.77		4.40	5.70
Salt	.06		.04	.04
Mineral	.05		.04	.04
Total	24.30		23,50	21.60
Feed per 100 lb. gain:				
Ground corn	1,355.00		1,556.00	5,000.00
C.S.M.	96.00		134.00	526.00
Prairie hay	685.00		396.00	1,999.00
Salt	5.00		4.00	14.00
Mineral	3.00		4.00	14.00
Total	2,146.00		2,093.00	7,553.00

Grass pasture + mineral mixture and salt

* Pasture 106 days + 49 days in dry lot.

TABLE XII

SUMMARY OF WEIGHTS, GAINS AND FEED INTAKE FOR THE 1947 PERIOD

	FIRST PHASE May 6 - August 26 1947		SECOND PHASE August 26 - October 17 1947	
Lot No.	I	II	III	IV
No. in lot	10	10	5	5
No. days in period	112	112	52	52*
Total initial wt.	6,885.00	6,895.00	4,945.00	5,080.00
Total final wt.	9,910.00	10,150.00	5,377.00	5,380.00
Total gain	3,025.00	3,255.00	432.00	300.00
Av. daily gain	2.73	2.93	1.66	1.15
Total feed in period:				
Ground corn	19,550.00		4,437.00	3,695.00
C.S.M.	1,518.00		382.50	382.50
Prairie hay	8,672.00		1,640.00	2,046.00
Total organic feed	29,740.00		6,459.50	6,123.50
Salt	19.00		20.00	20.00
Mineral	15.00		10.00	10.00
Grand Total Feed	29,774.00		6,489.50	6,153.50
Av. feed per head daily:				
Ground corn	17.60		17.10	14.20
C.S.M.	1.37		1.47	1.47
Prairie hay	7.81		6.31	7.87
Salt	.02		.08	.08
Mineral	.01		.04	.04
Total	26.82		24.97	23.70
Feed per 100 lbs. gain:				
Ground corn	646.00		1,027.10	1,231.00
C.S.M.	50.00		88.50	127.50
Prairie hay	287.00		379.60	682.00
Salt	.60		4.60	6.70
Mineral	.50		2.30	3.30
Total	984.00		1,502.10	2,051.20

Grass pasture + mineral mixture and salt

* Pasture 112 days + 52 days in dry lot.

TABLE XIII.

CAROTENE CONTENT OF FEEDS

Date of Collection	Description	Crude Carotene p.p.m.	True Carotene p.p.m.
6-1-45	Prairie Hay	22.6	17.4
"	Yellow Corn	3.4	1.2
"	Native Grass	291.6	257.6
8-22-45	Prairie Hay	18.7	7.4
"	Native Grass	58.8	50.4
5-15-46	Prairie Hay	15.1	11.0
"	Yellow Corn	3.4	1.3
"	Native Grass	250.3	220.7
8-19-46	Native Grass	58.6	43.7
"	Prairie Hay	10.1	6.4
5-27-47	Native Grass	110.0	100.0
"	Yellow Corn	3.4	1.2
"	Prairie Hay	4.8	2.4
7-2-47	Native Grass	199.0	173.0

lower than it had been in previous years. Due to the many variables which enter into the calculations, the exact carotene intake of the steers in this experiment could not be determined.

SUMMARY AND CONCLUSION

A three year study has been made of the influence of pasture and dry lot feeding upon the carotene content of fat, storage of carotene and vitamin A in the liver, blood plasma carotene and vitamin A content, tenderness of roasts, average daily gain and feed required per 100 pounds of gain. The results of these studies may be summarized as follows:

1. The fat from steers which had been on pasture for 110 days (Lot II) contained 50.1 more micrograms of carotene per 100 grams than did fat from steers which received a dry lot ration for the same length of time. Steers which received pasture for 110 days followed by a dry lot feeding period of 55 days contained 43.8 more micrograms of carotene per 100 grams of fat than did steers which received a dry lot ration for 165 days.
2. In this experiment a 55 day dry lot feeding period for steers which had been on pasture for 110 days decreased the carotene content by 5.5 mcg. per 100 grams of fat.
3. The blood plasma carotene of pasture steers placed in dry lot decreased rapidly for the first two months.
4. The blood plasma vitamin A of the steers in this experiment fluctuated between 16.8 mcg. and 30.6 mcg. per 100 ml. of plasma regardless of the system of management followed.
5. Steers which received pasture for 110 days contained a greater hepatic reserve of carotene and vitamin A than steers fed in dry lot for the same length of time; however placing pasture steers in dry lot of 55 days greatly reduced the hepatic re-

serve of carotene and vitamin A.

6. There was an interaction between years and treatments for fat pigment, blood plasma carotene, and liver carotene. There was also a significant difference between years for blood plasma carotene, blood plasma vitamin A, and liver carotene.

7. In this experiment the steers receiving pasture for 110 days and steers fed in dry lot for the same length of time produced the same average daily gain of 2.26 pounds.

8. Steers fed in dry lot for 165 days showed an average daily gain 0.43 pounds greater and required 44.1 percent less feed to produce 100 pounds of gain for the last 55 days of the period (Lot III) than did steers which had been on pasture for 110 days followed by 55 days of dry lot feeding (Lot IV).

10. A dry lot feeding period of 52 days following a 112 day grazing period reduced the tenderometer reading 4.2 pounds. Carcasses from steers on full feed 164 days (Lot III) had a tenderometer reading of 4.1 pounds less than carcasses from steers on full feed 112 days (Lot I).

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TYPED BY: FLORENE E. ADAMS