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THE CAROTENE AND VITAMIN A CONTENT OF PLASMA AND LIVER OF RANGE HEREFORD COWS AND THEIR CALVES IN THE NORTHERN GREAT BASIN [1]

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ONLY limited studies have been reported with respect to the carotene and vitamin A status of range cattle in the sagebrush-bunchgrass region of the Northern Great Basin. Hubbert *et al.* (1953) reported the influence of the age of meadow hay on carotene and vitamin A values of the plasma of range cows. The results indicated the necessity for controlled feeding experiments. Therefore, a three-year study was carried out on the response of Hereford cows and their calves to four levels of carotene intake, and a one-year study on blood and hepatic levels of carotene and vitamin A for cows and calves on a "normal" regime.

Experimental Procedure

This experiment involved four winter rations which provided daily carotene intakes of 1.5, 5, 15 and 25 mg. per 100 lb. of body weight, groups I through IV, respectively. Sixteen mature Hereford cows were selected from the Station herd in 1952 and assigned randomly to the four rations (four cows per group). These cows remained on the same ration during the subsequent three winter feeding periods with the exception of a few necessary replacements. (Twelve cows remained in the test groups throughout the three years.)

All cows were fed individually and received a basic ration of bleached native flood-meadow hay, ad libitum, and 3.0 lb. of barley daily. Vitamin supplementation was provided in groups II, III, and IV by adding a beta-carotene rich oil to the barley. This oil contained 7.9 mg. carotene per gram of oil.

The hay was about 90% rushes (*Juncus spp.*) and sedges (*Carex spp.*) and 10% grasses and forbs. The carotene content of the bleached hay was 1.3, 2.4 and 1.5 ppm and the crude protein content was 7.0, 8.0 and 8.1% in 1953, 1954 and 1955, respectively.

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The winter experimental feeding periods were initiated in December and terminated in early May of each year. The cows were then moved, with the main herd, to the Squaw Butte unit of the Station to graze sagebrush-bunchgrass range. This type of range provides only two to three months of green grass. The main forage producing species included bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), thurber needlegrass (*Stipa thurberiana*), June grass (*Koeleria cristata*) and squirreltail (*Sitanion hystrix*).

In September all cows and calves were moved to the meadow unit of the Station where they grazed flood-meadow aftermath until December. Very little regrowth occurs on these meadows following haying.

To investigate depletion rates of hepatic vitamin A storage, cows on the two low-carotene levels were kept on their respective winter rations throughout the summer and fall of 1955. Because of insufficient bleached hay, barley straw was substituted beginning October 13. Five of the cows were released from the experimental feeding in November and the remaining three in December, after approximately one year on the basal ration. Calves from those two groups of cows received bleached hay, *ad libitum*, and one pound of barley with no additional carotene or vitamin A available from May 12 to July 7. They were then allowed to graze meadows the remainder of the summer.

In May, 1955, six additional cows and their calves were selected from the main herd for an investigation of carotene and vitamin A values of plasma and liver. The cows were fed fair quality meadow hay for approximately five months during the winter. Otherwise the yearly management schedule was the same as the experimental group.

Blood samples were collected from the cows prior to the winter feeding period, before parturition, at the termination of the winter period each year, and at various times during the summer and fall. Blood samples were collected from calves at approximately 28 days of age. In 1955 liver biopsy samples were collected from the cows by the technique of Bone (1954). The liver samples were obtained through an incision between the eleventh and twelfth ribs about 25 to 30 cm. ventrolateral to the junction of the spine and ribs. Several animals posted soon after liver biopsy all showed incision cites in the right lobe.

The analytical methods used have been previously described by Byers *et al.* (1955).

Results and Discussion

Experimental Cows and Calves

Plasma Carotene and Vitamin A. The average plasma carotene and vitamin A values of cows and of their calves at approximately 28 days of age are presented in table 1.

The plasma carotene and vitamin A levels during the three-year study

TABLE 1. AVERAGE PLASMA CAROTENE AND VITAMIN A CONTENT OF COWS AND THEIR CALVES DURING THE EXPERIMENTAL FEEDING PERIODS OF 1953, 1954 AND 1955 (mcg. per ml.)

Blood plasma component	Group No.	1953 Initial 11/19/52	1953 Mid. 2/12/53	1953 Final 5/19/53	1954 Initial 11/12/53	1954 Mid. 2/3/54	1954 Final 5/1/54	1955 Initial 11/16/54	1955 Mid. 2/15/55	1955 Final 4/27/55	Av. 3 yr. Initial	Av. 3 yr. Final
						Cows						
Carotene	I	1.14	0.35	0.31	1.44	0.25	0.18	1.31	0.31	0.30	1.31	0.26
	II	1.17	0.64	0.97	1.76	0.18	0.42	1.07	0.77	0.67	1.33	0.74
	III	1.31	1.75	2.34	1.85	0.29	1.34	1.62	2.00	2.44	1.59	2.04
	IV	0.83	2.15	2.62	1.37	0.87	1.80	0.95	2.68	2.91	1.05	2.44
Vitamin A	I	0.33	0.25	0.15	0.24	0.22	0.12	0.35	0.28	0.22	0.30	0.16
	II	0.35	0.29	0.17	0.26	0.21	0.18	0.39	0.36	0.28	0.33	0.21
	III	0.32	0.32	0.19	0.22	0.20	0.19	0.40	0.38	0.35	0.31	0.24
	IV	0.29	0.22	0.15	0.23	0.23	0.14	0.37	0.38	0.29	0.30	0.19
						Calves						
Carotene	I			0.03			0.01			0.04		0.03
	II			0.02			0.06			0.03		0.04
	III			0.05			0.06			0.10		0.07
	IV			0.10			0.04			0.10		0.08
Vitamin A	I			0.03			0.02			0.05		0.03
	II			0.05			0.07			0.10		0.07
	III			0.10			0.12			0.14		0.12
	IV			0.11			0.06			0.14		0.10

are lower than the values reported by Watkins *et al.* (1950) for a similar period, but are in close agreement with the five-months prepartum levels obtained by Baker *et al.* (1954).

Highly significant differences in blood plasma carotene and vitamin A of cows at the terminal bleeding of the experimental period were demonstrated among the treatment groups all three years. The analysis of variance also showed a highly significant difference among years in both initial and terminal values of plasma carotene and vitamin A. The higher initial plasma carotene values in 1954 can lragely be attributed to the 1953 summer, which had a large amount of precipitation during the months of May and June and provided a longer grazing season on green forage. The

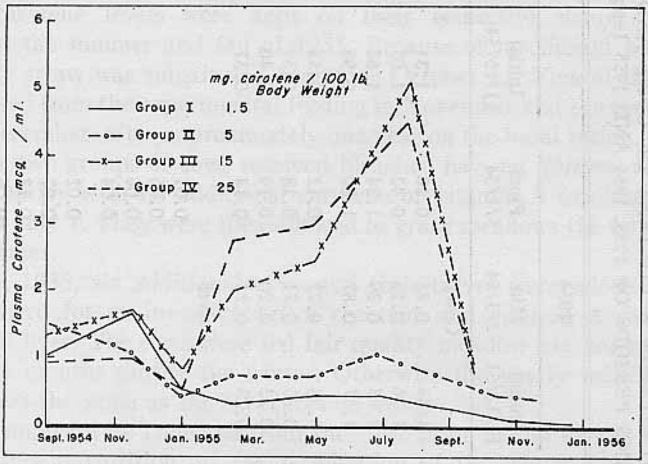

Figure 1. Average values of plasma carotene of cows on 4 levels of carotene intake.

reason for the lower initial plasma vitamin A values in 1954 cannot be explained. Cows in 1954 showed the lowest terminal plasma carotene and vitamin A values of the three-year study.

The plasma carotene of 28-day-old calves corresponded in relative magnitude to the rates of carotene intake of their dams. A similar trend is noted in plasma vitamin A, but it is not as clearly defined. Plasma vitamin A values of calves of groups I and II (table 1) were below the 10 mcg. per 100 ml. level reported by Boyer *et al.* (1942) who stated that plasma vitamin A levels of 7–8 mcg. % were borderline and values below this were inadequate for dairy calves.

Plasma carotene and vitamin A values obtained during July and September on the range showed no distinct differences among groups in 1953 and 1954. The carotene content of the range forage was sufficiently high to nullify the effects of the winter feeding trials.

Figures 1 and 2 demonstrate the effect of carotene intakes on blood

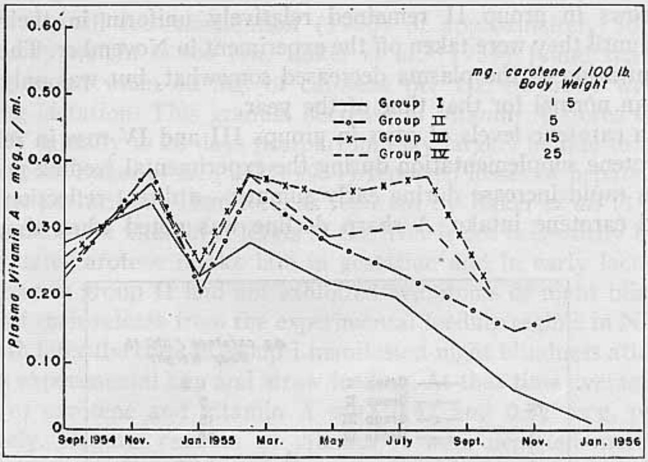

Figure 2. Average values of plasma vitamin A of cows on 4 levels of carotene intake.

plasma carotene and vitamin A of cows, respectively, in 1955. The effects of carotene supplementation were noted within 1.5 months by increased plasma carotene and vitamin A values. Baker *et al.* (1954) did not find an effect of carotene supplementation on plasma carotene until the third month of the experimental period.

There was a gradual decrease in plasma carotene and vitamin A to near zero in cows in group I, which were consuming bleached hay over a period of ten months and straw for two months. The straw contained 0.85 ppm carotene while the hay contained an average of 1.4 ppm.

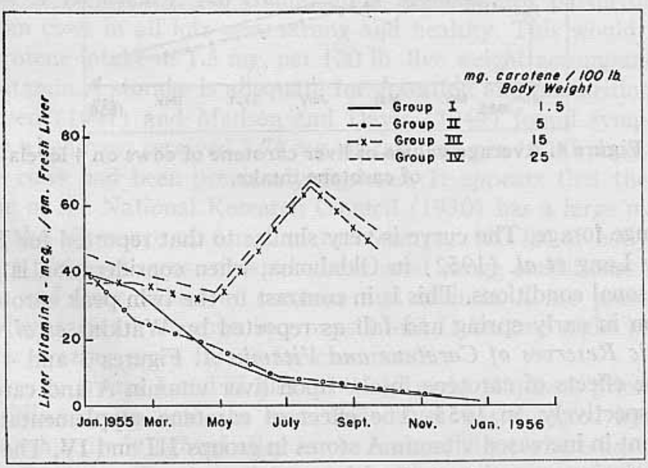

Figure 3. Average values of liver vitamin A of cows on 4 levels of carotene intake.

The cows in group II remained relatively uniform in their plasma carotene until they were taken off the experiment in November. The vitamin A concentration of the plasma decreased somewhat, but was only slightly lower than normal for that time of the year.

Plasma carotene levels of cows in groups III and IV rose in relation to their carotene supplementation during the experimental feeding period and showed a rapid increase during early summer—a direct reflection of their increased carotene intake. A sharp decline was noted when they grazed

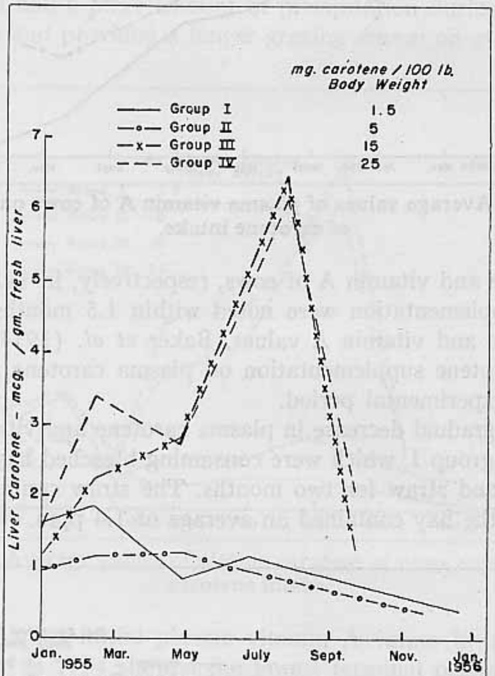

Figure 4. Average values of liver carotene of cows on 4 levels of carotene intake.

cured range forage. The curve is very similar to that reported for Hereford cattle by Long *et al.* (1952) in Oklahoma, when consideration is given to local seasonal conditions. This is in contrast to the twin peak carotene concentration in early spring and fall as reported by Watkins *et al.* (1950).

Hepatic Reserves of Carotene and Vitamin A. Figures 3 and 4 demonstrate the effects of carotene intake upon liver vitamin A and carotene of cows, respectively, in 1955. The effect of carotene supplementation was not evident in increased vitamin A stores in groups III and IV. The gradual decrease during gestation, parturition and lactation even when 25 mg. of carotene per 100 lb. body weight were fed may indicate that the National

Research Council recommendation (1950) of approximately 30 mg. per 100 lb. body weight is too low. Baker *et al.* (1954) found that hepatic stores decreased when 30 mg. of carotene per 100 lb. body weight was fed during lactation. This gradual decrease of vitamin A stores of groups III and IV initially to 28 days postpartum may largely be due to the effect of parturition. Baker *et al.* (1953, 1954) reported losses of hepatic vitamin A stores at parturition. Therefore, as reported by Baker *et al.* (1953), the failure to maintain vitamin A levels in the liver is not necessarily indicative of inadequate carotene intake late in gestation and in early lactation.

The cows in group II had not exhibited symptoms of night blindness at the time of their release from the experimental feeding regime in November. One month later the cows in group I manifested night blindness after almost a year on experimental hay and straw feeding. At that time average hepatic reserves of carotene and vitamin A were 0.42 and 0.82 mcg. per gram, respectively. Hepatic reserves of vitamin A were depleted more rapidly than carotene reserves. This is in agreement with the results of Frey and Jensen (1946).

Liver reserves of carotene and vitamin A of cows in groups III and IV increased when released to green range forage. (Groups I and II were not released to the range in 1955).

Hepatic carotene stores of cows in groups III and IV showed a direct relationship to carotene intake on summer range, peak values when grazing green forage and a rapid drop when grazing cured forage. The relationship of carotene intake to hepatic carotene levels are in agreement with the results reported by Frey and Jensen (1946). No definite relationship existed during the experimental hay feeding period and may have been due to the relatively low levels of carotene supplementation.

Vitamin A Deficiency. No complication accompanied parturition. The calves from cows in all lots were strong and healthy. This would indicate that a carotene intake of 1.5 mg. per 100 lb. live weight accompanied with hepatic vitamin A storage is adequate for gestation and parturition. Davis and Madsen (1941) and Madsen and Davis (1949) found symptoms of deficiency when cows received 2.74 mg. of carotene per 100 lb. body weight when the cows had been previously depleted. It appears that the recommendation of the National Research Council (1950) has a large margin of safety in the allowance of 6 mg. of carotene per 100 lb. of body weight for mature pregnant cows wintered under most range conditions.

Plasma and liver values of carotene and vitamin A are presented in table 2 when calves from cows in groups I and II became night blind and again after grazing green forage for one month.

All calves in groups I and II had exhibited night blindness prior to July 8. Night blindness in both the cows and calves was detected by driving them through a dimly lighted alley in the barn at night where barriers had been placed. On various occasions animals were removed from the range herd and run through the test alley concurrently with the experimental animals as controls. The control animals had no trouble in dodging the obstacles while the animals affected with night blindness would stumble and fall. The calves developed night blindness rapidly, being able to find their way through the alley one week but not a week later and during subsequent tests.

The plasma and liver levels were very low when night blindness occurred. After one month of grazing green native meadow, plasma and liver levels showed marked increases. Calf No. 547 remained blind after August 9. A necropsy of this animal showed some constriction of the optic foramen. All other calves had regained their night vision acuity within four weeks.

Calf scours were noted in 1953 and 1955 in all groups, but were more prevalent in the calves of groups I and II in 1953. These scours may have

TABLE 2. PLASMA AND LIVER VALUES OF CAROTENE AND VITAMIN A WHEN CALVES WERE DEPLETED OF VITAMIN A AND AGAIN AFTER GRAZING GREEN FORAGE FOR ONE MONTH

Calf No.	Plasma carotene		Plasma vitamin A		Liver carotene		Liver vitamin A	
	7/8/55	8/9/55	7/8/55	8/9/55	7/8/55	8/9/55	7/8/55	8/9/55
	mcg./ml.				mcg./g. fresh			
521	0.13	3.84	0.04	0.12	0.02	1.02	0.53	8.60
522	0.10	3.58	0.02	0.15	0.05	0.53	0.76	14.00
526	0.14	2.42	0.01	0.17	0.06	0.16	0.95	4.63
527	0.10	3.26	0.03	0.16	0.02	1.18	0.21	5.50
547	0.06	2.14	0.05	0.11	0.05	0.76	0.46	6.68
590	0.05	....	0.06	....	0.05	....	0.08	....
591	0.07	3.08	0.05	0.22	0.05	0.89	1.37	10.46
611	0.06	....	0.04	....	0.03	1.57	0.56	10.07
Av.	0.09	3.05	0.04	0.16	0.04	0.87	0.62	8.56

been precipitated by the crowded conditions under which the cows and calves were kept. In 1955 night blindness developed in calves in groups I and II from 13 to 38 days of age. No symptoms were observed in the calves of groups III and IV up to 28 days of age at which time they were released to sagebrush-bunchgrass range.

The fact that vitamin A deficiency occurred in the calves nursing dams receiving 5 mg. of carotene per 100 lb. of live weight demonstrates that this level of feeding is not adequate without other supplementation to support healthy calves. Possibly the calves from cows which received the 15 and 25 mg. levels of carotene would have developed deficiency symptoms also had they been held in the dry lot for an extended period of time. Under most range conditions the calves will have access to hay or range within a few weeks after birth.

Field Cows and Calves. Plasma and liver values of carotene and vitamin

A of the cows and their calves from the main herd are presented in figures 5 and 6, respectively. Plasma carotene and vitamin A and liver carotene values of cows and their calves reflect increased carotene intake on green

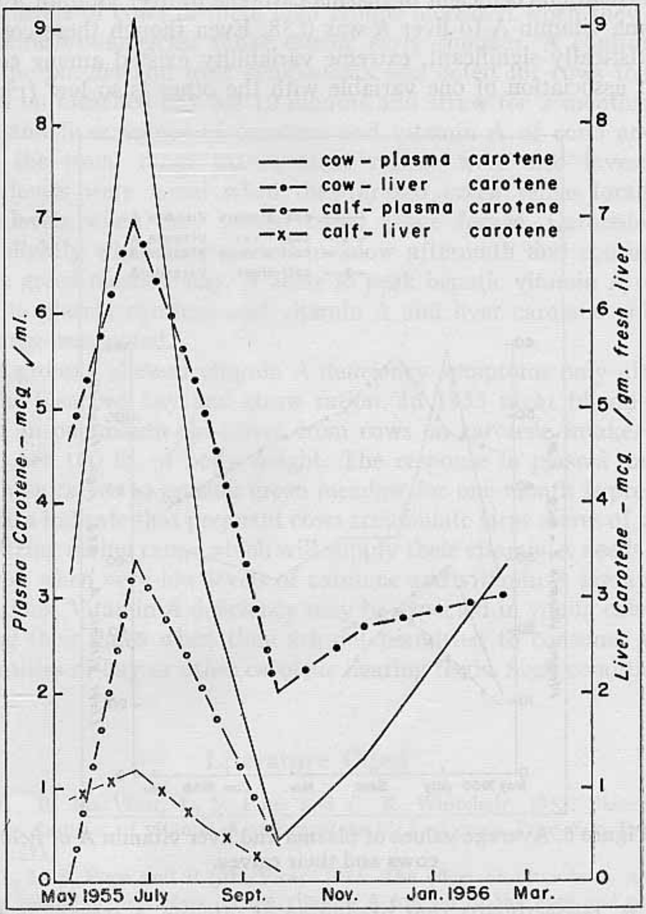

Figure 5. Average values of plasma and liver carotene of field cows and their calves.

spring and early summer forage, and decreased carotene intake on cured forage in the late summer and fall.

The peak of plasma carotene and vitamin A and liver carotene was reached in June, but the peak in hepatic vitamin A levels was not reached until August. These data indicate that plasma carotene and vitamin A and liver carotene values are more responsive to carotene intake than are hepatic vitamin A levels.

Correlation of Plasma Carotene and Vitamin A to Liver Vitamin A. Plasma carotene and vitamin A were both significantly correlated with hepatic vitamin A levels when all of the experimental and field cows were used.

The correlation coefficient of plasma carotene to liver vitamin A was 0.34 and plasma vitamin A to liver A was 0.38. Even though these correlations were statistically significant, extreme variability existed among cows. The degree of association of one variable with the other is so low (r^2=11.6% and 14.4%, respectively) that prediction of vitamin A storage in the liver of an individual cow from carotene and vitamin A concentrations of the plasma would be unreliable. This is in agreement with Thomas and Moore (1952) who reported that the use of plasma levels in a survey to estimate intake or storage may possibly lead to erroneous conclusions.

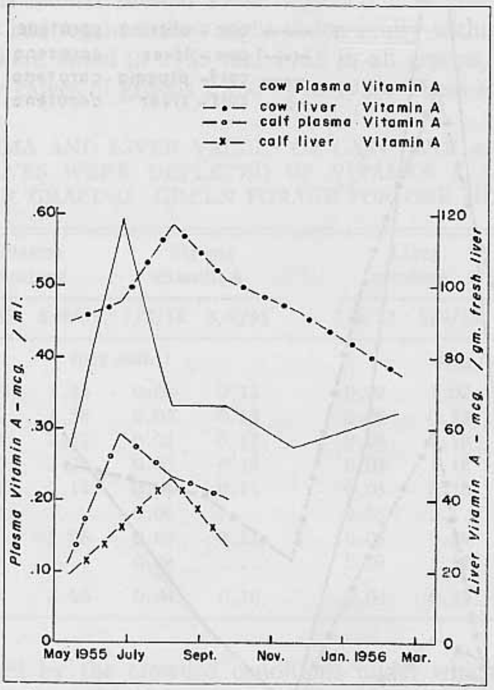

Figure 6. Average values of plasma and liver vitamin A of field cows and their calves.

Summary

Blood plasma and hepatic levels of carotene and vitamin A are reported for cows with carotene intakes of 1.5, 5, 15 and 25 mg. per 100 lb. body weight, respectively by groups I to IV.

Plasma and liver carotene showed a direct relationship to carotene intake during the four-month winter feeding period, and when cows grazed range forage. Hepatic vitamin A reserves were not maintained even at the highest rate of carotene intake during the winter feeding period. Liver vitamin A levels of cows in these high groups increased when they grazed green sagebrush-bunchgrass range during early summer. A continual decrease of the plasma and liver components was noted for cows that were maintained on bleached hay for 10 months and straw for 2 months.

Plasma and liver values of carotene and vitamin A of cows and their calves on the usual range management regime were also investigated. Increased levels were noted when they grazed green range forage, and decreased levels when they grazed cured range forage. Carotene levels increased slightly when they grazed meadow aftermath and continued to increase on green meadow hay. A delay in peak hepatic vitamin A reserves compared to plasma carotene and vitamin A and liver carotene values on summer range was noted.

Cows in group I showed vitamin A deficiency symptoms only after 350 days on the bleached hay and straw ration. In 1955 night blindness was manifested in one-month-old-calves from cows on carotene intakes of 1.5 and 5 mg. per 100 lb. of body weight. The response in plasma and liver levels of these calves to grazing green meadow for one month is presented.

These data indicate that pregnant cows accumulate large stores of vitamin A when grazing spring range which will supply their vitamin A needs during winters even when very low levels of carotene and vitamin A are available in their rations. Vitamin A deficiency may be expected in young calves that are nursing their dams when they are not permitted to consume at least small quantities of hay or other carotene bearing feeds. Such conditions are unusual.

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