Proceedings of the Iowa Academy of Science

Volume 58 | Annual Issue Article 26

1951

Effect of Iodinated Casein and Thiouracil on the Concentrations of Carotenoids and Vitamin A in the Blood Plasma of Young Dairy Animals

R. S. Allen
Iowa Agricultural Experiment Station

G. H. Wise
Iowa Agricultural Experiment Station

N. L. Jacobson
Iowa Agricultural Experiment Station

Effect of Iodinated Casein and Thiouracil on the Concentrations of Carotenoids and Vitamin A in the Blood Plasma of Young Dairy Animals[1]

R. S. ALLEN, G. H. WISE[2] and N. L. JACOBSON

In recent years attention has been directed to the role of the thyroid gland in the metabolism of carotene and vitamin A. Drill and Truant (1947) reported that carotene administration failed to prevent xerophthalmia in thyroidectomized rats, whereas vitamin A supplementation cured the eye lesions. Moreover, Johnson and Baumann (1947), using liver storage of vitamin A as the criterion of conversion of carotene to vitamin A, found that hyperthyroid rats accumulated larger stores of vitamin A than normal rats receiving equivalent doses of carotene, but rats rendered hypothyroid by feeding either thiourea or thiouracil stored little vitamin A. Similar experiments by Kelley and Day (1948) also indicated that thiouracil interferred with the conversion of carotene to vitamin A in rats. Conversely, Wiese and associates (1948), using growth as a measure of carotene utilization, found that the ability of rats to convert carotene to vitamin A was not impaired by feeding thiouracil.

Recently, Cama and Goodwin (1949) indicated that the thyroid acts, not by stimulating the conversion of carotene to vitamin A, but by controlling the absorption of carotene.

In view of the recognized importance of carotene and vitamin A in the nutrition of the bovine, the relation of the thyroid to carotene and vitamin A metabolism as reflected in levels of these constituents in blood plasma of young dairy animals seemed worthy of investigation.

Experimental

Five young dairy animals (one Guernsey and two Jersey males and two Jersey females [twins]) from the Iowa State College dairy herd were used for this investigation. The three males were used in trials I, II and III and the females in trial IV (Table I). In trial I all animals received at different times the iodinated casein treatment, two were fed the control diet and one received thiouracil. These subjects, previously employed in carotene and vitamin A absorption studies (Jacobson, Wise, Allen and Kempthorne, 1950),

[1]Journal Paper No. 1781 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 814.

[2]Present address: Department of Animal Industry, North Carolina State College, Raleigh.

Table 1

Summary of the Experimental Plan and the Initial Blood Plasma Vitamin A and Carotenoid Levels

Trial No.	No. Animals	Age at Start of Trial	Diet	Daily Supplemental Treatments		Initial Blood Plasma Levels	
				Carotene	Thyroidal Agent	Vitamin A	Carotenoids
		(months)		(I.U./100 lb. body weight)	(g./100 lb. body weight)	(μg./100 ml.)	
I	2	13[a]	concentrate	4500	none, control	6.7[a]	15.8[a]
	1	8	mixture	4500	thiouracil (5 g.)	8.2	32.4
	3	13[a]		4500	iodinated casein (3 g.)	6.1[a]	20.1[a]
II	1	12	concentrate	2500	none, control	2.4	12.9
	1	12	mixture	2500	thiouracil (10 g.)	4.8	31.4
	1	11		2500	iodinated casein (2.5 g.)	14.5	56.1
III	1	17	concentrate	none	none, control	54.5	10.5
	1	17	mixture	none	iodinated casein (3 g.)	45.1	12.7
IV	1	5	alfalfa hay &	none	none, control	22.4	73.0
	1	5	concentrate mixture	none	iodinated casein (1.5-2.5 g.)	19.5	39.8

[a]Average values.

had received a diet comprised of reconstituted separated milk and a concentrate mixture. Approximately one month before the present investigations were begun, the separated milk was omitted from the diet. The three males were restricted to a diet composed of the following: ground yellow corn, 400 lb.; crushed oats, 300 lbs.; wheat bran, 200 lb.; linseed oil meal, 100 lb.; steamed bone meal, 20 lb.; common salt, 10 lb.; and irradicated yeast, 1 lb. This diet supplied a low carotene intake and, consequently, these animals had low blood plasma vitamin A and carotenoid levels prior to the experimental trials. The Jersey heifers were fed a diet consisting of alfalfa hay and a concentrate mixture. The thyroid-active agent used was iodinated casein, "Protamone", and the anti-thyroid material was 2-thiouracil. Supplemental carotene and vitamin A in the form of carotene in oil and of fish liver oil concentrates, respectively, were fed by capsule. Blood samples were drawn at weekly intervals, and the plasma therefrom was analyzed for carotenoids and vitamin A by the method of Squibb *et al.* (1948).

Trials and Results

A summary of the experimental plan and the initial blood plasma levels of carotenoids and vitamin A are shown in Table I.

Trial I. The comparative effects of iodinated casein and of thiouracil on the changes in the blood plasma levels of vitamin A and of carotenoids are shown in Figure I. Iodinated casein appeared to prevent the normal rise in blood plasma levels of carotenoids and vitamin A in three animals when the diet was supplemented daily with 4500 I.U. of carotene per 100 lb. body weight. The vitamin A values during the period of iodinated casein consumption were essentially constant, whereas those of the control group increased during the first week, then remained relatively constant for the remainder of the trial. The blood plasma carotenoid level in the thiouracil-treated animal increased rapidly during the first two weeks and then steadily decreased, whereas the vitamin A levels were maintained above those of the control group.

The animals fed iodinated casein consumed slightly less concentrate mixture than did the other animals and decreased in body weight while the others increased.

Trial II. It was postulated that the carotene supplementation in trial I might have been too great to show the influence of the hyperthyroid condition on the conversion of carotene to vitamin A. Consequently, the daily carotene supplementation was reduced to 2500 I.U. per 100 lb. body weight and was maintained at this level

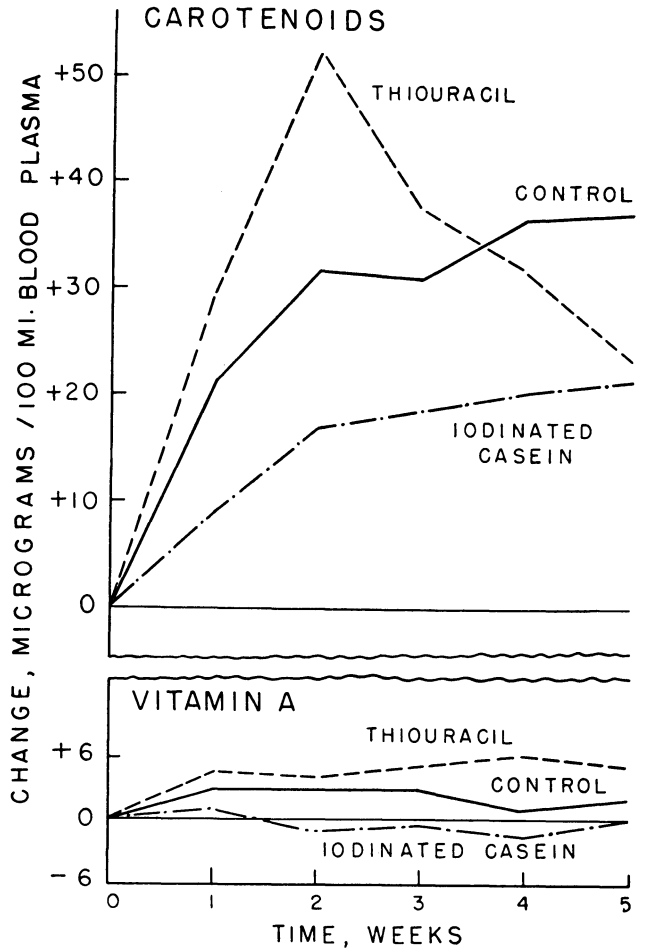

Figure 1. Effect of iodinated casein (3 g./day/100 lb. body wt.) and thiouracil (5 g./day/100 lb. body wt.) on the blood plasma levels of carotenoids and vitamin A in young dairy animals receiving daily supplements of carotene (4500 I.U./100 lb. body wt.).

for several weeks prior to and during the experimental period. Since the level of iodinated casein in trial I had an adverse effect on the well-being of the experimental subjects, the quantity of this thyroidal substance administered daily was reduced to 2.5 grams per 100 lb. body weight.

Results shown in Figure 2 indicate that thiouracil had little influence on plasma carotenoid and vitamin A levels, but iodinated casein caused marked declines in both. Although the iodinated casein-treated animal consumed approximately the same amount of concentrate mixture as the control, it gained only two pounds during

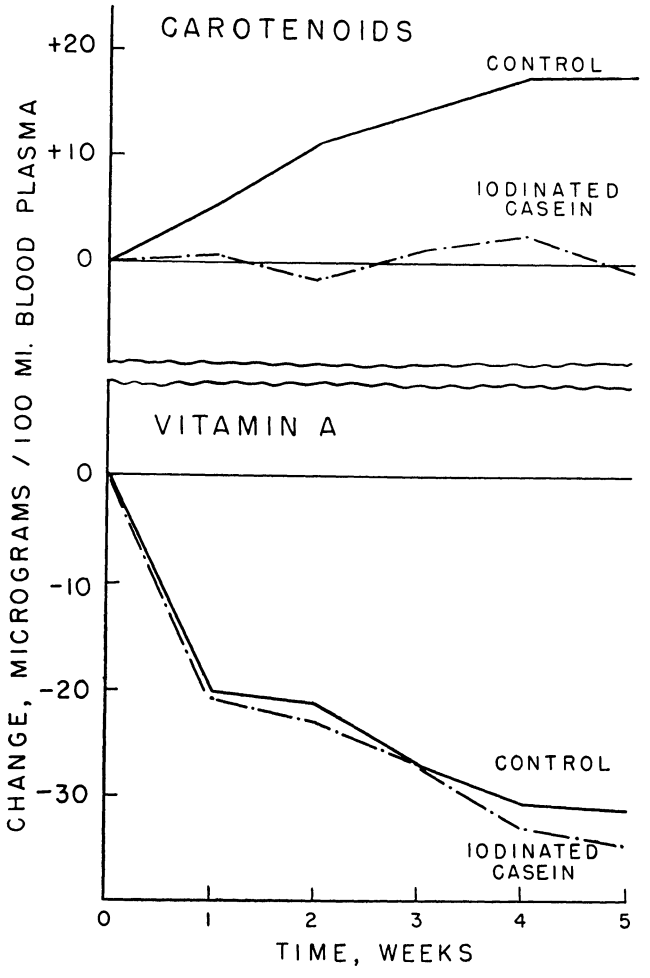

Figure 2. Effect of iodinated casein (2.5 g./day/100 lb. body wt.) and thiouracil (10 g./day/100 lb. body wt.) on the blood plasma levels of carotenoids and vitamin A in young dairy animals. Prior to and during the experiment the animals received daily supplements of carotene (2500 I.U./100 lb. body wt.)

the five weeks on experiment. The animal fed thiouracil at a rate double that employed in trial I consumed less feed and increased less in body weight than the control.

Trial III. Since the health of the experimental subjects was impaired by feeding iodinated casein when the animals were at a marginal level of vitamin A nutrition, the experimental plan was modified by the supplementation of the rations of two animals with approximately 50,000 I.U. vitamin A per animal daily for seven weeks. The blood plasma vitamin A levels increased rapidly and

then remained relatively constant for several weeks. At this point iodinated casein administration to one animal was initiated and the vitamin A supplementation of both animals was discontinued. This trial was planned to measure the influence of iodinated casein on the rate of depletion of the vitamin A reserves.

The blood plasma vitamin A levels decreased sharply during the first week after cessation of the vitamin A feeding; in successive weeks the values continued to decrease but at a diminished rate (Figure 3). Iodinated casein appeared to have no significant effect on this decline. The blood plasma carotenoid levels in the control, however, were observed to increase about 200% over the starting level whereas no increases were recorded in those of the animal fed iodinated casein.

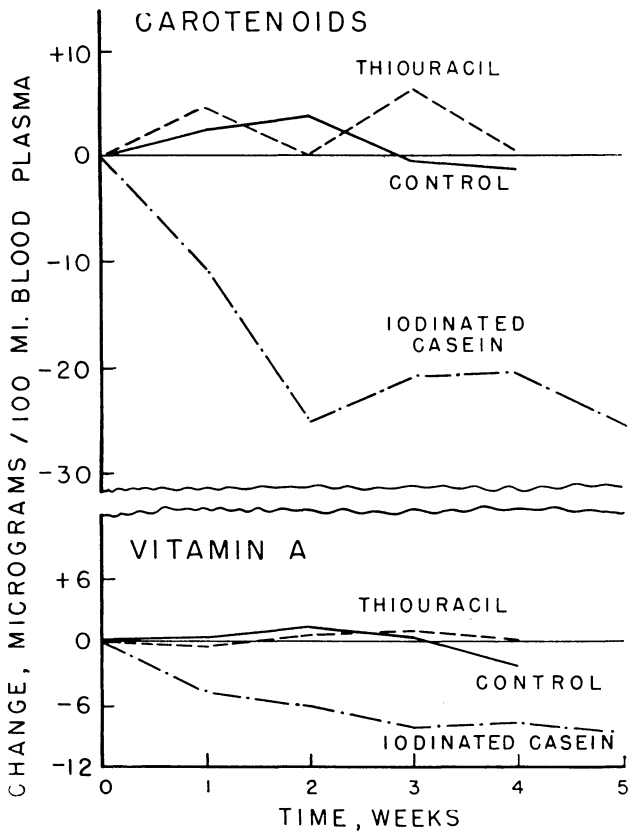

Figure 3. Effect of iodinated casein on the changes in the blood plasma levels of carotenoids and vitamin A in a young dairy animal after cessation of liberal vitamin A supplementation.

Trial IV. As previously indicated, the twin Jersey heifers were given a diet consisting of alfalfa hay and concentrate mixture. After a three-week preliminary period, iodinated casein, which was mixed with the concentrate, was fed to one of the animals at the rate of 1.5 grams daily per 100 lb. body weight. The control animal received the same diet except that the iodinated casein was omitted. Iodinated casein fed at this level over a period of three weeks had no significant effect on the concentrations of carotenoids and vitamin A in the blood plasma. In neither calf did the blood plasma levels of these vitamin substances change appreciably from the initial values shown in Table I.

At this point in the experiment the rate of administration of iodinated casein was increased to 2.5 grams daily per 100 lb. body weight. Improvement of the quality of alfalfa hay fed during a seven-week period resulted in substantial increases both in carotenoids and in vitamin A in the blood plasma of both animals. The rates of increase of each of these vitamin substances were similar for both animals. Thus, iodinated casein apparently had no significant influence on the blood plasma levels of carotenoids and vitamin A.

When a fair quality hay was substituted for the good roughage during another seven-week period and the administration of iodinated casein reduced to 1.5 grams daily per 100 lb. body weight, the rates of decrease of blood plasma levels of vitamin A and carotenoids in the control and in the experimental subject were similar.

Discussion

The observed depressing effect of iodinated casein on the blood plasma levels of carotenoids and vitamin A is difficult to interpret. Differences in feed consumption were not sufficiently great to account for the observed changes. One factor that might have been involved is a decrease in the absorption of carotene from the alimentary tract. Such an explanation would seem tenable since the blood plasma levels of both carotenoids and vitamin A were depressed by iodinated casein administration. These observations, however, are in direct contradiction to the work of Cama and Goodwin (1949), who found that desiccated thyroid increased the absorption of β-carotene from the intestinal tract of rats.

Another possible explanation for the observed results is that iodinated casein feeding resulted in an increased rate of conversion of carotene to vitamin A accompanied by a concomitant increase in the rate of storage and/or catabolism of vitamin A. Johnson and Baumann (1947) have reported that a hyperthyroid condition promoted an increased conversion of carotene to vitamin A in the rat.

The lower blood plasma carotenoid levels in young dairy animals following the administration of iodinated casein suggest the possibility of an increase in the conversion of carotene to vitamin A. Since the vitamin A levels also were consistently below those of the control groups, however, it might be postulated that an increase in vitamin A catabolism and/or storage offset the additional vitamin A resulting from the accelerated rate of conversion. Whether such a possible increase in the requirement for vitamin A in the hyperthyroid animal is a direct result of an increase in basal metabolic rate is obscure. It has been reported (Greaves and Schmidt, 1936) that the administration of thyroxine hastened the depletion of vitamin A reserves in rats, but that dinitrophenol, which is known to produce an increased basal metabolic rate, had no such effect. These findings are not entirely in accord with those of Heimer, *et al.* (1949), however, who suggested that the thyroid hormone does not affect the rate of destruction or the utilization of vitamin A.

The data presented herein reveal no effect of thiouracil on the conversion of carotene to vitamin A. These findings are in agreement with the report of Smith and associates (1948) who found that vitamin A-depleted thyroidectomized goats, which were fed thiouracil, were able to convert carotene to vitamin A. Moreover, Wiese, Mehl and Deuel (1948) found that carotene and vitamin A were about equally well utilized by rats rendered hypothyroid by feeding thiouracil. Conversely, it has been reported that thiouracil impaired the conversion of carotene to vitamin A in rats (Johnson and Baumann, 1947; Kelley and Day, 1948) and in feeder lambs (Barrick, Andrews, Beeson and Harper, 1948). Thiourea also has been found to suppress the conversion of carotene to vitamin A in rats (Johnson and Baumann, 1947) and in sheep (Bolin and Bolin, 1949).

Although Cama and Goodwin (1949) reported that thiouracil inhibited the absorption of β-carotene from the intestinal tract of rats, the present study offers no evidence that a similar relationship exists in young dairy animals.

When the carotene intake was adequate or above normal requirements, iodinated casein appeared to have little or no influence on the blood plasma levels either or vitamin A or of carotenoids in Jersey heifers. This is in agreement with the work of Cama and Goodwin (1949) who reported that desiccated thyroid, even in large doses, had no significant effect on the blood plasma vitamin A levels of rabbits which were maintained on a high carotene diet.

Summary

The blood plasma levels of carotenoids and vitamin A in young dairy animals receiving a low-carotene diet were not measurably affected by feeding thiouracil but were depressed by the administration of iodinated casein. When the carotene intake was liberal, iodinated casein had little or no influence on the blood plasma levels of these vitamin substances.

Acknowledgment

The authors wish to express appreciation to the following organizations for materials furnished for these experiments: Cerophyl Laboratories, Kansas City, Mo. for the iodinated casein; Lederle Laboratories Division, American Cyanamid Co., New York, N. Y. for the 2-thiouracil; and the Bordon Co., New York, N. Y., through the courtesy of Dr. L. T. Wilson, for the vitamin A concentrate.

Literature Cited

Barrick, E. E., Andrews, F. N., Beeson, W. M. and Harper, C. 1948. Effects of thiouracil and similar compounds on feeder lambs. J. Animal Sci. 7:539.

Bolin, F. M. and Bolin, D. W. Effect of thiourea upon conversion of carotene into vitamin A in sheep. Proc. N. Dakota Acad. Sci. 2:46-48. 1949. (Chem. Abs. 43:5096).

Cama, H. R. and Goodwin, T. W. 1949. Studies in vitamin A. 9. The role of the thyroid in carotene and vitamin A metabolism. Biochem. J. 45:236-41.

Drill, V. A. and Truant, A. P. 1947. Effect of thyroidectomy on the conversion of carotene to vitamin A. Endocrinology. 40:259-64.

Greaves, J. D. and Schmidt, C. L. A. 1936. Studies on the vitamin A requirements of the rat. Am. J. Physiol. 116:456-67.

Heimer, C. B., Maslow, H. L. and Sobel, A. E. 1949. Influence of thyroid on utilization of vitamin A. J. Nutrition 38:345-52.

Jacobson, N. L., Wise, G. H., Allen, R. S. and Kempthorne, O. 1950. Rate of absorption of carotene and of vitamin A from the alimentary tract of dairy calves. I. Effect of method of administration. J. Dairy Sci. 33:645-56.

Johnson, R. M. and Baumann, C. A. 1947. The effect of thyroid on the conversion of carotene into vitamin A. J. Biol. Chem. 171:513-21.

Kelley, B. and Day, H. G. 1948. Thiouracil and the conversion of carotene to vitamin A in the rat. J. Biol. Chem. 175:863-6.

Smith, V. R., Niedermeier, R. P. and Schultz, L. H. 1948. The effect of thyroidectomy plus thiouracil feeding on carotene metabolism in the goat. J. Animal Sci. 7:544.

Squibb, R. L., Cannon, C. Y. and Allen, R. S. 1948. Effect of raw soybeans and of soybean oil on plasma carotene and on vitamin A as measured by activated glycerol dichlorohydrin. J. Dairy Sci. 31:421-27.

Wiese, C. E., Mehl, J. W. and Deuel, H. J. 1948. Studies on carotenoid metabolism. IX. Conversion of carotene to vitamin A in the hypothyroid rat. J. Biol. Chem. 175:21-8.

Iowa Agricultural Experiment Station
Ames, Iowa