The effects of sources of Vitamin A and yeast upon utilization of Vitamin A by beef calves : the effect of feeding stilbestrol and antibiotics to cattle on a high barley fattening ration
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Abstract:
I. The first portion of the thesis presents the results of a study to determine the effects of sources of vitamin A, and yeast, upon utilization of vitamin A by beef calves. Two types of concentrated; vitamin A were studied: a corn-oil suspension of vitamin A (potency 1,600,000 I. U. per gram) and vitamin A palmitate in gelatin (potency 250,000 I.U. per gram). Yeast was added to the depletion rations of half the calves. The sixteen Hereford steer calves used in the trial were first depleted of vitamin A stores. Supplemental vitamin A was then fed via capsule at levels of 50,000 I. U. per steer daily for five or ten days, or 100,000 I. U. daily for ten days* Changes in blood plasma and liver vitamin A levels were used to determine utilization of vitamin A, There were no consistent' differences in the effects of the two types of vitamin A supplements used on plasma vitamin A content, or vitamin A storage in the liver. The depletion of vitamin A from the liver was faster when the steers received the corn-oil suspension of vitamin A. The addition of yeast to the ration had no apparent effect upon plasma-vitamin A values, but did tend to induce higher liver stores of vitamin A with slower subsequent depletion of liver stores® The level of 50,000 I.U. of vitamin A per steer daily for five days, was insufficient to initiate liver storage. When increased to ten days, 50,000 I. TL did initiate liver storage, and 100,000 I. U. per steer daily provided substantial liver storage. After vitamin A supplementation stopped, plasma and liver vitamin A content decreased rapidly at first, but tended to level off as the plasma and liver-vitamin A values decreased.

II. The second portion of the thesis presents the results of a cattle fattening trial designed to study the effects of adding stilbestrol and/or aureomycin to a high-barley fattening ration. Forty yearling Hereford steers were randomly divided into four lots of ten head each. The treatments used were: Lot 1, 10 milligrams of stilbestrol plus 75 milligrams of aureomycin per steer daily; Lot 2, 75 milligrams of aureomycin per steer daily; Lot 3, control; and Lot 4, 10 milligrams of stilbestrol per steer daily. The stilbestrol and aureomycin were incorporated into pelleted supplements which were group fed to each lot of steers at a rate of one pound per head daily. In addition to the pelleted supplements each lot was full-fed a basal ration of two-thirds barley and one-third beet pulp plus alfalfa hay free-choice. The animals fed stilbestrol gained 9.3 percent faster than the controls while the aureomycin or aureomycin-stilbestro1-fed animals gained 2.9 percent and 7 percent slower than the controls, respectively. The stilbestrol-fed and aureomycin-fed steers required 39 and 8 pounds less feed per hundredweight gain than the control steers, respectively, and the aureomycin-stilbestrol-fed steers required 57 pounds more. All four lots of steers lost money as follows: stilbestrol $12.18 per steer, aureomycin $14.67 per steer, aureomycin-stilbestrol $17.20 per steer; and control $l5.48 per steer.

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ABSTRACT

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I. THE EFFECTS OF SOURCES OF VITAMIN A AND YEAST UPON UTILIZATION OF VITAMIN A BY BEEF CALVES

INTRODUCTION

Vitamin A, required by all animals, is essential for maintenance, growth, reproduction, and milk production. One of the most important functions of vitamin A is to keep the epithelial structures of the body healthy and in proper functioning condition. Lack of the vitamin causes the proteins of the epithelial cells to be transformed into keratin, an insoluble protein. When keratinization progresses very far, the functions of the epithelial structures are impaired, and, in many cases, the tissues are so weakened that infections may get a foothold. Vitamin A is also necessary for the formation of visual purple which is required for vision in dim light, for the proper functioning of the nervous system, and for proper growth.

Although vitamin A does not occur as such in feeds of plant origin, green-leaved plants and certain other feeds of plant origin contain substances grouped under the term carotenoids. The most important of these carotenoids is Beta-carotene. Carotene is converted into vitamin A within the animal body and is, therefore, under natural conditions, the source of vitamin A for farm livestock.

When considering the nutrients required by farm livestock, vitamin A probably ranks near the first in importance, especially for ruminants in range areas. For, in these areas, livestock must subsist for considerable portions of each year on dry, mature range which has lost most, if not all, of its vitamin A potency. The possibilities of encountering a vitamin A deficiency are lessened considerably by the fact that animals have the

ability to store considerable amounts of vitamin A during periods of high vitamin A intake. However, the relatively dry climate in range areas, bringing about early maturing of the grass, seriously shortens the lush growing season when vitamin A storage is possible. Consequently, vitamin A storage is often insufficient to carry the animals through the winter months, especially after periods of drouth. To safeguard against possible vitamin A deficiencies, many range livestock producers have adopted the practice of fortifying winter supplemental livestock feed with vitamin A.

The trial reported herein was undertaken to study the utilization and storage of two types of vitamin A concentrate which might be used to fortify commercial feed mixtures. Changes in liver and blood plasma-vitamin A levels were used as yardsticks to determine vitamin A storage and/or utilization. The liver and blood plasma-vitamin A levels were determined by chemical analysis of blood and liver samples collected at regular intervals. It was also desired to determine levels of orally administered vitamin A (fed for only a short period of time), which would initiate liver storage.

During a mineral study with beef steer calves during the winter of 1953-54 (Thomas, 1954), routine blood plasma analysis indicated that yeast in the ration had a tendency to decrease plasma-vitamin A and carotene levels. To obtain further information on possible interrelationships between yeast and vitamin A, active dry yeast was incorporated into the rations of half the steers in the trial reported herein.

LITERATURE REVIEW

The presence of the water soluble vitamins B and C in certain food materials was ascertained primarily from data gathered from observations on disease. In contrast, the conception of fat-soluble vitamin A arose from the failure to secure normal growth in experimental animals for a long period of time on purified diets which furnished adequate proteins, fats, carbohydrates, and salts. Hopkins in 1906 and Stepp in 1909 both presented data showing that certain fat-soluble substances were indispensable for growth in mice and rats. It was not until 1913, however, that the existence of vitamin A was first clearly recognized. In work with rats that appeared almost simultaneously in that year, McCollum and Davis, and Osborne and Mendel, ascertained the presence of a growth factor, "fat-soluble A", differentiated from other compounds in cod liver oil and in butter. In 1931, Karrer obtained a highly concentrated vitamin A preparation and determined the structure of the vitamin and in 1933 he and associates established its chemical nature. In 1937, Kuhn and Marrion announced the synthesis of vitamin A and Holmes and Corbet obtained vitamin A for the first time in crystalline form. Carotene was isolated from carrots by Wachenroder in 1831 and Willstatter established the emperical formula in 1906. The vitamin A activity of the carotenoids was discovered by Stennbock in 1919. (Sherman and Smith, 1931, and Rosenberg, 1945).

Guilbert et al (1935, 1937, 1940) did much of the early work that established the minimum requirements of vitamin A for farm animals. Their work was based upon nightblindness as a criterion supplemented by checks on vitamin A storage. Evidence was presented which indicated that the amounts

of vitamin A or carotene that just prevent nightblindness represent a physiological minimum. Based on this criteria their stated requirements for cattle, sheep, swine and horses all fell within the same relative ranges. The minimum carotene requirement was 25-33 micrograms per kilogram of body weight daily, and the minimum vitamin A requirement was 5 to 8 micrograms per kilogram of body weight daily. Excellent growth occurred at these levels yet storage after extended periods was meager. Studies of storage at different levels of intake indicated that levels of at least five times the minimums would be a desirable minimum for practical purposes of significant storage and reproduction. The requirements per unit of body weight were about the same for young and old animals, but the young were more susceptible to pathological manifestations during privation. Evidence was also advanced that indicated vitamin A requirements are related to body weights rather than energy requirements as was previously supposed. If vitamin A requirements were related to energy requirements, the rat, with its higher metabolic rate, should have a requirement of about five times that of farm animals when based on unit of body weight. The data indicated that in actuality the requirements were very nearly the same per unit of weight. The data also showed a tendency for the rate of depletion of vitamin A stores to decrease as depletion advanced and reserves became smaller. Moore (1939), using nyctalopia and papillary edema as criteria substantiated the requirements established by Guilbert and co-workers. Lewis and Wilson (1945), using growth, blood levels, and liver storage as criteria also indicated that about eight micrograms was the minimum requirement for calves. Moore et al (1943) presented data which indicated that the measure-

ment of spinal fluid pressure is a fairly critical index of adequacy or inadequacy of carotene intake. Using this as a criteria they determined that a carotene intake of 66 micrograms per kilogram body weight was a daily winter minimum requirement for dairy calves.

Riefman et al (1943) in working with rats found the rate of absorption of vitamin A to be proportional to the concentration of the administered material. There was no relationship found between the rate of absorption of neutral fat and vitamin A. Barrick et al (1948) studied the absorption of carotene and vitamin A from the gastrointestinal tract of the sheep. They found that relatively large amounts of vitamin A were required to cause a noticeable rise of vitamin A in the blood plasma. The change in the vitamin A content of the blood was much slower and less pronounced following the administration of carotene than in the case of vitamin A. No absorption was observed as a result of administering either vitamin A or carotene into the colon. Esh et al (1948) reported that, in dairy animals, there was an indication that lecithin enhanced absorption of vitamin A. Lecithin added to vitamin A increased the transmission of colostral vitamin A.

Although most textbooks state that the conversion of carotene into vitamin A occurs chiefly in the liver, considerable data is accumulating to indicate the intestinal wall is the primary site of conversion. However, conflicting observations occur in the literature and it is probable that conversion can occur at more than one site in the body. Kon and Thompson (1951), on the basis of evidence presented in an extensive literature review, concluded that carotene is transformed to vitamin A mainly in the intestinal wall and that it is carried thence by the lymphatics to the blood stream and

finally to the liver. Alexander and Goodwin (1950) demonstrated conversion of carotene to vitamin A in rats in either the intestine or the intestinal wall. Oral administration of carotene to rats with the intestinal lymphatic vessel cannulated resulted in a marked increase in the vitamin A content of the lymph. No carotene was observed in the lymph. Thompson et al (1950) made extensive studies of intestinal conversion in rats and pigs. They found that very little conversion took place until after the bile and pancreatic juice entered the intestine with the peak of conversion just proximal to the middle of the intestine. When the intestinal contents were washed out from the living intestine, vitamin A appeared almost exclusively in the wall of the intestine, indicating conversion in the wall rather than in the contents of the digestive tract. The efficiency of conversion of carotene increased with the state of dispersion. Evidence also indicated that vitamin A is transported to the liver by the lymph.

Klosterman et al (1949) injected carotene suspended in water or carotene in cottonseed oil into the blood stream of sheep. They found that injected carotene was very rapidly removed from the blood stream. However, apparently this carotene was not converted to vitamin A as no increase of the vitamin in blood or storage in the liver was noted. Lambs given carotene by mouth or allowed green grass for a short period showed an increase of vitamin A in the blood serum. These observations, coupled with the fact that no measurable amount of carotene is found in the blood of normal sheep, suggest that carotene is converted to vitamin A by sheep during digestion and/or absorption rather than by the liver. Swick et al (1952) reported that when large doses of carotene were given pigs six to seven hours before

slaughter, there was a marked increase (up to 20 fold) in the concentration of vitamin A in the mesenteric lymph with a smaller rise in the blood plasma and intestinal wall.

Church et al (1954) studied the utilization of intravenously administered carotene by sheep and cattle. The carotene used was an aqueous preparation. In wethers, increases in plasma-vitamin A after carotene injections were highly significant. In calves, on the other hand, carotene injection caused no significant differences in plasma-vitamin A values or liver storage. In addition, advanced vitamin A deficiency symptoms present in some of the calves were not relieved and appeared to progress during the ten days of the experiment. Eaton et al (1951) reported a very limited conversion of carotene to vitamin A in the blood of vitamin A deficient dairy calves given intravenous injections of aqueous suspensions of carotene. Warner and Maynard (1952) reported that intravenously injected carotene in coconut oil gave no beneficial effects when administered to vitamin A deficient dairy calves. However, in a second trial with aqueous colloidal carotene administered intravenously, a significant increase in plasma-vitamin A was obtained.

Parrish et al (1951) studied the relative values of vitamin A and carotene in swine rations during gestation and lactation. Although there was no positive evidence that the carotene supplemented gilts or their pigs suffered from a vitamin A deficiency, the data clearly showed that, unit for unit, carotene is less effective than preformed vitamin A as a vitamin A supplement for swine during gestation and early lactation. Hentges et al (1952) studied the effects of carotene administered orally, intramuscularly and intravenously on vitamin A deficiency in pigs. It was found that, with

aqueous preparations of carotene, all three methods afforded complete recovery from vitamin A deficiency symptoms and normal plasma-vitamin A levels. Orally administered carotene was converted most rapidly while intravenous injections were utilized before intramuscular injections. Carotene in cottonseed oil administered intramuscularly remained at the site of injection and was ineffective in relieving avitaminosis A. Bieri and Pollard (1953) demonstrated rapid conversion of carotene to vitamin A in rats, using intravenous injections of carotene dispersed in water.

During periods when the carotene or vitamin A intake is high animals have the ability to store vitamin A and carotene. In studies with rats, Davies and Moore (1935) showed that the adult rat is able to store, with massive doses, enough vitamin A in its liver to supply its theoretical requirements for a century, but that these superfluous stores are eliminated at a very rapid rate until a state of stable storage is reached. Guilbert and Hart (1934) reported that the liver tissue of mature beef cows, reared under favorable conditions, was found to have a concentration of vitamin A approximating that of high potency cod liver oil.

There is some evidence that in storage, as in absorption, an aqueous medium may be superior to an oily medium. Sobel et al (1948) in experiments with rats demonstrated that vitamin A was more effective (as measured by liver storage) when dispersed in aqueous media than in oily solutions. Sobel and Rosenberg (1950) reported that, in rats, orally ingested vitamin A in an aqueous dispersion was more effectively transferred to milk and stored in the suckling offspring than vitamin A in oil solution (stores were four times as great). Johnson and Baumann (1949), in studying depletion

and utilization of vitamin A in rats, found that the retention of vitamin A is improved when the intake of food is restricted. Also, they reported that in normally growing rats, a decrease in the hepatic reserves of vitamin A was accompanied by an increase in the amount and concentration of the vitamin in the kidney. No such kidney increase occurred in rats whose growth was restricted during depletion.

Frey and Jensen (1946) reported that, in cattle, the rate of depletion of the hepatic reserves of vitamin A and carotene decreased as the hepatic reserves of the two constituents decreased. The data indicated that hepatic reserves of carotene are maintained in cattle in direct proportion to the carotene intake, and that an increasing rate of loss of hepatic reserves of vitamin A occurred with decreased carotene intake. Braun (1945) presented data which suggested that utilization of stored vitamin A first forces available carotenoid stores to be converted into vitamin A, thus decreasing the carotenoid level without decreasing the vitamin A level at first. There was no correlation between carotenoid and vitamin A values of the liver and those of the blood under normal conditions. Only upon rapid depletion and below normal storage was low vitamin A storage reflected by low blood levels. Watkins and Knox (1954) reported on a study of supplemental feeding of range breeding cows during the precalving and calving period. The data indicated that even without supplemental feeding of carotene, there were no major deficiencies over an eight year period, even in the most critical season.

Riggs (1940) reported wide variations in the time required for depletion of vitamin A reserves, particularly in older animals. Apparently the

condition of the range plays a large part. A range in depletion times, for 260 range cattle, was from three to sixteen months with shorter times in dry years with limited green grass. Also, he reported one steer which remained on a deficient ration for 381 days without becoming completely night blind, but which showed numerous other symptoms of deficiency, including swelling of the joints, suggesting a possible difference between individuals in the ability to utilize carotene or vitamin A for a given physiological function. Guilbert and Hart (1934) in experiments with steers, heifers, and mature cows, reported that the carotene in the adipose tissue, which constitutes a part of the vitamin A reserve, may be withdrawn during vitamin A privation without coincidental withdrawing of depot fat.

Sheep apparently have a slower depletion rate than cattle, and under normal conditions the possibility of a vitamin A deficiency in sheep is probably rather remote. Cunha et al (1946) reported that when ewes had grazed on green mountain feed during the summer, low quality roughages during the winter did not affect reproduction. Blood plasma-vitamin A determinations of the ewes and lambs showed very little difference, regardless of roughage fed. Weir et al (1949), on the other hand, found that the quality of winter roughage fed to ewes which had been on pasture during the summer did influence the blood plasma-vitamin A levels and the liver vitamin A reserves of ewes and their lambs. However, the ability of sheep to withstand extended periods on a low carotene ration was demonstrated by ewes which were on a straw ration for two successive winters. While these ewes did not maintain as high a blood level or liver storage, they did maintain levels above the critical levels. Pierce (1954) in a study covering seven

years and five reproductive cycles also found that depletion of vitamin A reserves in sheep was slow. It took at least 16 to 19 months to lower the plasma-vitamin A value from about 30 micrograms per hundred milliliters down to about 20 micrograms per hundred milliliters.

Davis and Madsen (1941) reported on an extensive study of vitamin A and carotene in cattle blood plasma. The data indicated that long continued inadequate carotene intake and vitamin A deficiency in cattle can be determined by blood analysis. The critical level of carotene in the plasma was found to be 20 to 25 micrograms per hundred milliliters and for vitamin A in the same sample about 16 micrograms per hundred milliliters. Cattle having carotene and vitamin A values at these levels or above usually did not show the characteristic clinical symptoms of vitamin A deficiency. The data also indicated that after cattle have been depleted of carotene reserves the blood carotene level is dependent upon carotene intake, and the vitamin A content of blood plasma is closely related to its carotene content. However, vitamin A values tend to reach a stable level and do not increase proportionally with increasing carotene levels (above 0.9 milligrams per hundred milliliters, also reported by Braun in 1945). Heifers receiving 20 to 45 micrograms of carotene daily produced deficient calves although the mothers themselves remained apparently normal. When heifers received 60 micrograms of carotene daily, apparently normal calves were born. Payne and Kingman (1947) reported that, to support normal gestation, first calf, range Hereford heifers must have considerably higher plasma-carotene levels than aged Hereford cows. The data indicated that the level for first calf heifers must be at least 110 micrograms per hundred

milliliters to support normal gestation whereas aged cows with levels as low as 83 micrograms per hundred milliliters had no abortions or deficiency symptoms over a two year period. Braun (1945) and Sutton et al (1945) reported that vitamin A and carotene decrease markedly in blood plasma of cattle at the time of parturition and beginning lactation. The maximum decrease in blood plasma-carotene was reached one week following parturition and amounted to 46 percent of the three week prepartum level. For vitamin A it was three days and 52 percent, respectively. Parrish et al (1951) stated that, in swine, vitamin A concentrations in the blood serum of the dams decreased as parturition approached and increased during the days immediately following parturition. Rasmussen et al (1944) reported that the horse has normal plasma values considerably below those of the cow, and apparently is inefficient in the conversion of carotene to vitamin A.

Jackson (1931) in studies with rats showed that mineral oil causes a considerable loss of vitamin A if it is mixed with the source of vitamin A prior to ingestion. Separate administration only slightly affected vitamin A utilization. Dutcher et al (1934) reported that the presence of mineral oil had no adverse effect upon the vitamin A potency of cod liver oil. However, relatively small amounts of mineral oil had a marked effect in lowering vitamin A potency from carotene. The carotene absorbed in unassimilated mineral oil was voided in the feces in almost direct proportion to the amount of carotene fed, indicating that the utilization of carotene was almost completely prevented by the mineral oil.

Lease and Steenbock (1939) presented data showing that the rate of loss of vitamin A from the liver of the rat was not affected greatly, if at all,

by the amount of fat in the diet, by feeding of rancid fats, or by the rapid depletion of fat from the liver as effected by the administration of choline. Muelder and Kelly (1942) found, with rats, that adding ten percent fat to a basal diet aided absorption of vitamin A sufficiently to produce statistically significant gains in weight over a basal diet containing no fat, but not over a basal diet containing five percent fat. Brown and Bloor (1945) reported that the nature of the fat being absorbed seemed to be of some importance in the utilization of carotene from carrot by the rat. Liver storage was higher when the rats were fed liquid acid diets than when fed solid acid diets. Parham et al (1950) studied the influence of solvent extracted versus hydraulic processed cottonseed meals in beef cows. They found that although the difference in levels of blood fat was statistically significant, this difference appeared to have little relationship to levels of carotene and vitamin A in the blood. Raper (1950), in work with beef calves, found that when the fat content of the ration was raised from two to five and one-half percent, the plasma-carotene level rose significantly. Plasma-vitamin A, and liver-vitamin A and carotene were not affected. Thomas et al (1949) found that when young calves (under 90 days) had been on a high vitamin A intake, the elimination of carotene and vitamin A did not immediately change the plasma-vitamin A concentration whereas elimination of fat as well resulted in a marked increase in plasma-vitamin A.

Ross and Gallup (1949) reported on studies with beef cattle with indicated an inverse relationship between the level of plasma-inorganic-phosphorus and plasma-carotene. Cattle with low plasma-phosphorus levels had been observed to have higher plasma carotene levels than cattle with normal

or above normal levels of plasma-phosphorus. Klosterman et al (1952) found that, in rats given equal amounts of carotene or vitamin A, liver stores of vitamin A were greater in the animals fed low phosphorus than in those fed high phosphorus rations. They also reported a highly significant negative correlation between plasma-inorganic-phosphorus and vitamin A in lambs fed low and adequate phosphorus rations deficient in carotene. Gallup et al (1953) reported similar results with steers and lambs. In steers which had been depleted in phosphorus and vitamin A reserves and then given daily carotene supplements (half also received phosphorus), the plasma-carotene levels were consistently higher in the steers on the low-phosphorus ration, while the plasma-vitamin A values were lower. There was decreased liver vitamin A storage in the phosphorus deficient steers. The results obtained with lambs in a similar experiment showed a different trend to that noted with cattle. Plasma-vitamin A values were higher in the phosphorus deficient lambs and the liver vitamin A stores were greater in the phosphorus deficient lambs. Thomas et al (1953) reported similar results in beef cows with plasma-carotene values generally higher in the phosphorus deficient cows than in those fed adequate phosphorus. Milk from the phosphorus deficient cows contained more carotene but less vitamin A than that from the cows fed adequate phosphorus.

King et al (1940) reported that, in cattle, a reduced plasma-vitamin C level occurs shortly after the sumptoms of avitaminosis A appear. The subcutaneous injection of crystaline ascorbic acid seemed to alleviate several symptoms associated with a lack of vitamin A, namely, a noticeable improvement in the rough scaly condition of the hair and skin and an attenuating

effect upon retinal hemorrhages. Boyer et al (1942) also reported a definite indication of an interrelationship between blood plasma-ascorbic acid and vitamin A in dairy calves, particularly when vitamin A values fell below 10 micrograms per hundred milliters. It was also found that in rats, when vitamin A deficiency develops, the excretion of vitamin C is greatly reduced, indicating that the lowered blood and tissue vitamin C is the result of impaired synthesis. Mayer and Krehl (1948) found that one of the first symptoms of the vitamin A deficiency syndrome in the rat was a depletion of the animal's vitamin C reserves, evidenced by symptoms resembling scurvy and curable by ascorbic acid as well as by a decrease in the ascorbic acid content of the liver, blood, and adrenals.

Davies and Moore (1941) and Hickman et al (1942) reported a pronounced synergistic effect between vitamin A and vitamin E. It was noticed that vitamin E deficient rats had much lower vitamin A reserves than rats receiving equal amounts of vitamin A plus supplements of vitamin E. The data indicated that the effect of the vitamin E deficiency does not lie entirely in the inability of the liver to absorb vitamin A but also in a decreased power of retention after absorption. Prolonged deficiency of vitamin E led to a secondary deficiency of vitamin A as indicated by the disappearance of vitamin A from the liver. Also, a vitamin A deficiency was prevented by the administration of vitamin E to low vitamin A rations.

McGillwray (1951) published a report on the apparent intestinal synthesis of carotene by sheep. Carotene-lignin ratios were studied and measured at different points of the digestive tract, ingested food, and voided feces. The lignin recovery in the feces was 96 percent indicating negligi-

ble digestibility. The ratios remained relatively stable through the stomachs. In the intestine the carotene-lignin ratios decreased through the upper portion of the small intestine, increased through the ileum reaching a maximum in the caecum, and decreased slightly through the colon and rectum. Some animals actually showed a negative carotene balance. The author stated that synthesis of carotene by intestinal micro-organisms had been demonstrated on an agar medium innoculated with caecal contents.

PROCEDURE

General

The experiment consisted of two experimental periods of vitamin A supplementation. Previous to each of the two periods of vitamin A supplementation, the steers were fed rations low in vitamin A until the blood plasma-vitamin A levels dropped to approximately 12 micrograms of vitamin A per hundred milliliters of plasma. Two forms of vitamin A concentrate--a corn-oil vitamin A suspension with a potency of 1,600,000 I. U. of vitamin A per gram and vitamin A palmitate in gelatin with a potency of 250,000 I. U. of vitamin A per gram---were used as supplemental vitamin A sources during the two experimental periods.

On December 23, 1954, sixteen Hereford steer calves were divided into two lots of eight calves each and placed in separate, but adjoining, pens. Each pen contained eight individual feeding stalls in a shed, where the steers were individually fed, and an outside exercise area. A common watering tank was located inside the shed. During the period from December 23, 1954 to January 10, 1955, the calves were individually fed two pounds per head daily of a grain supplement (about 17 percent crude protein) and approximately six pounds of low quality hay per head daily. On January 6, one steer died of urinary calculi, and was replaced by a healthy animal on January 10.

First Depletion Period

On January 11, the calves were weighed and initial blood samples were taken from the jugular vein. The calves were then fed vitamin A depletion rations consisting of approximately seven pounds of wheat straw per animal

daily plus three pounds of a grain supplement containing about 30 percent crude protein. The grain ration for half the calves (four from each pen) contained 3.5 percent active dried yeast, which provided an intake of approximately 0.1 pound of yeast per steer daily. The composition of the supplemental rations is presented in Table I.

The steers remained on vitamin A depletion rations for a period of 127 days, until May 18. For the first three months of thie period, weights and blood samples were taken every 28 days, except the third period which was delayed a week (to 35 days) because of excessive snow. After April 12, weights and blood samples were taken every 14 days. On April 12, the intake of concentrates was increased to four pounds per head daily (yeast was decreased to 2.5 percent of the ration to hold intake steady at approximately 0.1 pound daily). By this time, some of the steers were beginning to show deficiency symptoms such as incoordination and impaired vision.

After April 12, seven steers which had plasma-vitamin A levels of less than 15 micrograms per hundred milliliters were given a daily supplement of approximately 2500 I. U. of vitamin A to stop further depletion of vitamin A stores until the remaining steers became sufficiently depleted. A commercial source of vitamin A (potency: 10,000 I. U. per gram) was used for this purpose and was mixed with soybean oil meal so that the final mixture would contain 2500 I. U. of vitamin A in one tablespoon of the soybean oil meal. The desired amount of soybean oil meal was then added to the daily grain ration of the steers requiring vitamin A supplementation. On May 2, supplementation of vitamin A was adjusted, with some calves being reduced to 1250 I. U. per day and others added to the supplemental list, at a level of

Table I. Depletion Rations Used

Ration No.	1	2
Ingredients:	%	%
Barley	28.75	25.25
Beet Pulp, D.M.	20.00	20.00
Soybean Oil Meal	25.00	25.00
Linseed Oil Meal	10.00	10.00
Urea (262)	3.00	3.00
Wheat Bran	10.00	10.00
Bonemeal	2.00	2.00
Trace Minerals	0.25	0.25
Salt	1.00	1.00
Active Dry Yeast	0.00	3.50 1/

1/ Decreased to 2.5% after April 12th.

Table II. Average Weights Per Steer During Depletion Periods

Ration No. Treatment	1 No Yeast	2 Yeast 1/
Date:	Average weight per steer (Lbs.)	
December 22	497	507
January 11	475	486
February 8	465	483
March 8	500	514
April 12	552	559
April 24	551	560
May 10	552	554
June 14	573	580
Total Gain Per Steer	76	73
Daily Gain Per Steer to June 14	0.43	0.42

1/ Yeast was not included in the ration until January 11.