EFFECTS OF HIGH VITAMIN A INTAKE ON MILK AND FAT YIELDS AND ON VITAMIN A CONSTITUENTS IN MILK, BLOOD, AND LIVERS OF DAIRY COWS

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Recognition of the importance of vitamin A constituents in the diets of dairy cattle has resulted in extensive investigation of the effects of various vitamin A supplements on the health of the cow and on the properties of milk. A summary (2) of reports on the effects of feeding crude cod-liver oil and menhaden fish oil to lactating cows indicates that when these oils are given in sufficient quantities to augment the vitamin A potency of the milk, the percentage of fat is reduced. In recent years the feeding of vitamin A supplements such as shark liver oil and vitamin A concentrates has come into common use for certain classes of livestock. The addition of these high potency vitamin A materials to the diets of cows has increased, in varying degrees, the concentrations of this vitamin in the blood (5, 8, 9, 15), in the milk (1, 2, 7, 8, 10, 15, 18, 21), and in the liver (6), but has produced discrepant effects on yields of milk and of fat (1, 2, 7, 8, 10, 15, 18, 21, 23, 24).

The variability and the diversity of the results reported warranted further study of the effects of feeding vitamin A supplements to dairy cows maintained in a good state of nutrition. Hence, in an investigation designed to ascertain the effects of prolonged supplementation of massive amounts of vitamin A on the course of mastitis, additional observations were made on the yields of milk, the percentage of fat, and the concentrations of vitamin A in the milk, the blood, and the liver. The results from this phase of the investigation are reported herein.

EXPERIMENTAL PROCEDURES AND RESULTS

Grouping and Care of Experimental Animals

Experimental cows. Two comparable groups of dairy cows, the control and the supplemented, were used in this trial. The following factors, in the order listed, were considered in grouping the cows: breed, mastitic history, daily milk yields, stages of gestation and lactation, and body weights. Each group at the beginning of the trial consisted of nine mature cows, two Ayrshires, two Guernseys, and five Holsteins. Six of the cows in each group were lactating, being past the stage of peak production but not sufficiently maintained in a good state of nutrition. Hence, in an investigation designed to ascertain the effects of prolonged supplementation of massive amounts of vitamin A on the course of mastitis, additional observations were made on the yields of milk, the percentage of fat, and the concentrations of vitamin A in the milk, the blood, and the liver. The results from this phase of the investigation are reported herein.

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2 Contribution no. 165, Department of Dairy Husbandry, and no. 328, Department of Chemistry.
advanced in gestation to accentuate the rate of decline in yield; the remain-
ing three cows, two Ayrshires and a Holstein, were in the early stages of the
dry rest period, from 44 to 52 days prepartal. These dry cows were included
to determine the effects of prepartal supplementation on postpartum changes.

In addition, two non-lactating Ayrshire cows in the last month of gesta-
tion were used to study in detail the effects of level of vitamin A intake on
the changes in carotenoids and vitamin A of the serum during the terminal
stages of gestation and early period of lactation. The two cows had prac-
tically the same carotenoid and vitamin A content of the serum before they
were subjected to experimental conditions.

Feeding and management. Prior to the initiation of the trial and
throughout the experimental period of 12 weeks, during the months of
November, December, and January, all cows of the two groups received a
standard milking herd ration consisting of a 16 per cent protein concentrate
mixture, Atlas sorgo silage, and alfalfa hay. The carotenoid content of the
hay, on the moisture-free basis, ranged from 0.06 mg./g. in the early part
of the trial to 0.03 mg./g. in the latter. The lactating cows were fed daily
1 lb. of concentrate mixture for each 4 lbs. of 4 per cent fat-corrected milk,
20 to 25 lbs. of silage per 1,000 lbs. body weight, and hay ad lib. The dry
cows were fed daily 8 lbs. of the concentrate mixture per 1,000 lbs. of body
weight and the roughages, the same as for the lactating cows. In addition
to the barn feeds, the cows of the two major groups grazed on rye pasture
30 to 40 days before initiation of the experiment and 16 days following.

Throughout the experimental period, all cows (both the dry and the
lactating) in the supplemented group received daily 1,250,000 USP units of
vitamin A in a powdered medium. Since this vehicle, described as a "soy-
bean oil meal like" product, supplied nutrients in addition to vitamin A,
the cows of the control group received soybean oil meal in quantities equal
to the amount of vitamin A supplement fed to the other group. These addi-
tional feeds and supplements were given once daily in combination with the
concentrate mixture. Considerable quantities of the vitamin A supple-
mented mixture were refused during the first several days of feeding, but
after the cows became accustomed to the foreign flavor, no consumption
difficulties were encountered.

All cows were subjected to standard herd management, which included
feeding and milking twice daily, exercise whenever weather conditions per-
mitted, and free access to water, common salt and hay in the same paddock.

Yields of Milk and Concentrations of Fat and of
Vitamin A Constituents

Milk yields and fat percentages. Detailed records of the milk yields of
individual cows were made throughout the experimental period. Samples

"Dry vitamin A", having 2,500−2,700 USP units per gram.
of milk were collected during two consecutive milkings each week for the determination of fat concentration by means of the standard Babcock procedure. The weekly milk and fat yields of the respective groups were summarized and subsequently converted to a 4 per cent fat-corrected basis according to the Gaines (11) formula. The yields of milk and fat (fig. 1) revealed no marked differences that could be ascribed to the rations fed.
Initiation of vitamin A supplementation during the early stages of the dry rest period revealed no advantage in production during the first month of lactation. Thus it appears that the daily addition of massive amounts of "dry vitamin A" to the dairy ration used in this experiment neither augmented total milk yield nor suppressed the fat percentage of the milk.

**Concentration of carotenoids and vitamin A in the milk fat.** During the terminal week of the experiment, a 1-day composite sample of milk was collected from each of seven individual cows in the respective groups for assays of carotenoids and vitamin A. (Milk from two pairs of cows was excluded because of mastitis complications.)

The analytical method employed was a modification of the double extraction procedure of Boyer et al. (4). A total of 70 ml. of ether was used in extracting vitamin A and carotenoids, and the volumes of wash solutions were adjusted accordingly. The washed solution of extracted vitamin A and carotenoids was dried by means of anhydrous sodium sulphate, and the ether was removed from the extract by suction while heating in a water bath at 50–60°C. The residue was dissolved in 15 ml. of Skellysolve B. A 10-ml. aliquot was used for the final determination of carotenoids and of vitamin A. Shaking the ether solution with 5 ml. of a saturated solution of sodium chloride, as outlined in the original method, was omitted. Photometric measurements were made on a Coleman spectrophotometer, model 11, modified to reduce light intensity. Since the fat percentage in the samples was variable, the carotenoid and the vitamin A values were expressed as concentration per unit of milk fat.

The average, by breeds, of vitamin A in the milk fat from supplemented cows was approximately four times higher than that from the control cows. The carotenoids throughout were low, but, in accord with other reports (2, 8, 9, 10, 15), tended to be lower in the milk fat from vitamin A supplemented cows. There was, however, an exception in the case of two of the three pairs of cows of the Holstein breed; hence the average for this breed did not reveal

### TABLE 1
*Average concentrations of vitamin A and carotenoids in the milk fat of cows on different levels of vitamin A intake*

<table>
<thead>
<tr>
<th>Daily supplement of vitamin A</th>
<th>Breed of cows</th>
<th>No. of cows</th>
<th>Vitamin A</th>
<th>Carotenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Guernsey</td>
<td>2</td>
<td>6.4</td>
<td>24.1</td>
</tr>
<tr>
<td>Holstein</td>
<td>3</td>
<td>7.3</td>
<td>30.5</td>
<td></td>
</tr>
<tr>
<td>Ayrshire</td>
<td>2</td>
<td>7.8</td>
<td>36.1</td>
<td></td>
</tr>
<tr>
<td>1,250,000 USP units</td>
<td>Guernsey</td>
<td>2</td>
<td>24.1</td>
<td></td>
</tr>
<tr>
<td>Holstein</td>
<td>3</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ayrshire</td>
<td>2</td>
<td>30.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.1</td>
<td></td>
</tr>
</tbody>
</table>

and carotenoids was dried by means of anhydrous sodium sulphate, and the ether was removed from the extract by suction while heating in a water bath at 50–60°C. The residue was dissolved in 15 ml. of Skellysolve B. A 10-ml. aliquot was used for the final determination of carotenoids and of vitamin A. Shaking the ether solution with 5 ml. of a saturated solution of sodium chloride, as outlined in the original method, was omitted. Photometric measurements were made on a Coleman spectrophotometer, model 11, modified to reduce light intensity. Since the fat percentage in the samples was variable, the carotenoid and the vitamin A values were expressed as concentration per unit of milk fat.
The effects of high vitamin A intake (table 1). Since preliminary assays were not made, individual differences could account for these exceptions.

Concentration of Carotenoids and Vitamin A in Blood Serum

Total carotenoids and vitamin A were measured in the serum of venous blood. Since the cows were on a high carotenoid intake during the early stages of the experiment, the non-saponification method of Boyer et al. (3) was chosen in lieu of the more generally used Kimble (16) procedure, which is recognized to be inaccurate for vitamin A measurements in the presence of high concentrations of carotenoids (15). Though the non-saponification method of Boyer et al. (3) apparently is unsuitable for dog blood, which is presumed to be high in the ester form of vitamin A, this procedure was reported to be applicable to normal bovine blood.

<table>
<thead>
<tr>
<th>Daily supplement of vitamin A</th>
<th>Breed of cows</th>
<th>No. of cows</th>
<th>Vitamin A and carotenoids in serum*</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Guernsey</td>
<td>2</td>
<td>23.2 1007 22.8 487</td>
</tr>
<tr>
<td></td>
<td>Holstein</td>
<td>5</td>
<td>20.3 617 18.6 385</td>
</tr>
<tr>
<td></td>
<td>Ayrshire</td>
<td>2</td>
<td>8.7† 279† 21.6 340</td>
</tr>
<tr>
<td>1,250,000 USP units</td>
<td>Guernsey</td>
<td>2</td>
<td>23.5 501 27.1 239</td>
</tr>
<tr>
<td></td>
<td>Holstein</td>
<td>5</td>
<td>26.0 310 24.6 177</td>
</tr>
<tr>
<td></td>
<td>Ayrshire</td>
<td>2</td>
<td>23.6† 234† 33.9 245†</td>
</tr>
</tbody>
</table>

* Boyer et al. (3) non-saponification procedure.
† One week postpartum.

Effect of the diet on the concentration of vitamin A and carotenoids in the blood serum. The carotenoid and the vitamin A values in table 2 are averages of assays of blood serum samples collected from individual cows of the three breeds in the respective groups. The first period of collection, a span of 14 days, was 6 weeks after the initiation of the trial and approximately 1 month after discontinuing rye pasture; the second period of 7 days was 1 month later, near the termination of the trial.

The vitamin A content of the blood serum of the supplemented cows was higher than in the controls, but the carotenoid values were lower. The magnitude of the difference in vitamin A concentration tended to vary with breeds, being least in the Guernsey and greatest in the Ayrshire.

The concentration of carotenoids in the serum from the Guernsey and the Holstein breeds decreased from the first period to the second, but the vitamin A values showed no significant changes. This marked decline of the carotenoids probably was due to the continued reduction of reserves fol-
owing removal from rye pasture and to a decrease in the carotene content of the hay consumed. Though the Ayrshires were subjected to the same dietary regime as the other two breeds, the vitamin A was low during the first period as a result of a reduction associated with parturition (5, 17, 22). With postpartum physiological readjustments, the vitamin A concentration increased to a decidedly higher level, whereas the carotenoids changed very little.

**Relation of the analytical procedure to vitamin A values of serum.** Since the differences in vitamin A concentration in the serum from cows of the respective groups were not of the magnitude observed in similar experiments by other investigators (9, 15), the non-saponification procedure of Boyer et al. (3), by which the values in table 2 were obtained, was compared with

<table>
<thead>
<tr>
<th>Daily supplement of vitamin A</th>
<th>Breed of cows</th>
<th>No. of cows</th>
<th>Vitamin A values by different methods</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>Kimble</td>
<td>Boyer et al.*</td>
</tr>
<tr>
<td>Guernsey</td>
<td>2</td>
<td>22.6</td>
<td>21.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Holstein</td>
<td>1</td>
<td>20.7</td>
<td>18.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>2</td>
<td>20.5</td>
<td>18.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Av.</td>
<td>5</td>
<td>21.4</td>
<td>19.6</td>
<td>1.8</td>
</tr>
<tr>
<td>1,250,000 USP units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guernsey</td>
<td>2</td>
<td>29.7</td>
<td>23.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Holstein</td>
<td>1</td>
<td>39.6</td>
<td>30.5</td>
<td>9.1</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>2</td>
<td>45.1</td>
<td>32.9</td>
<td>12.2</td>
</tr>
<tr>
<td>Av.</td>
<td>5</td>
<td>37.8</td>
<td>28.8</td>
<td>9.0</td>
</tr>
</tbody>
</table>

*Non-saponification method.

The comparison was made near the termination of the trial when the carotenoid content of the blood serum was sufficiently low to minimize interference.

The Kimble (16) procedure yielded higher values throughout than did the non-saponification method of Boyer et al. (3), but the average difference was greater in the vitamin A supplemented group, 31.3 per cent, than in the non-supplemented group, 9.2 per cent (table 3). Further comparisons of the results revealed that the average values for the supplemented cows were 76.6 per cent higher by Kimble but only 46.9 per cent higher by Boyer et al. The lower values by the non-saponification method of Boyer et al., particularly in serum from cows receiving dietary vitamin A, suggested that either this procedure failed to include all the vitamin A or the Kimble method yielded excessively high values. Recent observations (19) indicate that as the vitamin A content of serum increases from vitamin A feeding, the values obtained by the non-saponification procedure of Boyer et al. tend to be too low. In view of this, it is probable that the total vitamin A in the serum of
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The cows receiving the vitamin A supplemented ration was nearer the level indicated by the Kimble method than that by the Boyer et al. This phase of the problem is being investigated further.

The effect of prepartal dietary supplementation of vitamin A on the carotenoid and the vitamin A concentration in the blood serum of the dairy cow during the stages of terminal gestation and initial lactation.

A preferable method would have been the saponification procedure outlined by Boyer et al. (3), but early attempts to apply it yielded spurious results. Subsequent investigation revealed that the difficulty was due to a contaminant, presumably aldehyde (12), in the alcohol used.

Effect of prepartal vitamin A intake on the changes of carotenoids and
vitamin A in the serum of the parturient cow. As suggested by the average vitamin A values in the serum from cows of the Ayrshire breed (table 2), the vitamin A supplementation did not prevent the usual gestational reduction but did maintain a higher level than observed in the control cows. This is illustrated further (fig. 2) by the prepartum and the postpartum changes in the blood serum of an Ayrshire cow from each of the two dietary groups, control and vitamin A supplemented. Though the two cows selected had about the same carotenoid and vitamin A levels prior to supplementation, dietary vitamin A increased the vitamin A of the blood serum but reduced the carotenoids, as measured by the Kimble method (16) of analysis. The curves, on a semi-logarithmic scale, show that in both animals the prepartum rate of vitamin A decline was more pronounced than that of the carotenoids. The drop of vitamin A, however, was more precipitous in the serum of the cow receiving vitamin A. A temporary rise in the concentration of vitamin A was noted in both cows the day following parturition. Further data (19) indicate that this phenomenon also is common in other cows, but the frequency of occurrence is unknown and the factors involved are obscure. The minimum postpartum concentration usually occurred about the third day unless complicated by infections (5). Whether or not continued postpartum supplementation would have accelerated the rate of recovery when adequate liver stores were available is problematical.

Concentration of Vitamin A in the Livers and in the Serum of Cows Slaughtered

Livers were salvaged from seven cows to determine the effect of vitamin A intake on storage. During the week prior to slaughtering, blood samples were collected for vitamin A determinations. The assay procedure for livers was a slight modification (25) of the Guilbert and Hart (13) method, and for blood serum the non-saponification procedure of Boyer et al. (3) was used. With the exception of one animal, no. 169, vitamin A supplementation was continued to within 24 hours of slaughtering.

When an abundance of vitamin A was present in the daily ration, the cows accumulated pronounced liver reserves of this vitamin, approximately four times the amount detected in the livers of cows on unfortified rations (table 4). Though several of the livers had isolated abscesses, this pathological condition apparently did not interfere with vitamin A storage. If it is assumed that prior to cessation of supplementation the liver reserves of cow no. 169 had reached the same general level as in the other cows of her group, the rate of depletion of vitamin A stores was rapid. The vitamin A concentration in the serum from the individual cows revealed, in accord with the report of Braun (6), no correlation between the liver reserves and the levels in the blood serum.
### TABLE 4
Concentrations of vitamin A in the livers and in the serum of cows on different levels of vitamin A intake

<table>
<thead>
<tr>
<th>Daily supplement of vitamin A</th>
<th>Breed of cows</th>
<th>Herd no.</th>
<th>Wt. of liver (kg)</th>
<th>Vitamin A Liver (γ/g)</th>
<th>Vitamin A Serum (γ/100ml)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Holstein</td>
<td>104A</td>
<td>8.2</td>
<td>150</td>
<td>26.4</td>
<td>Non-breeder. Healthy liver.</td>
</tr>
<tr>
<td></td>
<td>Ayrshire</td>
<td>222A</td>
<td>7.5</td>
<td>142</td>
<td>23.4</td>
<td>Brucellosis reactor.</td>
</tr>
<tr>
<td></td>
<td>Jersey</td>
<td>332A</td>
<td>5.2</td>
<td>138</td>
<td>19.3</td>
<td>Healthy liver.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Healthy liver.</td>
</tr>
<tr>
<td>1,250,000 USP units</td>
<td>Holstein</td>
<td>144</td>
<td>9.5</td>
<td>600</td>
<td>28.8</td>
<td>Non-breeder. Mastitic.</td>
</tr>
<tr>
<td></td>
<td>Holstein</td>
<td>161</td>
<td>8.6</td>
<td>733</td>
<td>23.8</td>
<td>Abscesses in liver.</td>
</tr>
<tr>
<td></td>
<td>Holstein</td>
<td>169</td>
<td>8.9</td>
<td>421</td>
<td>27.2</td>
<td>Vitamin A withheld</td>
</tr>
<tr>
<td></td>
<td>Holstein</td>
<td>173</td>
<td>9.8</td>
<td>867</td>
<td>23.2</td>
<td>20 days preceding slaughter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mastitic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Abscesses in liver.</td>
</tr>
</tbody>
</table>

* Wet basis.

**DISCUSSION**

The data presented on milk and milk fat confirm reports by other investigators (2, 10, 15, 18, 21) indicating that production is not stimulated by vitamin A supplementation when the lactating cows are in a good state of nutrition. Probably when favorable responses are elicited by vitamin A feeding (1, 7, 8, 23, 24) either this vitamin *per se* or some other nutrient for which an increased level of vitamin A tends to compensate is the limiting factor. The apparent adequacy of rations for lactating cows at any particular time may be misleading unless cognizance is taken of their nutritional history, productive capacity, and feed consumption. Wilson (24) suggested that access to good quality roughages high in carotene does not insure adequate intake, particularly by high producing cows that have much of their feed capacity utilized by rations low in vitamin A active substances. It is conceivable that in many herds a slight submarginal deficiency of vitamin A may prevail as a result of unrecognized depletion. In these cases a favorable production response to vitamin A feeding would be expected.

Since "dry vitamin A" supplementation did not depress the milk fat percentage, as is observed commonly when cod-liver oil is fed, it is probable that the unsaturated fatty acids that are believed to cause the toxic reaction were not present in sufficient amounts to affect the mammary function. This indicates that the vitamin A concentrate used in this investigation may be...
fed in sufficient quantities to increase the vitamin A potency of the milk without adversely affecting the fat content.

The observed increases in the vitamin A potency of the milk from dietary supplementation are in accord with the findings of others (1, 2, 7, 8, 9, 10, 15, 18, 21, 24). This means of fortifying milk, however, is uneconomical since the efficiency of secretion of ingested vitamin A is exceptionally low (8, 9, 15). Moreover, the concomitant reduction of carotene with increases in vitamin A (2, 8, 9, 10, 15) suggests that dietary vitamin A possibly reduces the nutritional value of carotenoids in the ration, thus presenting a provocative problem.

The interference of carotenoid metabolism has been ascribed to vitamin A per se rather than to other associated constituents (9, 20). Several possible explanations of this phenomenon have been presented. According to Hickman (14), "in vitro experiments show that vitamin A is a specific prooxidant for beta-carotene, lycopene, and probably zeaxanthin." Data supplementary to those already presented showed that the carotenoid concentration in a composite sample of feces from cows on a standard ration was approximately the same as in a similar sample from vitamin A supplemented cows. The vitamin A content of the feces from the latter group, however, was about 60 per cent higher. Either vitamin A was not a factor affecting the carotenoids in the bowel or it simultaneously suppressed absorption and accelerated oxidation. Recent studies (20) with chickens revealed retarded pigmentation of the shanks after cessation of vitamin A supplementation. Deuel et al. (9) noted a similar post-supplementation lag in recovery of carotenoid levels in dairy cows. The foregoing observations indicate that the carotenoid suppression is not exclusively an intestinal phenomenon.

A further explanation advanced by Deuel et al. (9) is that increases of vitamin A accelerate the destruction of carotenoids in the tissues through the development of a new enzyme system. It was suggested also that this enzyme system may destroy vitamin A. If this proves to be correct, feeding massive amounts of vitamin A over a prolonged period may be detrimental to the organism instead of beneficial.

Another viewpoint is that vitamin A may aid in the conversion of certain carotenoids to this vitamin, thus enhancing the accumulation of a maximum reserve. If it is assumed further that the capacity for storage in the body is limited, the suggested reduction of vitamin A (20) might be an accelerated elimination after the threshold is reached instead of a process of systemic destruction.

Though a decline of carotenoids and vitamin A of the blood seems to be a normal accompaniment of parturition (17, 22), the specific causes of this depression are obscure. A drop occurs regardless of the prepartal intake, but Kuhlman and Gallup (17) observed that the percentage decrease of carotene was related directly to its level in the plasma. This, as indicated by data reported herein, seems to apply to vitamin A levels also.
Attempts to associate these changes of carotenoid and vitamin A concentrations of the blood with mammary function have yielded negative results. Although the secretion of colostrum withdraws vast amounts of nutrients from the blood, Sutton et al. (22) found no statistical correlation between levels of carotene and vitamin A of plasma and the output of these constituents in colostrum. Braun (5) reported that a temporary reduction of vitamin A occurred when cows aborted, under which conditions colostrum secretion would be negligible. Similar reductions of carotenoids and vitamin A were observed in a mammectomized cow following premature calving (26). As suggested by Sutton et al. (22), many factors and complex interrelationships may be involved. Investigation of the endocrinological aspects of the problems may aid in clarification.

The regulatory role of the liver in maintaining vitamin A concentrations in the blood, particularly in advanced gestation and early lactation, has not been elucidated. The reserves in this organ apparently are not a limiting factor except at subnormal storage levels. The changes in the vitamin A concentrations of the liver during this critical transitory period in the reproductive cycle merit study.

The amount of vitamin A in the livers of cows can be modified, as noted by others (6, 13), by dietary means. Data presented by Braun (6) suggested an optimum level for storage in this organ, but a comparison of his results with those reported herein indicates a wide margin between the optimum and the possible maximum levels attainable. Though the concentrations in the livers of the supplemented cows were at a uniformly high level, this does not indicate that the maximum was attained. Present information on the subject raises the question of whether or not the maximum attainable concentration of vitamin A in the liver is the same from carotenoid feeding as from vitamin A supplementation.

Most nutritional studies with dairy cattle have been directed toward determinations of effects of deficiencies and the establishment of minimum requirements. The results of this study suggest the need for considering the results from optimum and/or excess quantities of nutrients in the diet.

SUMMARY

The effects of daily supplementary feeding of 1,250,000 USP units of vitamin A in the form of a dry concentrate ("dry vitamin A") to individual lactating cows over a period of 3 months were compared with the results from similar cows on a standard dietary regime. The following conclusions were reached:

1. Vitamin A feeding had no significant effect on total milk and fat production.
2. The "dry vitamin A" concentrate did not depress the milk fat percentage.
3. The high intake of vitamin A increased the concentration of this vitamin markedly in the milk fat but tended to suppress the carotenoid content.

4. Prolonged dietary supplementation of vitamin A increased the level of this vitamin in the blood serum but reduced the carotenoid values. The apparent magnitude of the vitamin A values varied with the analytical procedure used in the assay.

5. Supplemental feeding of vitamin A throughout the terminal stages of gestation did not prevent the characteristic declines at parturition but did maintain a higher level at this period than observed in non-supplemented cows.

6. The differences in vitamin A intake were reflected in the concentrations of vitamin A in the liver. There was no evidence of a correlation between vitamin A levels in the blood and in the liver of any of the cows that were slaughtered.

The authors are grateful to Distillation Products, Inc., Rochester, New York, for supplying the vitamin A supplements (“dry vitamin A”), and to John Morrell and Company, Topeka, Kansas, for their cooperation and assistance in obtaining liver samples.

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