FURTHER STUDIES ON THE INFLUENCE OF TOCOPHEROL SUPPLEMENTATION ON THE VITAMIN CONTENT OF THE MILK FAT, STABILITY OF MILK AND MILK AND FAT PRODUCTION

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It has been shown at this Station that feeding of cod liver oil to cows renders milk more sensitive to deterioration resulting in the development of oxidized flavors, and involving ascorbic acid oxidation and that feeding mixed tocopherols along with oil augments the ability of milk to resist these oxidative changes (4, 5, 7, 17). Likewise, more stable milk was produced when barn-cured birdsfoot trefoil hay (Lotus corniculatus) of excellent quality was fed to cows as compared with the milk from cows which received poor quality late-cut hay (5, 8, 13). While several factors may be involved (4, 5, 6, 9, 10, 11, 12), it was desirable, nevertheless, to learn the possible value of a tocopherol supplement in maintaining the stability of milk during the winter season when large amounts of poor quality hay are fed, especially since dairy plants experience most trouble with oxidized milk during the winter.

The study was planned also to test more critically the influence of tocopherol supplements upon the fat content of milk, using longer experimental periods than previously reported (17).

EXPERIMENTAL

Eight Holstein cows divided into two equal groups were used in this study. Both groups received a basal ration of late-cut timothy hay (U. S. no. 3 Grade), well-eared corn silage and a commercial concentrate mixture containing 18 per cent protein. Records were kept of the amounts of feeds consumed. Following a preliminary period of 2 wk., the ration of the cows in group 1 was supplemented with 2 g. of mixed tocopherols 1 daily, while group 2 was retained as a control. Period one was of 14-wk. duration and was followed by a second period of 5 wk., during which group 1 was given the basal ration only, and group 2 received the tocopherol supplement. At the end of this period, the tocopherol supplement was discontinued and both groups of cows were transferred to a pasture of mixed birdsfoot trefoil and blue grass.

Milk was weighed and sampled at each milking for the Babcock fat test which was made weekly on composited aliquots. Samples of milk were taken weekly from the morning milking of each cow for studies on tocopherol content and stability of the milk. The milk was pasteurized at 62° C. for 30 min., and the stability of the milk was determined on the basis of its ability to resist the reactions which produce oxidized flavors during 7-day storage at 0 to 5° C. One tenth mg.

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1 "Myvadry." Distillation Prod., Inc., Rochester, N. Y. ("Distilled tocopherol concentrate on soybean-flour containing 5 per cent of mixed tocopherols.")
of Cu per liter was added to all samples of milk prior to storage at refrigeration temperatures to enhance oxidative changes (4). The milk was protected from light throughout the experimental trial.

A quart of each weekly sample of milk was separated by gravity creaming. The cream was churned and the butter obtained was melted, centrifuged clear, filtered and the fat was analyzed for tocopherol content using Quaife (15) and Quaife and Harris (16) methods.

RESULTS AND DISCUSSION

Tocopherol levels of the milk fat. The average tocopherol levels of the weekly samples of milk are presented in figure 1. The data reveal that during the first 14-wk. period, the tocopherol content of the fat diminished progressively when the cows (group 2) were fed the standard ration only, suggesting that the vitamin intake from the basal ration was inadequate to maintain the body reserves of the cow and the amount secreted into the milk. On the basis of an estimated dry matter intake per cow per day and the analysis of the feedstuffs fed to the cow, the animal consumed 1.951 g. tocopherols daily. By comparison, the supplementation of standard ration with mixed tocopherols during the 14-wk. period (group 1) resulted in a consumption of 3.951 g. tocopherols per day, and the vitamin content of the milk fat not only was maintained at much higher levels, but actually showed a slight increase over that for the prefeeding samples of milk fat.

However, when at the end of the 14th week the treatments were changed, and the cows in group 2 were fed mixed tocopherols, the vitamin content of the fat of

![Fig. 1. The average tocopherol content of the milk fat of weekly samples as influenced by standard winter ration, tocopherol supplement and pasture.](image)
both groups of cows declined. At this time the supplement was analyzed and found to contain slightly less than half of its original potency. It is possible that a daily intake of approximately 2.9 g. tocopherols per cow (supplement plus feedstuffs) was not adequate to maintain the vitamin level of the milk fat. However, the elliptic-like path of tocopherol content of the fat and especially its leveling off toward the end of second period (figure 1), indicate that the physiological response of the cow to the feed consumed, together with the negative effect of steadily deteriorating ration on the assimilation and deposition of tocopherols into the milk fat could not be disregarded. The latter statement is supported also by the data in figure 1, which show that the subsequent feeding of birdsfoot trefoil-blue grass pasture effected a sharp increase in the tocopherol content of the fat when the cow consumed approximately 3.7 g. tocopherols per day.

Fat production. The average fat percentage of the milk is shown in figure 1. Feeding mixed tocopherols over a period as long as 14 wk. had no significant effect on the average fat test. Likewise, the average daily production of 4 per

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Period</th>
<th>Oxidized samples</th>
<th>Stable samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>Tocopherol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>content of fat</td>
</tr>
<tr>
<td></td>
<td>wk.</td>
<td>(µg./100 g.)</td>
<td>(µg./100 g.)</td>
</tr>
<tr>
<td>Tocopherol supplement</td>
<td>I</td>
<td>14</td>
<td>2,493 ± 451</td>
</tr>
<tr>
<td>Control</td>
<td>II</td>
<td>5</td>
<td>2,777 ± 163</td>
</tr>
<tr>
<td>Pasture</td>
<td>III</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Control</td>
<td>I</td>
<td>14</td>
<td>2,404 ± 404</td>
</tr>
<tr>
<td>Tocopherol supplement</td>
<td>II</td>
<td>5</td>
<td>1,932 ± 420</td>
</tr>
<tr>
<td>Pasture</td>
<td>III</td>
<td>7</td>
<td>2,309 ± 242</td>
</tr>
</tbody>
</table>

cent fat-corrected milk (1) was not affected (data not shown). These observations are in agreement with those of Phillips et al. (14), Gullickson et al. (2) and Whiting et al. (17), and fail to confirm the report of Harris et al. (3).

Oxidized flavors. Summary data showing the number of samples of milk which either underwent or resisted oxidative deterioration during 7-day storage, together with the mean tocopherol content of the fat for each feeding period, are presented in table 1.

Samples of milk which underwent oxidative deterioration averaged low in tocopherol content as compared with those which remained stable. The difference in the average tocopherol content of stable and oxidized samples of milk was statistically highly significant \( P < 0.01 \). The data in table 1 and figure 1 reveal, however, that the cows (group 2) which were fed standard ration alone during the first 14-wk. trial, produced milk with fat of comparatively low tocopherol content, and the milk itself showed practically no resistance to oxidized flavors. Supplementation of the ration with mixed tocopherols during the fol-
lowing 5-wk. period, failed not only to counteract the decrease in tocopherol content of the fat, which dropped to its lowest level, but also to improve the resistance of milk to deterioration. By comparison, both the tocopherol content of the milk fat and the resistance of milk to oxidative deterioration were significantly improved (group 1) when the standard ration was supplemented with mixed tocopherols throughout the first 14-wk. trial. Moreover, this beneficial effect of the supplemental feeding extended itself to milk produced on standard ration only during the following 5-wk. period.

When the cows were placed on excellent pasture, the tocopherol content of the fat increased rapidly to high levels, and the unstable milk regained its ability to resist deterioration within 2 to 3 wk.

Whether the large intakes of tocopherols and the physiological response of the cow to the feed consumed are entirely responsible for the results obtained can not be stated at the present time. There is a reason to believe that certain pasture herbage and some roughages fed to the cow during the winter season contain other factors influencing the reactions which produce the oxidized flavors.

These tests show clearly, however, that tocopherol supplementation cannot be depended upon to prevent or correct oxidized flavors in milk under all conditions.

SUMMARY

When Holstein cows were fed a standard winter ration of late-cut timothy hay, corn silage and commercial concentrate mixture, a gradual decrease occurred in the tocopherol content of the milk fat and the milk showed practically no resistance to oxidative deterioration resulting in the development of oxidized flavors.

Supplementation of standard ration with 1 to 2 g. daily of mixed tocopherols at the beginning of the trial appeared to improve both the tocopherol levels of the fat and the ability of milk to resist the reactions which produce the oxidized flavors. No such improvement occurred when the tocopherol feeding was shifted to cows toward the end of winter season.

The data show that the tocopherol supplement cannot be depended upon to maintain the tocopherol content of the fat and to prevent or correct oxidized flavors under all conditions.

Feeding mixed tocopherols over 14-wk. period (1 to 2 g. daily) had no significant effect on the average fat tests.

REFERENCES

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