THE CAROTENOID CONTENT OF MILK FAT

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A study of the carotenoid content of milk fat from New York State cows has been made during the year 1936–37 to get additional information on content and the extent of variation with individual cows, seasons, and breeds. Carotenoid content in the fat from 551 milk samples was determined by photoelectric measurement of light absorption in samples of melted fat using Corning glass filters 585 and 428 by the method described in detail in a preceding publication (9). The results of our analyses are shown in Tables 1 and 2, and Figures 1 and 2.

TABLE 1
Carotenoid content of milk fat present in samples of commercial bottled milk collected in various cities in New York State

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of samples</th>
<th>Carotenoid content mg./liter of fat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
</tr>
<tr>
<td>July 1, 1936</td>
<td>75</td>
<td>4.85–24.0</td>
</tr>
<tr>
<td>Feb. 10, 1937</td>
<td>173</td>
<td>1.54– 7.26</td>
</tr>
<tr>
<td>March 29, 1937</td>
<td>86</td>
<td>1.51– 7.19</td>
</tr>
<tr>
<td>May 29, 1937</td>
<td>79</td>
<td>3.52–21.5</td>
</tr>
</tbody>
</table>

TABLE 2
Carotenoid content of the milk from individual cows of the Cornell herd

<table>
<thead>
<tr>
<th>Breed</th>
<th>Barn-silage feed</th>
<th>June 8, 1937</th>
<th>Summer-pasture feed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>April 7, 1937</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of samples</td>
<td>Carotenoid content mg./liter of fat</td>
<td>Number of samples</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>Guernsey</td>
<td>13</td>
<td>4.68–12.0</td>
<td>8.50</td>
</tr>
<tr>
<td>Jersey</td>
<td>25</td>
<td>4.15–11.5</td>
<td>5.87</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>3</td>
<td>5.14– 6.29</td>
<td>5.65</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>11</td>
<td>1.93– 9.58</td>
<td>4.27</td>
</tr>
<tr>
<td>Holstein</td>
<td>20</td>
<td>1.45– 8.42</td>
<td>3.49</td>
</tr>
<tr>
<td>Herd</td>
<td>72</td>
<td>1.45–12.0</td>
<td>5.42</td>
</tr>
</tbody>
</table>

Expressing the carotenoid concentration in mg. per liter of melted fat* at 75°C, we have observed variations from 1.5 mg. per liter to 24.6 mg. For

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* The unit of mg. per liter has been selected because of the colorimetric method of determination which depends directly on concentrations, and eliminates the necessity of measuring or calculating densities. The method yields the value for total carotenoid which in milk fat is about 94 per cent beta carotene and 6 per cent xanthophylls.
commercial milks the average seasonal variation was about 300 per cent, i.e. from 3.4 mg. per liter on winter barn feed to 10.2 on summer pasture feed.

The seasonal variation in the Cornell herd was not so great, the carotenoid values holding up better in the winter. The breed variation was considerably greater than the seasonal variation in the Cornell herd. For example, Holstein fat in July contained 5.78 mg. carotene per liter as against 16.4 mg. per liter for Guernsey. We have observed other instances of a similar nature where studies on a single herd yielded results different from those with commercial milks. For example, the seasonal variation in riboflavin is less in the Cornell herd than in commercial market milk samples (10).

The curves in Figure 1 are intended to show the uniformity in milk

![Figure 1. Distribution of carotenoid in milk fat.](image)

samples. Winter samples were very much more uniform than summer samples. The difference between Guernsey and Holstein was so pronounced that there was practically no overlapping of the curves.

A further study was made on the individual and seasonal variation in carotenoid content of milk fat in a group of 6 cows during the 3 months of May, June and July, 1938. The group contained 3 Guernsey and 3 Holstein cows and were being fed molasses grass silage or, in some cases, phosphoric acid grass silage for the first 5 days. After going on pasture there was a delay of about 1 day before the carotenoid content of the milk fat began to increase. Approximately 2 weeks were required before the maximum value was reached.
During June and July there was no further increase in carotenoid content. The results are shown graphically in Figure 2.

Our results are consistent with most of the reports in the literature. Gil-lam (7) studied 70 cows in England and found an average of 0.327 mg. caro-
tene per 100 grams dry butter (2.88 mg. per liter melted butter at 75° C.). His values of 0.15 mg. carotene per 100 grams dry butter for winter feed and 0.6 mg. for moderate grass feed are about one-half as large as the correspond-
ing values for New York State cows. Knudsen and Nielson (11) studied seasonaI variations in the color of butter fat, observing the lowest color in April and maximum color in May-June. Baumann and Steenbock (1) re-
port samples of March butter of 2.2 micrograms per gram dry butter and July samples of 8.6 micrograms. These samples are very similar to many analyzed by us. Baumann and Steenbock (2) found among breeds that the Guernsey had the highest carotene content in the fat, that the Holstein and Ayrshire were lowest, and that the Jersey and Brown Swiss were inter-
mediate. We have confirmed this and found, for the cows examined, that Ayrshire milk fat has more carotene than Holstein, and Jersey more than Brown Swiss. The results of Wilbur, Hilton and Hauge (14) are much higher than any other values in the literature, namely, 1.8 mg. per 100 grams fat for Ayrshire and 3.6 to 4.0 for Guernsey. Their determinations were made with a Lovibond tintometer and no actual experimental data were reported.

In going from breed to breed there is no direct relationship between caro-
tenoid content of milk fat and vitamin A potency. A small fraction of the carotenoid pigment is inactive xanthophyll and a large part of the vitamin A potency is due to the colorless vitamin A. Wilbur, Hilton and Hauge (14)
found the vitamin A in both Ayrshire and Guernsey milk fat to be practically the same by biological tests. Baumann and Steenbock (2) also reported that breed differences in milk fat with respect to vitamin A activity are small (spectrographic method). Thus on the same feed vitamin A per se is lower in the milk fat from those breeds which are high in carotene. In commercial (mainly Holstein) milk carotene accounts for only 15 per cent of the vitamin A potency (1) but for most of the activity in Guernsey milk. Gillam and others (3, 8) have studied both vitamin A and carotene by the spectrographic method in milk fat from 8 cows of 4 English breeds and they have found large individual variations, but no significant differences between breeds. Davis and Hathaway have observed that whole milk from different breeds is uniform in vitamin A potency (6). Because of the small number of samples investigated in these studies there is some uncertainty in the actual values. Obviously some of the results are contradictory because if there is no difference between breeds with respect to whole milk there must be a difference with respect to milk fat.

As far as individual variations in the same breed are concerned, Treichler, Grimes and Fraps (13) find that highly colored milk fats are apt to be high in vitamin A potency, but not necessarily. Carotene makes up anywhere from 1 to 90 per cent of the potency. Calculations of potency from direct determinations of carotene and vitamin A are somewhat uncertain because 1 mg. of carotene in butter may yield anywhere from 0.16 (3) to 0.6 (5) mg. of vitamin A as measured by activity. It would be valuable to make comparative studies of vitamin A and carotene on a much larger number of cows than any of these workers have studied. Determinations of vitamin A by SbCl₃ have been greatly simplified but are still time-consuming. The presence of an inhibitor in summer milk fat prevents development of the color (4) unless the fat is saponified. Methods have been developed for the extraction of carotene and vitamin A from whole milk (12, 15) when the samples are too small for convenient separation of the milk fat.

**SUMMARY**

The average carotenoid content of the commercial, bottled market milk in New York State was 3.4 mg. per liter of melted fat in winter and 10.1 in summer. The corresponding values for average Holstein milk from the Cornell herd was 3.49 and 5.78; for Jersey milk 5.87 and 10.5 and for Guernsey milk 8.50 and 16.4.

Bottled market milk ranged from 1.51 to 7.26 in winter and from 4.85 to 24.6 in summer. Individual variations within the same breed are much larger than the variations among average values for the different breeds. Individual samples of Holstein milk in June ranged from 2.72 to 10.6, and Guernsey milk from 10.4 to 20.8.
REFERENCES


