FAT DIGESTIBILITY BY DAIRY CALVES

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SUMMARY

The utilization of fat in milk replacers by the dairy calf was studied. When a milk replacer composed predominantly of dried skim milk was supplemented with tallow, coconut fat, grease, or butter, in the unhomogenized state, the fat was poorly digested. However, the inclusion of crude soybean lecithin in the milk replacer improved the utilization of tallow, coconut fat, and grease. The digestibility of coconut fat was improved to a greater extent than was that of tallow or grease by the inclusion of lecithin in the milk replacer.

Milk replacers containing homogenized tallow, lard, butter oil, or hydrogenated soybean oil have been shown to be equal, or nearly equal, to whole milk in promoting growth in the dairy calf. On the other hand, the inclusion of non-hydrogenated vegetable oils, such as soybean oil and cottonseed oil, have been shown to be detrimental to the health of calves (2, 7, 9, 10, 13, 14). The digestibility of certain fats by the dairy calf has been studied to a limited extent. Parrish et al. (16) and Noller et al. (15) found the apparent digestibility of the ether extract of whole milk to be between 96 and 98%. Blaxter and Wood (3) concluded that the ether extract of whole milk had an apparent digestibility of 96%. A recent report by Raven and Robinson (17) demonstrated that the digestibility of butterfat in spray-dried whole milk was 97% by 2-wk.-old calves. When liquid skimmilk containing homogenized palm oil was spray-dried, the digestibility of the fat was 92%. Wing (20) found that homogenized hydrogenated soybean oil was 92% digested by the dairy calf. Cunningham and Loosli (5) fed calves purified milk replacer diets containing either lard or hydrogenated coconut oil in the homogenized state. They found that coconut fat was 86.4, 89.7, 85.5, 88.6, and 71.9% digested during the second, fourth, sixth, eighth, and 11th wk. of age, respectively. Lard was found to be 72.6, 77.0, 92.5, and 93.7% digested during the second, fourth, sixth, and 11th wk., respectively. Blaxter and Wood (4) noted that lard and a small amount of other fatty material had an apparent digestion coefficient of 44.9% when fed in a nitrogen-free diet. However, the apparent digestibility of this fat was increased if the calories of the diet supplied by protein were increased. They postulated that fat digestibility plateaued at slightly over 90% when between 15 and 18% of the dietary calories were supplied in the form of protein.

In most studies of high-fat milk replacers, the fats have been homogenized with the diet. Little information is available on the value of different fats when mixed directly with the dried milk replacer and fed in the unhomogenized state. Kastelic et al. (11), while developing a purified diet for the calf, noted that a

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mixture of butter and soybean lecithin did not need to be homogenized to produce adequate growth. On the other hand, cottonseed oil had to be thoroughly homogenized with lecithin to be a successful dietary ingredient. Huff et al. (8) observed a loss of hair about the tail and inside of the thighs of calves fed unhomogenized hydrogenated cottonseed oil with glycerol monostearate as an emulsifying agent. This characteristic alopecia was not noted if the diet was homogenized with or without glycerol monostearate. Lambert et al. (12) noted that when calves were fed a milk replacer containing hydrogenated soybean oil, superior growth resulted if lecithin was included in the diet. The following study was initiated to obtain additional data on the utilization of several fats when fed to dairy calves.

EXPERIMENTAL PROCEDURES

Experiments were designed to study the digestibility of the following unhomogenized fats by the calf: (1) tallow, (2) coconut fat, (3) sweet butter, (4) tallow plus crude soybean lecithin, (5) coconut fat plus crude soybean lecithin, (6) homogenized coconut fat and crude soybean lecithin, (7) choice white grease, and (8) choice white grease plus lecithin. Originally, the design included the study of homogenized tallow plus crude soybean lecithin. Sweet butter was substituted for this fat after one period because of difficulties that occurred while attempting to homogenize the tallow. In addition, the fat clumped badly after homogenization, making representative sampling impossible. The first experiment involving Diets 1-6 was a randomized block design, consisting of five blocks of six calves each obtained at a different time over 12 mo. The second experiment, involving Diets 7 and 8, was of a completely random design and conducted later than the first experiment.

The composition of the experimental milk replacer diets is given in Table 1. The basal mixture had the following composition: spray-dried skim milk, 100; Aurofac D (5 g. of chlortetracycline per pound), 1.50; vitamin A (20,000 I.U. per gram.), 0.25; irradiated yeast (9,000 U.S.P. units of vitamin D per gram),

TABLE 1
Composition of the high-fat milk replacers used

<table>
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<th>Diet No.</th>
<th>1</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
<td>Ingredients:</td>
<td>(lb.)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Basal mixture</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Edible coconut fat</td>
<td>20</td>
<td>20</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Bleachable fancy tallow</td>
<td>20</td>
<td>20</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Choice white grease</td>
<td>20</td>
<td>20</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Crude soybean lecithin</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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</tbody>
</table>

*Stabilized with 10 g. B.H.T. per 100 lb.
*Stabilized with Tenox 2 (propylene glycol, B.H.A., and citric acid).
*Stabilized with 45 g. B.H.T. per 100 lb.
*Alcolec S—American Lecithin Co., Woodside, N. Y.
0.017. In earlier studies at this laboratory, this basal mixture has been observed to be 94% digested by 2-wk.-old calves when fed as a reconstituted milk replacer. The fats used in these studies had the following titers (solidification temperature of the saponified fatty acids; A.O.A.C. Official Methods of Analysis, 8th ed.): tallow, 42° C.; coconut fat, 23° C.; butter, 37° C.; grease, 39° C.

The fat that was to be added to the basal mixture was melted and lecithin, when it was included, was added to the melted fat. The melted blend was combined with the basal mixture and stored at barn temperature. At the time of feeding, these diets were reconstituted with water at a ratio of one to ten. The homogenate of Diet 6 was prepared in a Gaulin two-stage homogenizer with 500 and 2,000 lb. p.s.i. pressure at the first and second valves, respectively. The homogenate contained three parts water and one part fat. The particle size of the homogenate was about 2μ. At the time of feeding, the basal mixture of Diet 6 was reconstituted with water and an appropriate amount of homogenate added.

The diets for the second experiment were prepared in a similar manner.

The animals used in these experiments were male Holstein calves obtained from local dairymen or auctions and were approximately three days of age upon arrival at our laboratory. The animals received a diet of whole milk alone for several days after arrival. The milk replacers were gradually substituted for the whole milk, so that after seven days the calves received only 200 g. of the milk replacer, reconstituted at the rate of one part to ten parts of warm water and fed in open pails. No hay or grain was fed. Water and iodized salt were offered ad libitum. The calves were housed in a heated barn in elevated box-type pens with metal-grid floors. In pens such as these, the calves could move about freely and the metal-grid afforded satisfactory footing. Previous attempts to confine calves in stanchions had proved to be unsatisfactory.

Between the ages of 2 and 3 wk., digestibility trials of at least six days’ duration were initiated. Fecal collections were made by attaching polyethylene bags to the calves in the manner described by Noller et al. (15). In the event of diarrhea during the preliminary period of the digestion trial, the trial was postponed. If diarrhea occurred during the digestion trial the data were, with one exception, discarded. The exception was made in Period Two of the tallow treatment in which the feces were collected for three days, discarded for two days because of diarrhea, and again collected for three days. During the preliminary period of the digestion trials, a carmine marker was fed with the night feeding. The time from the feeding of the marker until its initial appearance in the feces was recorded as transit time.

Feeds were analyzed for fat by extraction in a Soxhlet apparatus. Aliquots of the fat homogenates were analyzed by adding subsamples to tared extraction flasks filled with shredded asbestos. The flasks were dried, and the unevaporated residue of the subsample was calculated as total fat. Samples of dried feces were extracted for 48 hr. with ethyl ether in a Soxhlet apparatus. Following this preliminary extraction, the sample was ground and analyzed for total fat including soaps, by an adaptation of the Saxon method (18). The sum of the extractions was used in calculating the digestion coefficients.
Statistical analyses were made of the digestibility data as follows: An arc-sin transformation was made of the digestion coefficients to correct for heterogeneous variance as well as non-normality. Missing plots were estimated and an analysis of variance was made by the methods outlined by Snedecor. The upward bias of the treatment mean square caused by the calculation of missing plots was corrected (19). If a significant F value was obtained, the multiple range test of Duncan (6) was used to test the significance of individual means. Except for the transformation, the transit time data were analyzed in a similar manner.

RESULTS AND DISCUSSION

The apparent digestion coefficients of total fat of the experimental diets are given in Table 2. As has been mentioned, the butter treatment was not assigned in the first block. The other missing observations resulted from removal of the animals from experiment, due to scours. Statistical analysis of Experiment I showed the fat digestibility to be significantly higher at the 1% level for the animals fed the diets containing homogenized coconut fat plus crude soybean lecithin and coconut fat plus crude soybean lecithin, than for the animals fed any of the other experimental diets. Tallow plus lecithin was better digested than tallow. In Experiment II (Table 2), the calves fed grease plus lecithin digested the fat significantly better (1% level) than those fed grease alone. No other statistically significant difference was noted.

Apparently, when skim milk is supplemented with an unhomogenized fat without an emulsifying agent, the fat is rather poorly utilized. However, the inclusion of lecithin in a high-fat diet appears to increase the digestibility of the fat. Because of the excellent utilization of coconut fat plus lecithin in this experiment, homogenization could not be expected to improve its utilization by any appreciable amount. Rather inexact data were collected in the one digestion trial in which the basal mixture was supplemented with homogenized tallow plus lecithin. Due to a sampling problem it was calculated from chemical analyses that between 370

<table>
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<th>Block</th>
<th>1</th>
<th>2</th>
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<th>5</th>
<th>Avg. Transit time (hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>Avg. Transit time (hr.)</td>
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<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Avg. Transit time (hr.)</td>
</tr>
<tr>
<td>Experiment I</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Avg. Transit time (hr.)</td>
</tr>
<tr>
<td>1. Tallow</td>
<td>64.6</td>
<td>52.4</td>
<td>53.8</td>
<td>66.2</td>
<td>59.2</td>
<td>22</td>
</tr>
<tr>
<td>2. Coconut fat</td>
<td>66.0</td>
<td>60.1</td>
<td>64.4</td>
<td>71.3</td>
<td>65.4</td>
<td>25</td>
</tr>
<tr>
<td>3. Butter</td>
<td>73.3</td>
<td>52.8</td>
<td>66.1</td>
<td>76.9</td>
<td>67.3</td>
<td>22</td>
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<tr>
<td>4. Tallow + lecithin</td>
<td>85.0</td>
<td>68.9</td>
<td>57.1</td>
<td>77.5</td>
<td>72.1</td>
<td>17</td>
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<tr>
<td>5. Coconut fat + lecithin</td>
<td>96.0</td>
<td>97.9</td>
<td>90.4</td>
<td>98.2</td>
<td>95.4</td>
<td>21</td>
</tr>
<tr>
<td>6. Coconut fat + lecithin (homogenized)</td>
<td>90.4</td>
<td>96.1</td>
<td>96.9</td>
<td>96.0</td>
<td>94.9</td>
<td>22</td>
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</table>

Experiment II

<table>
<thead>
<tr>
<th>Diet</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Avg. Transit time (hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Choice white grease</td>
<td>59.1</td>
<td>44.2</td>
<td>51.1</td>
<td></td>
<td>51.5</td>
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<tr>
<td>8. Choice white grease + lecithin</td>
<td>77.8</td>
<td>81.2</td>
<td>79.2</td>
<td></td>
<td>79.4</td>
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</table>
and 550 g. of fat were fed. However, since only 25 g. of fecal fat were collected, the digestibility of the tallow homogenate must have been between 93 and 96%. This single observation is indicative that homogenization does indeed improve fat utilization of a poorly digested fat and helps explain the good growth responses that have been obtained when homogenized tallow is fed to calves.

The low digestion coefficients obtained from butter are of interest in view of the high digestion coefficients that have been reported for the ether extract of liquid and of spray-dried whole milk. These observations further suggest that the physical form of fat is important for maximum utilization by the calf. It should be noted, however, that significant amounts of the lecithins of whole milk are not present either in churned butter or in skim milk, but are concentrated in the buttermilk.

It is apparent that crude soybean lecithin improves the digestion of fats by young dairy calves. While this improvement would seem to be due to the action of the lecithin as an emulsifying agent, it may result from some other action or a constituent of the crude lecithin. It is of interest to note that the digestion of the coconut fat, a low-melting fat, was improved more than was the digestion of tallow, a high-melting fat. Auger et al. (1) observed that the digestibility of high-melting fats by rats was improved more than that of low-melting fats by the inclusion of lecithin in the diet. However, these workers fed fats with higher melting points than we used, and they observed sizable differences in digestibility between the different fats fed without lecithin.

The transit times of the diet that were obtained with the carmine marker are presented in Table 2. Transit times of the rations were found to vary widely from calf to calf. Analysis of variance of the data gave a nonsignificant F of 1.3. Thus, the speed of passage did not seem to be an important factor in fat digestion in this experiment.

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REFERENCES


