Evaluation of Milk Replacers Containing a Soy Protein Concentrate and High Whey

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Abstract
Three milk replacers compared contained per cent of dried whey, dried skim-milk, a soy protein concentrate (Promosoy, Central Soya Co.), and lard oil, respectively, as follows: A-76.6, 0, 12.2, 10; B-67.9, 14.9, 6.0, 10; and C-59.2, 29.6, 0, 10. The three replacers were equal in supplemental vitamins, minerals, antibiotic, and contained approximately 18.5% protein. They were fed to calves for 35 days. Average gains (kg) and fecal scores, scale of 0 (normal) to 3 (fluid), of calves on Replacers A, B, C were: 13.0, 17.8, 16.2 and 0.69, 0.60, 0.97. Blood serum protein, hemoglobin, and packed cell volumes of these groups were similar.

Introduction
There is need for profitable, nonpolluting methods of disposing of whey from cheese manufacturing plants. Dried whey contains approximately 70% lactose, the carbohydrate of choice for young calves, so whey is commonly used in milk replacers. Amounts of protein calves require and the diarrhetic effect of whey limit the amount of whey in milk replacers. For maximum use of whey in replacers, an economical, concentrated source of protein that is well utilized by young calves is needed. In this study we evaluated a soybean protein concentrate as a protein supplement for milk replacers high in whey.

Experimental Procedure
Seventeen female and 3 male Holstein and Holstein-Angus cross-bred calves were randomly assigned by breed and sex to one of three milk replacers (Table 1). They remained with their dams until three days of age; from then until the end of the experiment they were in individual stalls bedded with wood shavings. Four additional bull calves kept in metabolism crates during the experimental period permitted more extensive observation and metabolism studies.

All calves received milk at 8% of body weight daily from 3 to 7 days of age. From then for four weeks heifer calves were fed reconstituted milk replacer (15.5% total solids) at 10% of body weight daily, in two equal feedings. Then for one week each calf got 2.3 kg reconstituted replacer daily. In addition, each consumed ad libitum the calf starter used in studies by Morrill et al. (7). Bull calves received only reconstituted milk replacer at 12% of body weight daily, in two equal feedings, from 1 to 6 weeks of age.

Milk replacers were prepared by procedures developed by Guy et al. (4). Fresh fluid skim-milk and spray-dried sweet whey were used. All formula components, both liquid and solid, were mechanically mixed into sufficient tap water to make up an 18% dispersion. The resulting dispersion was condensed under vacuum to 42% total solids in a falling film evaporator and conventionally spray-dried by an air inlet temperature of 137 C and 76 mm nozzle in the atomizer.

General health and appearance of each calf and consistency of feces were recorded twice daily. Body weights and jugular blood samples were taken weekly. Blood hemoglobin, packed cell volume, and serum protein were determined by a copper sulfate method (8, 10, 11).
TABLE 1. Composition and analysis of experimental milk replacers used.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>A (%)</th>
<th>B (%)</th>
<th>C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried sweet whey</td>
<td>76.57</td>
<td>67.88</td>
<td>59.17</td>
</tr>
<tr>
<td>Dried skim milk</td>
<td>0</td>
<td>14.87</td>
<td>29.60</td>
</tr>
<tr>
<td>Promosoy</td>
<td>12.20</td>
<td>6.02</td>
<td>0</td>
</tr>
<tr>
<td>Lard oil</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Mg C12</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Antibiotic (Aurofac 25)</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Methionine hydroxy analogue</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Vitamins and trace minerals</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Protein = 18.4
Ash = 7.4
Lactose = 53.5
Proportion protein from soybeans = 44% 22% 0%

Soy protein concentrate manufactured by Central Soya Co., Chicago, Illinois. Typical analysis (% as is basis): Protein, 65.8; ether extract, 0.3; crude fiber, 3.9; ash, 5.0.

Supplied through courtesy of Milk Specialties, Inc., Dundee, Illinois.

The supplement provided these amounts per 45.4 kg of air dry milk replacer: Vitamin A, 1,625,000 IU; vitamin D3, 375,000 IU; vitamin E, 1,000 IC units; calcium pantothenate, 1 g; ascorbic acid, 1 g; riboflavin, 500 mg; niacin, 500 mg; thiamine monohydrate, 125 mg; and vitamin B12, 125 µg.

The supplement provided these amounts (grams) per 45.4 kg of air dry milk replacer: FeSO4·7H2O, 50; MnSO4·H2O, 2.8; ZnSO4·7H2O, 1.8; CuSO4·5H2O, 1.5; KI, 0.06; CoSO4·7H2O, 0.05.

Average weight gains by calves in individual stalls are shown in Table 2. Incidences of loose feces, not accompanied by elevated temperatures or other indications of infection assumed to be of nutritional origin were greater with calves kept in metabolism crates. Therefore, data from these calves are not included in Table 2. There were no significant (P > .05) differences between average initial weights of calves assigned to the three rations, nor was there a significant (P > .05) effect of ration on calf starter consumption, or of breed or sex on weekly or overall weight gain.

Average fecal scores of calves, by rations, are in Table 3. Dry matter content of feces, estimated visually, did not differ by ration. Average fecal scores for Holstein heifers, Holstein-Angus heifers, Holstein-Angus bulls, and Holstein bulls kept in metabolism crates were 0.50, 0.75, 1.10, and 1.15, for the entire experiment; differences between bulls kept in crates and both groups of heifers, and between Holstein-Angus bulls and Holstein heifers were significant (P < .05). Method of feeding, rather than sex, probably caused feces excreted by the bulls to be more fluid.

Calves were observed at least twice daily but feces were not always voided that often. Because one type of feces might have been observed more readily than another, differences in types voided could influence the accuracy of observations and thus bias the results. To check that possibility, the number of observations of feces from calves on the three rations

TABLE 2. Average weight gain of calves.

<table>
<thead>
<tr>
<th>Ration</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2.2</td>
<td>1.4</td>
<td>3.5</td>
<td>2.8a</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>B</td>
<td>2.9</td>
<td>2.9</td>
<td>4.2</td>
<td>4.2b</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>C</td>
<td>3.2</td>
<td>1.6</td>
<td>3.2</td>
<td>4.7b</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

abc Means in a column with different letters differ significantly (P < .05).

Average fecal scores of calves on indicated milk replacers.

<table>
<thead>
<tr>
<th>Ration</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(fluid)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>B</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>C</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

a Scale of 0 (normal) to 3 (fluid).
were subjected to analysis of variance. There were more observations recorded each week from calves fed Ration 2, but this difference was significant (P < .05) only during Week 3. An analysis of variance of square roots of numbers of observations per week, conducted to correct for possible increased variance with increased average numbers of observations, showed no significant differences due to ration.

Average serum protein, hemoglobin, and packed-cell-volume are in Table 4. None showed significant (P > .05) differences due to ration, breed, sex, or where calves were kept. Average serum protein declined from 7.15 to 5.56 g/100 ml from when calves were less than one week old to the end of the experiment.

Discussion

Our results indicate that good quality dried whey, properly supplemented, can make up at least 68% of the dry matter of calf milk replacers. Calves fed a replacer containing that amount gained approximately 0.51 kg/day, slightly in excess of the 0.5 kg/day suggested by Jacobson (5) to be adequate for herd replacement heifers. The poorer response of calves fed Ration 1 was probably not due to the higher whey, since lactose and minerals were similar in all 3 rations. This would suggest that, with proper protein supplementation, whey as high as 76% might be satisfactory.

In this study, Promosoy successfully replaced 22%, but not 44%, of the protein from milk sources, confirming results of Schmutz.2 Gor- rill and Thomas (3) and Gorill and Nicholson (2) reported that calves grew as well when Promosoy replaced 86 and 70%, respectively, of the milk protein in a milk replacer. Lower protein and higher growth rates in our work are two factors which may explain some of the difference in results. We intentionally used less protein to put more stress on the protein source. Nielsen3 has shown that quality of protein to furnish protein in excess of 18% of milk replacer dry matter is less important than quality of protein to furnish up to 18% protein.

We attempted to measure digestibility of protein and other nutrients in the three rations, but the high incidence of loose feces made complete fecal collections difficult so those data are not presented. Gorrill and Nicholson (2) recently reported significantly lower digestibility of protein from Promosoy than from milk.

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2 Schmutz, W. G., Central Soya Co., personal communication.
3 Nielsen, V. W., unpublished results, 1968.
The cause of the high incidence of loose feces in this study is not known. Wallace et al. (12) reported that milk replacers containing as much as 60% dried whey caused a high incidence of diarrhea. Feces voided by our calves that consumed the most whey were no more fluid than those of calves that consumed the least whey.

Hemoglobin and blood-packed-cell volumes were measured to determine if including soybean protein in milk replacers might interfere with use of trace minerals in blood formation. Miller (6) reported reduced availability to calves of zinc fed with soy protein. The marked similarity in blood values of calves in our study, whether the calves were fed all milk protein or part soy protein, or whether or not they received dry feed indicated that any soy protein effect was too small to affect blood formation when fed with trace minerals at the level we used.

We found, as did Genskow et al. (1), Schmutz et al. (9), and Wendlandt et al. (13), that growth improved when part of the milk protein was replaced by another protein. This may indicate that the supplementary protein was supplying one or more amino acids that were limiting the response that could be attained from the quantity of milk protein that was fed. More information concerning the amino acid requirements of calves is needed.

References