Pre-weaning growth and feed intake of dairy calves receiving different combinations of soybean flour, whey powder and colostrum

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Introduction

Pre-weaning feeding costs of dairy calves are relatively high and numerous research papers deal with the concept of replacing whole milk with alternative liquid diets. Protein sources of vegetable origin, such as soybean flour and soybean-protein concentrate, are often included in milk-replacer formulae with varying degrees of success (Gorrill & Nicholson, 1969; Gorrill, Cameron & Nicholson, 1971; Erbersdobler & Gropp, 1973; Campos, Huber & Bergen, 1982; Campos, Huber, Morrill, Brownson, Dayton, Harrison & Warner, 1982; Akinyele & Harshbarger, 1983). Although skimmed milk-powder is an outstanding protein source of animal origin, it is very expensive, but whey powder is often included successfully in large amounts in milk replacers for calves (Morrill, Melton, Dayton, Guy & Pallansch, 1971; Bouchard, Brisson & Julien, 1973; Volcani & Ben-Asher, 1974; Volcani, Gordin & Nitsan, 1974). Since plant proteins and animal protein sources (except those containing casein, such as skimmed milk-powder) lack the ability to clot in the abomasum of calves, the quality of milk replacers consisting primarily of these products is often questioned.

It has been shown that surplus colostrum can be preserved successfully with the addition of formaldehyde (Rindis & Bodol, 1977) and fed in combination with soybean flour and whey powder until calves are weaned at 30 days of age (Cruywagen, 1982). In the above-mentioned trial, calves received liquid diets only, and bodymass gains were not according to expectation, probably because of insufficient energy intake. According to Griffiths & McGann (1966) and Raven (1970), calves consume more concentrates as the energy content of milk replacers is lowered. In the present study, a complete ration was available from 4 days of age to examine the effect of an additional energy source to liquid diets on pre-weaning performance of calves.

Procedure

Thirty-five Friesian bull calves were allotted (according to birthmass) to five treatments in a randomized block design. Initial bodymass of each calf was determined at the commencement of the trial, which was immediately after the colostrum feeding period, at 2 days of age. The composition of the liquid experimental diets (ratios of components) is presented in Table 1.

Treatments 1 - 4 represent four divergent treatments from a previous trial in which the present Treatment 4 resulted in the highest gains, while Treatment 1 resulted in negative pre-weaning gains (Cruywagen, 1982). In the trial referred to, calves received no extra concentrates and the poor gains were

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attributed to insufficient energy intake.

Colostrum from the first eight milkings post-partum was preserved, according to the method described by Rindsig & Bodoh (1977), with 1,25 ml formaldehyde/l colostrum. The total amount of colostrum required was collected before commencement of the trial and then mixed in a bulk tank to obtain a homogeneous composition. It was then stored in 75 l polythene drums at 4°C until required. The soybean flour was a defatted product of which the trypsin inhibitor was inactivated by heat treatment.

A chemical analysis of the diet components (as determined by Cruywagen, 1979) is presented in Table 2, and the calculated chemical composition of the final diet mixtures is presented in Table 3.

For the determination of nitrogen, samples were prepared according to the micro-Kjeldahl digestion technique and nitrogen determined colorimetrically with the aid of an automatic analyser according to the method described by Clare & Stevenson (1964). The Gerber test for butterfat (as described by Newlander & Atherton, 1964) was used to determine the butterfat content of colostrum. Fat in the soybean flour and whey powder was determined by ether extraction according to the Weende method.

Liquid diets (Treatments 1-4) were offered in such a way that each calf received 12 g of dry matter (DM)/kg initial bodymass daily. This represented a DM intake comparable with a calf receiving whole milk at a rate of 10% of its bodymass, as was the case in Treatment 5 (assuming the mean DM content of whole milk (WM) to be 12%). The diets were prepared daily by reconstituting the calculated amount of soybean flour and whey powder to obtain a DM content of 15%. Hot water (ca 50°C) was used for reconstitution. The correct amount of colostrum, which also had a DM content of 15%, was then added and the mixture well-stirred. The final temperature of the mixture was about 30°C.

A complete ration consisting of 48,5% maize meal, 30% of a commercial high-protein concentrate (42% crude protein (CP)), 20% ground lucerne hay, and 1,5% NaCl (calculated crude protein and metabolizable energy values of 21% and 10,4 MJ/kg respectively), was available ad libitum from 4 days of age.

Calves were weaned at 30 days of age and bodymass gain was determined weekly.

Results and Discussion
Changes in bodymass

Total empty bodymass gains during the experimental period are presented in Table 4, and weekly changes in bodymass are indicated in Figure 1.

It is evident from Table 4 that calves receiving whole milk (Treatment 5) had the highest gains, followed by calves in Treatments 3 and 4. There were no significant differences (P>0,05) in gain between calves in Treatments 3, 4 and 5, but calves in Treatment 5 showed a highly significant (P<0,01) better bodymass gain than those in Treatments 1 and 2. Calves in Treatment 3 gained significantly (P<0,05) better than those in Treatment 1. Apart from whole milk, the best results (>300 g daily gain) were obtained when the minimum colostrum and maximum whey powder contents of the diet were both 40%. This tendency is in accordance with previous results (Cruywagen, 1979). It should be kept in mind, however, that only two levels of whey powder were

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Table 4  Total body mass gains of calves (mean per group) during the 28-day experimental period (n = 7)

<table>
<thead>
<tr>
<th>Mean gain (kg)</th>
<th>ADG (g)</th>
<th>Treatment number</th>
<th>Significance of difference for treatment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.67</td>
<td>203</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6.07</td>
<td>217</td>
<td>2</td>
<td>NS</td>
</tr>
<tr>
<td>9.26</td>
<td>331</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>8.74</td>
<td>312</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>10.51</td>
<td>375</td>
<td>5</td>
<td>b, b</td>
</tr>
</tbody>
</table>

NS Difference not significant

a Difference significant, LSD = 3.32 kg (P≤0.05)

b Difference highly significant, LSD = 4.40 kg (P≤0.01)

Table 5  Dry feed intake by calves (mean per group) during the 28-day experimental period (n = 7)

<table>
<thead>
<tr>
<th>Total intake (kg)</th>
<th>Mean daily intake (g)</th>
<th>Treatment number</th>
<th>Significance of difference for treatment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.21</td>
<td>25.8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6.21</td>
<td>22.2</td>
<td>2</td>
<td>NS</td>
</tr>
<tr>
<td>8.96</td>
<td>32.0</td>
<td>3</td>
<td>NS, a</td>
</tr>
<tr>
<td>10.79</td>
<td>38.5</td>
<td>4</td>
<td>a, b, NS</td>
</tr>
<tr>
<td>5.4</td>
<td>1.9</td>
<td>5</td>
<td>NS, NS b, b</td>
</tr>
</tbody>
</table>

NS Difference not significant

a Difference significant, LSD = 2.57 kg (P≤0.05)

b Difference highly significant, LSD = 2.49 kg (P≤0.01)

Table 6  Total dry matter (DM) intake by calves (mean per group) during the 28-day experimental period (n = 7)

<table>
<thead>
<tr>
<th>Mean DM intake (kg)</th>
<th>Treatment number</th>
<th>Significance of difference for treatment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.64</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>18.66</td>
<td>2</td>
<td>NS</td>
</tr>
<tr>
<td>20.54</td>
<td>3</td>
<td>NS, NS</td>
</tr>
<tr>
<td>22.10</td>
<td>4</td>
<td>NS, NS, NS</td>
</tr>
<tr>
<td>18.17</td>
<td>5</td>
<td>NS, NS, NS</td>
</tr>
</tbody>
</table>

NS Difference not significant

a Difference significant, LSD = 3.62 kg (P≤0.05)

Feeding costs

The following prices were applicable (June 1984):

Liquid diet components:
- Soybean flour : R1.33/kg
- Whey powder : R0.65/kg
- Colostrum (production cost) : 12c/l (80c/kg DM)
- Whole milk : 34c/l (R2.83/kg DM)

Dry feed components:
- Maize meal : 22.0c/kg
- High protein concentrate (42% CP) : 50.9c/kg
- Lucerne hay : 18.0c/kg
- Salt : 3.2c/kg

Table 7  Efficiency of feed conversion (EFC) by calves during the 28-day experimental period (kg DM/kg body mass gain) (n = 7)

<table>
<thead>
<tr>
<th>Mean EFC ratio</th>
<th>Treatment number</th>
<th>Significance of difference for treatment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.81</td>
<td>1</td>
<td></td>
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<tr>
<td>3.56</td>
<td>2</td>
<td>NS</td>
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<tr>
<td>2.43</td>
<td>3</td>
<td>NS, a</td>
</tr>
<tr>
<td>2.73</td>
<td>4</td>
<td>a, NS, NS</td>
</tr>
<tr>
<td>1.82</td>
<td>5</td>
<td>b, NS, NS</td>
</tr>
</tbody>
</table>

NS Difference not significant

a Difference significant, LSD = 1.95 (P≤0.05)

b Difference highly significant, LSD = 2.64 (P≤0.01)
Feeding expenses are indicated in Table 8.

It is evident that the cost of the liquid diet for Treatment 5 (283c/kg DM) was much higher than that of any other treatment (81.6, 76.3, 84.6, and 79.3c/kg DM for Treatments 1 – 4 respectively). It is also clear that Treatment 5 resulted in the highest pre-weaning feeding cost (R37.74), being at least three times more expensive than any other treatment, and although calves receiving whole milk had the highest bodymass gain, the cost/kg gain of these calves (R3.59) was considerably higher than for calves in Treatments 1 – 4 (R2.02, R1.87, R1.35 and R1.39 respectively). The percentage saving in pre-weaning feeding costs of Treatments 1 – 4, compared to whole milk, was 69.6%; 70.0%; 67.0%; and 67.8% respectively.

In conclusion, dairy calves can be reared successfully until weaning on mixtures of soybean flour, whey powder and colostrum with a considerable saving in feeding costs compared to whole milk. A complete ration should be available ad libitum from 4 days of age, and the best results can be expected when the liquid diet mixture contains at least 40% colostrum and less than 60% whey powder on a dry matter basis.

Acknowledgement

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