Short communication

The effect of four fibrous feed supplementations on different welfare traits in veal calves

J.P. Morisse, D. Huonnic, J.P. Cotte, A. Martrenchar*
Agence Francaise de Sécurité Sanitaire des Aliments B.P. 53-22440 Ploufragan, France

Received 12 January 1999; received in revised form 28 June 1999; accepted 4 January 2000

Abstract

The aim of the present study was to evaluate the optimum starch-fibre content of manufactured dry feed for veal calves. In three identical barns (B1, B2, B3), 126 calves were assigned to seven groups fed the same milk replacer. In each barn there was a control group (C1, C2, and C3), fed only the all-liquid diet, and one (or two in B3) group(s) receiving additional pellets (P1, P2, P3, and P4). Pellets differed by their composition; their starch and NDF characteristics were as follows: 48.0–26.2% (P1); 32.6–43.4% (P2); 25.0–52.2% (P3); and 1.8–78.2% (P4), respectively (in % of dry matter). Health, characteristics of the rumen, performance, and ruminating behaviour were compared between treatments. In calves having access to solid feed, the weight of reticulo-rumen increased by 23–46% compared to controls \((p<0.05)\). The ruminal mucosa became covered with small size papillae (non-existent in controls) and stomach hairballs were consistently reduced. In P1, P2 and P3, rumen fermentation was assumed because of the darkening of the mucosa and the carcass weight increased by 6.5, 7.5 and 5.6%, respectively, when compared to their respective controls \((p<0.05)\). Abomasal ulcerations occurred in two barns but they were unrelated to solid feed. Rumination was more frequently observed in P3 and in P4, but in this latter group some digestive troubles occurred and the growth was slightly lower than in control (C3). It is suggested that, within the range of investigated diets, the best dietary compromise could be starch 25% and NDF fibre 50% of feed dry matter. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Veal calves; Welfare; Fibrous feed; Behaviour; Health; Growth; Rumen

* Corresponding author. Tel: +33-2-96-01-62-20; fax: +33-2-96-01-62-23.
E-mail address: a.martrenchar@ploufragan.afssa.fr (A. Martrenchar)
1. Introduction

Usually, veal calves were exclusively fed on milk replacer with a restricted iron content to produce a light coloured meat (Morisse et al., 1994). However, all-liquid feeding induced non-nutritive oral behaviour (Sambraus, 1985; Kooijman et al., 1991; Veissier et al., 1998), and enhanced the frequency of stereotypies such as tongue rolling (Van Putten, 1982).

According to the Scientific Veterinary Committee (SVC), the lack of solid feed led to impairments in the development of the rumen and the formation of papillae on the ruminal mucosa in such a way that calves could not express their natural condition of ruminants (Report on the Welfare of Calves, 1995).

To alleviate the behavioural and anatomical impairments induced by an all-liquid diet, the European Directive laying down minimum standards for the protection of calves (Council Directive 91/629/EEC, 1991) was amended. The new formulation (Council Directive 97/2/EC, 1997) stipulated that calves should be provided ‘with a minimum daily amount of fibrous feed, ranging from 50 g/day at 8 weeks of age to 250 g/day at 20 weeks of age’.

We previously demonstrated (Morisse et al., 1999) that supplementing calves between 3 and 20 weeks of age with a total amount of 25 kg of pellets per animal (NDF fibre: 22.6%, starch: 48.0% in dry matter) resulted in the development of the rumen and its papillae, a reduction of hair balls in the stomach, and a 6.5% increase in carcass weight. Nevertheless rumination was not observed, probably due to the level of fibre and/or to the size of the fibre particles which may be too small. In fact, the expression ‘fibrous material’ used in the European Directive 97/2/EC is unclear and the present study was carried out to investigate different starch-fibre ratios which would be likely to induce rumination in addition to anatomical and zootechnical improvements already observed in our previous work.

2. Material and methods

2.1. Animals and management

The study was carried out in standard conditions, in three commercial barns (B1, B2, and B3), especially selected for their identical characteristics concerning housing capacity, air controlled system and isolation. They were equipped with individual crates (1.7 m long, 0.81 m wide), on wooden slatted floor. The crates were separated by open sides allowing visual contacts. The calves were not tethered; they were bucket fed twice daily with a standard milk replacer, according to a standard feeding program. Light was available 8 h daily.

One hundred and twenty-six male Friesian calves aged 1 week were involved, from which 42, 34 and 50 were assigned to B1, B2 and B3, respectively. In each barn a control group was fed only on the milk replacer: C1 (n=21); C2 (n=17); and C3 (n=16). The remaining calves were supplied in addition to the milk replacer with an individual total amount of 25 kg of pelleted solid food of different compositions (P1, P2, P3, and P4 as
shown in Table 1). Calves were distributed as follows: P1, n=21 in B1; P2, n=17 in B2; P3, n=17 and P4, n=17 in B3. Three days after their arrival, when their total blood volume was completely restored, calves were then allocated, within each barn, between control ‘C’ and treated ‘P’ on the basis of their body weight and haematocrit.

Pellets were made of agglomerated ground barley and straw; variations of composition were obtained by adding increasing amounts of barley straw pellets (P4) to the basal concentrate P1 consisting essentially in barley. Manufactured pellets rather than roughage were intentionally used in our study to avoid any dysfunction of manure removal systems by wasted roughage (hay or straw), to bring energetic complements and in prevision of the potential utilisation of computerised feeding systems.

Main characteristics of pellets and corresponding analytic procedures were as follows:

- Starch was measured by polarimetry, according to procedures described in the European Directive 72/199/EEC, 1972.
- Fibre fractions using the method described by Van Soest et al. (1991).
- Nitrogen content was determined using the method by combustion according to the Dumas principle, (Norme Française NF V 18-120, 1997) described in NF V 18-120 by the French Association of Standardization (AFNOR).
- Total ash contents by destruction of the organic matter at 550°C.
- Iron was measured by atomic absorption spectrophotometry according to procedures described in the European Directive 78/633/EEC, 1978.

Since straw was specially processed to contain a very low iron content (straw grinding and pellets processing were achieved in stainless-steel equipments), the iron content of diets was, respectively: 182 ppm in P1; 134 ppm in P2; 110 ppm in P3; and 39 ppm in P4. The size of particles agglomerated in pellets ranged from 2 to 5 mm in variable proportions depending on the respective proportions of cereals (small particles) or straw (large particles). Solid feed was given daily from 3 weeks of age in individual buckets, 30 min after the first of the two milk distributions. The amounts of solid feed ranged, according to the age of animals, from 50 g at 3 weeks to 300 g at 17 weeks. Calves were slaughtered for commercial purposes at the standard age of 20 weeks.

<table>
<thead>
<tr>
<th>Item</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>48.0</td>
<td>32.6</td>
<td>25.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Fibre fractions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude fibre</td>
<td>11.6</td>
<td>21.2</td>
<td>26.0</td>
<td>40.5</td>
</tr>
<tr>
<td>NDF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.2</td>
<td>43.4</td>
<td>52.2</td>
<td>78.2</td>
</tr>
<tr>
<td>ADF&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.8</td>
<td>25.2</td>
<td>30.9</td>
<td>47.9</td>
</tr>
<tr>
<td>Lignin</td>
<td>2.0</td>
<td>3.6</td>
<td>4.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Crude protein</td>
<td>9.7</td>
<td>7.8</td>
<td>6.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Total ash contents</td>
<td>6.0</td>
<td>7.5</td>
<td>8.2</td>
<td>10.4</td>
</tr>
</tbody>
</table>

<sup>a</sup> Neutral detergent fiber.
<sup>b</sup> Acid detergent fiber.
2.2. Measurements

2.2.1. Reticulo-rumen characteristics

At slaughter, each reticulo-rumen was individually weighed after the contents were removed; the presence of hairballs of a minimum diameter of 4 cm was checked. A fragment of ruminal wall (10 cm x 10 cm) was removed from each rumen, at the edge delimited by the groove and the reticulum. The pigmentation of mucosa samples was measured by means of a photometer (CR Minolta 300) as described by Morisse et al. (1992). The development of papillae was evaluated qualitatively (4 levels) from their length in millimetre.

2.2.2. Health and performance

Mortality was recorded and the prevalence of diarrhoea was estimated from the number of calves individually medicated. Calves not drinking their total amount of milk were noted. On the day before departure to slaughter, individual blood samples were collected from each calf by jugular vein puncture into heparinized tubes to determine haemoglobin concentration by spectrophotometry, and to compare the results with the standard of 4.5 mmol/l (7.25 g/100 ml) enacted by the Council Directive 97/2/EC, 1997. At slaughter, each abomasum was individually observed and ulcerations (with penetration of the mucosa) larger than 0.5 cm in diameter were recorded.

Daily gain was calculated by the difference between individual weightings at 1 and 20 weeks of age. Carcasses were electronically weighed on the processing line and a standard reduction of 2% was systematically applied to give a cold carcass weight. Pigmentation of carcasses was measured by means of a photometer at the Rectus abdominis muscle, which is considered to be representative for the colour of the whole carcass (Quilichini, 1987). Pigmentation was expressed in a standard scale based on three components: L*,a*, and b*. L* was a gradient of luminosity ranging from 0 (black) to 100% (white). a* and b* were gradients of coloration ranging from 0 to 100%, from green to red (a*) and from blue to yellow (b*).

2.2.3. Feeding and ruminating behaviour

Each calf was individually studied by instantaneous sampling method (Martin and Bateson, 1986). The observations were carried out during 20 sequences of 1 min every 12 min throughout one 4-h session every month from 4 to 20 weeks of age. Each session took place in the morning and started 60 min after the distribution of pellets, as rumination is considered to begin 5–15 min after the end of food ingestion (Jarrige, 1988). The way the pellets were ingested (rapidity-quantity) was studied and rumination was assessed from the chewing movements performed when animals were at rest.

2.2.4. Statistical analysis

Statistical comparisons were performed between each feeding group (P1, P2, P3, and P4) and their corresponding controls (C1, C2, and C3) within each barn. Qualitative values (presence of hairballs, papillae length, health data except haemoglobinemia) were analysed using $\chi^2$-test. Behavioural data did not fit a normal distribution and were
analysed by the non-parametric Mann–Whitney test while other continuous variables were analysed by Anova.

3. Results

3.1. Reticulo-rumen characteristics

In calves supplied with solid feed, the weight of the reticulo-rumen increased by 35% in P1, 23% in P2, 46% in P3 and 42% in P4 with regard to the respective controls C1, C2, C3 ($p<0.05$). Hairballs were strongly reduced (No. of calves with hair-balls: 17, 17, 14 in C1, C2, and C3 vs. 2, 7, 5, and 1 in P1, P2, P3, and P4, respectively, $p<0.05$) and a darker pigmentation of ruminal mucosa was observed ($L^*_{\text{avg}}=51, 69, 64$ in C1, C2, C3 vs. 44, 48, 55, and 58 in P1, P2, P3, and P4, respectively, $p<0.05$). Small papillae were completely absent in calves fed only a milk replacer, whereas they were noticed in most calves supplied with dry feed.

3.2. Health and performance

Haemoglobinemia was significantly higher in P1 and P2 than in C1 and C2, respectively, 7.2 vs. 6.5 g/100 ml and 8.7 vs. 7.8 g/100 ml ($p<0.05$), whereas it did not differ between P3–P4 and C3. Only one calf died (in C1) in the course of the study, after an unsuccessful treatment for respiratory disease. Whereas digestive troubles were nearly non-existent in P1, P2 and to a lesser extent in P3, the following problems occurred in P4: bloat, occasional milk refusals (in 12 out of 17 calves) and diarrhoea (in 6 out of 17 calves). The prevalence of abomasal ulcerations was very variable, although unrelated to the composition of pellets: 20–38% in B1; 67–88% in B2 whereas ulcers were nearly non-existent in calves of B3.

Growth was significantly enhanced by pellets including cereals. In P1, P2 and P3 carcass weight increased, respectively, by 6.5, 7.5 and 5.6%. Conversely, when calves were given additional all-straw pellets, growth, dressing percent, and carcass weight tended to be lower. Pigmentation of carcasses was observed to be darker in P1 than in C1 (Table 2).

3.3. Feeding and ruminating behaviour

In P1, P2 and P3 solid feed was ingested quickly (within 30 mn) and completely, according to the feeding program (Table 2). With the all-straw diet (P4), calves were reluctant to ingest their total provision and by 7 weeks of age, their daily provision had to be reduced by 25–50 g daily.

On average for the whole study, the frequency of ruminating activities in calves fed milk only rose as they grew up from 1.4, 2.5 and 3.4% of total observations in C1, C2, C3, respectively, at 4 weeks of age, it reached 8.5, 10.3 and 6.9%, respectively, at 20 weeks of age.

In calves having additional dry feed, the influence of pellets was very different according to their composition. In P1 and P2, ruminating activities tended to be or were
less frequent than in C1, and C2 respectively, especially at 8 weeks in P1 (1.4% vs. 8.8%, p<0.05) and at 12 weeks in P2 (1.8% vs. 8.3%, p<0.05). Conversely, ruminating was found to be more common in P3 than in C3 (6.8% vs. 3.4% at 4 weeks, 10.3% vs. 2.8 at 8 weeks, and 14.1% vs. 8.7% at 12 weeks, respectively, p<0.05). Moreover, the frequency of ruminating traits was significantly higher in P4 compared with C3 at any age: from 10.6% vs. 3.4%, respectively, at 4 weeks to 17.8% vs. 6.9%, respectively, at 20 weeks (p<0.05).

4. Discussion

The influence of dry feed on the development of the reticulo-rumen was quite clear even with the low fibre diets P1 and P2. The fermentation activity of the rumen and its motility were attested by the darkening of the mucosa, induced by volatile fatty acids (VFA) resulting from the digestion of starch and of digestible fractions of the fibre (Morisse et al., 1992), the presence of many small size papillae (2–3 mm length), and the marked reduction of hairballs which, as already reported in a previous work (Morisse et al., 1999), was likely to result from a continuous elimination of ingested hair, induced by ruminal motility. Similar development of the reticulo-rumen and reduction of hairballs have been previously described by Toullec (1988).

As expected, additional iron provided by the pellets induced a higher haemoglobin concentration in calves in P1 and P2. The fermentation activity of the rumen and its motility were attested by the darkening of the mucosa, induced by volatile fatty acids (VFA) resulting from the digestion of starch and of digestible fractions of the fibre (Morisse et al., 1992), the presence of many small size papillae (2–3 mm length), and the marked reduction of hairballs which, as already reported in a previous work (Morisse et al., 1999), was likely to result from a continuous elimination of ingested hair, induced by ruminal motility. Similar development of the reticulo-rumen and reduction of hairballs have been previously described by Toullec (1988).

As expected, additional iron provided by the pellets induced a higher haemoglobin concentration in calves in P1 and P2 when compared with C1 and C2. Except in C1, the mean haemoglobin concentration of calves fulfilled the European standard of 4.5 mmol/l. Since haemoglobin concentration was not lower in P4 than in P3, the poor sanitary and growth results observed in P4 compared with P3 was likely to be unrelated to anaemia.

On the whole, health was excellent throughout the fattening period in P1, P2 and P3, but not in P4. Such a situation is consistent with results of van de Braak and Mol (1991) who observed bloat in veal calves daily supplemented with 300 g of all-straw pellets. As already pointed out by Welchman and Baust (1987) who reported a very high frequency of ulcerations in veal calves fed either an all-liquid diet or having access to straw, the
aetiology of these ulcerations remains largely unclear. It must be stressed that in spite of the very high frequency of abomasal lesions commonly observed in veal calves, their health conditions and their growth remain generally not altered.

Improvement of growth rate was obvious in P1, P2 and P3 but it is uneasy to determine the respective parts in this improvement taken by the extra energy and protein intake. In the same way, relations between the improvement of growth in P1–P2 and the extra iron intake through solid feed cannot be excluded. However, this last hypothesis is worthless for P3 and P4 where increased (P3) and reduced (P4) growth rate were observed independently of the haemoglobin concentration. In the whole, it appeared that the more starch (i.e. cereals) was included in pellets, the faster was the growth, in such a way that if only performance was concerned, it could be suggested to use an all-cereal additional feed with, however, an increased risk of enterotoxemia (Larvor, 1977).

In P4, the relative reluctance to ingest the all-straw diet is explained by its low nutritive value. Nevertheless, the reduction of daily intake never exceeded 17% of the scheduled amount, during the last weeks of the fattening period.

From the results, it is clear that an additional solid feed induced a consistent increase in the frequency of rumination only when the level of fibre reached 50% NDF.

5. Conclusion and implications

If manufactured solid feeds are chosen as additional dry feed for veal calves, their formulation has to be done in such a way that it fulfils the different requirements of animals. For the development of rumen, formation of papillae and fermentary activities, as well as for growth, a high starch content is required but excess starch can be harmful and insufficient fibre content reduces rumination behaviour. To improve rumination, high fibre pellets are needed but intake of all-straw pellets is low and the lack of fermentable materials can lead to digestive troubles (bloat and diarrhoea). Finally, when compared to the respective controls (C1, C2 and C3) in each of the three barns (B1, B2, and B3), results obtained with the following feeding composition: starch 25%, and NDF 50% of dry matter (P3) are likely to represent the best compromise between rumen characteristics, health, performance, and ruminating behaviour.

Acknowledgements

The authors are grateful to E. Boilletot for his technical assistance and to professionals who took part in the experiment. They are grateful to the French Ministry of Agriculture (Animal Protection Department) for his financial support.

References


