INFLUENCE OF DRY FEED SUPPLEMENTS ON DIFFERENT PARAMETERS OF WELFARE IN VEAL CALVES

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Abstract

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The aim of the study was to compare different behavioural, physiological and performance traits in three groups of veal calves fed either a routine all-liquid diet with milk replacer (G0) or the same diet supplemented with a total of 10kg (G10) or 25kg (G25) of pelleted straw and cereals. Each of the three feeding programmes involved 21 male Friesian calves kept in individual crates for 20 weeks (from 1 to 21 weeks of age). Oral activities, haematological variables, ruminal characteristics, health and performance were all investigated. In calves supplied with dry feed, there was no evidence of ruminating behaviour; and chewing, regarded as a non-nutritive oral activity, was clearly reduced. The incidence of tongue playing and manipulating objects was not influenced by additional pellets.

Haemoglobin concentrations were higher in G25 than in other groups as a result of the extra iron supplied in the pellets. Other blood variables were unchanged. In G10 and G25 changes in rumen characteristics were clearly demonstrated by the following observations: i) the weight of reticulo-rumens increased by 11 and 35 per cent, respectively; ii) small papillae (virtually non-existent in calves fed an all-liquid diet) were present, and there was a darkening of the mucosa; and iii) there was a marked reduction in the number of hairballs, resulting from a continuous elimination of ingested hair by ruminal motility. In G25, carcase weight was significantly ($P < 0.05$) increased by 6.5 per cent compared with controls and no detrimental effects such as bloating or abomasal ulceration were observed when dry feed was added. Supplying calves with straw-cereal pellets was considered positive for the physiological aspects of welfare in veal calves. However, other diet compositions capable of inducing rumination behaviour should also be investigated.

Keywords: *animal welfare, solid feed, veal calves*

Introduction

Feeding veal calves exclusively on milk replacer allows a strict control of iron intake and the production of pale meat. With all-liquid diets, however, calves cannot perform the normal behaviours of rumination and chewing (Wiepkema 1987; Broom 1991). As a result, they develop non-nutritive oral activities characterized by sucking, licking or biting inanimate objects, and by tongue playing (van Putten 1982; de Wilt 1985; Sambraus 1985). Other abnormalities related to exclusive liquid feeding and to the lack of fibre in the diet include frequent ruminal drinking[1] (van Weeren-Keverling Buisman *et al* 1991), leading to severe economic losses, and the non development of papillae in the rumen, impairing normal fermentation (van de Braak & Mol 1991). On the other hand, an increased frequency of abomasal lesions has been reported in veal calves with access to roughage (van Putten 1982). It seems that straw alone is an unsuitable solid feed for young veal calves and that an excess of starch can induce harmful fermentation (Toullec 1991).

In their report on the welfare of calves, submitted to the European Commission in November 1995, the Animal Welfare Section of the Scientific Veterinary Committee (SVC) suggested that '...every calf should be fed fermentable material, *appropriate* in quality and *sufficient* in quantity, to maintain the microbial flora of the gut and *sufficient* fibre to stimulate the development of villi in the rumen'. Numerous ambiguities and uncertainties surrounding feed requirements[2], led the SVC (in Chapter 8 of their report) to suggest a need for additional research in this area to improve the level of knowledge about solid feeding. The aim of the present study was to investigate the impact of dry feed in the form of pellets and to evaluate the effects of two levels of supplement intake on oral activities, ruminal characteristics, health and performance.

Materials and methods

Experimental design

The present study was performed under routine conditions (in a production unit) when Directive 91/629/CEE was still in force (ie when individual crates were not prohibited). All the authors held an individual ethical approval delivered by the French Ministry of Agriculture and Fisheries which permitted them to use live animals according to ethical principles of experimentation. Sixty-three male Friesian calves were assigned to three groups (n = 21 animals each). Calves were housed in individual crates from 1 to 21 weeks of age. These crates (1.7m long and 0.81m wide) had slatted floors and were separated by open sides allowing visual contact. Following a 3-day period of adjustment, calves were allocated to groups on the basis of mean (± SEM) body weight (55.3 ± 2.2 kg in G0, 55.4 ± 3.1 kg in G10, and 55.7 ± 2.3 kg in G25) and haematocrit value (34.6 ± 6.7 % in G0, 34.7 ± 6.6 % in G10, and 34.7 ± 7.5 % in G25). There were no statistically significant differences between the groups for either parameter.

Calves were tethered for the first 5 weeks and they were bucket-fed, twice daily, with a milk replacer (Univor®, Coopagri, Landerneau, France) containing an iron concentration of 40–50 mg kg^{-1} during the first 6 weeks of rearing and 10 mg kg^{-1} thereafter. One group (G0) was only fed an all-liquid milk replacer; but in addition to this liquid feed, the second and third groups were given solid feed in the form of pellets, a total of 10kg $calf^{-1}$ (G10) and 25kg $calf^{-1}$ (G25), respectively, over the 20 weeks of the study. Details of the feeding regimes are given in Table 1. The pellets were made of agglomerated, ground straw and cereals (with a particle size not exceeding 1–2 mm). The chemical composition of the pellets with respect to the percentage of dry matter was as follows: de Weende crude fibre, 11.6 per cent; van Soest Neutral Digestible Fibre (NDF), 26.2 per cent; crude protein, 9.7 per cent;

[1] Backflow of milk from the abomasum to rumen, with associated impairment of digestion and growth rate.

[2] In EC Directive 97/2/EC, the characteristics of recommended dry feed requirements are also imprecise: '...calves should be fed *fibrous* material...'

starch, 48.0 per cent; and iron 182 mg kg^{-1}. Solid feed was given daily in individual troughs, 30min after the first of the two milk replacer feedings.

Table 1 **Amount of dry feed supplied to calves in groups G10 and G25 according to age.**

Age (weeks)	G10 (g day^{-1} $calf^{-1}$)	G25 (g day^{-1} $calf^{-1}$)
0–2	0	0
3–5	50	50
6–7	50	100
8–10	50	200
11–12	100	200
13–16	100	250
17–20	100	300

Behavioural traits

Each calf's behaviour was individually recorded, using an instantaneous sampling method (Martin and Bateson 1986). Observations were carried out every 15min during a 4h session (17 scans) every 2 weeks, when the calves were between 4 and 20 weeks of age (9 sessions). This gave a total of 153 scans for each calf. Each session started 30min after the distribution of pellets (or 60min after distribution of milk in G0) as rumination is generally deemed to begin 5–15 min after the end of food ingestion (Jarrige 1988).

Total activity (ie all activities, excluding resting/idling) was recorded, as well as the following specific behaviours: grooming (self licking); activities related to feeding (chewing or rumination); and non-nutritive oral activities. The latter activities included: (i) manipulating objects (sucking, licking, biting and any oral contact with inanimate objects); and (ii) tongue playing (rolling the tongue and repeated movements of the tongue outside the mouth).

Haematology

Individual, 10ml blood samples were collected from each calf at 1 week and 20 weeks of age (6 days before slaughtering), by jugular venepuncture into heparinized tubes.

Packed cell volume (PCV) was determined in 1-week-old calves to allow for distribution of calves of comparable condition within the three groups. PCV, red blood cell concentrations (RBC), and white blood cell concentrations (WBC) were determined in 20-week-old calves with an electronic cell counter (MS9.Vet, Melet-Schloesing Laboratories, Cergy-Pontoise, France). Plasma iron and haemoglobin concentrations were measured by spectrophotometry.

Health and stomach lesions

Mortality and morbidity were recorded. At slaughter, each reticulo-rumen was individually weighed after its contents had been eliminated. The presence of hairballs (≥ 4cm in diameter) was recorded. A fragment of ruminal wall (10 x10 cm) was removed from each rumen. Pigmentation and papillar development were sampled at a site on its edge, delimited by the groove and reticulum. The pigmentation of mucosa samples was measured with a photometer

(CR Minolta 300, Minolta France SA, Carrierès-sur-Seine, France) as described by Morisse *et al* (1992). Papillar development was evaluated from their length and density by assigning scores in the following categories. For length: 0 = absence of papillae, 1 = short (< 1mm), 2 = medium (1mm to < 2mm) , 3 = long (2–3mm); for density: 0 = absence, 1 = low (10–12 papillae cm^{-2}), 2 = medium (13–25 papillae cm^{-2}), 3 = high (confluent papillae). Any abomasal lesions exceeding 0.5cm in diameter were recorded. Every lesion was categorized by its size and by the degree of mucosal penetration as either an erosion or an ulcer.

Performance

Average daily weight gain was determined from differences between final and initial body weights. Carcases were electronically weighed on the processing-line and their pigmentation was measured by means of a photometer (CR Minolta 300) at the *rectus abdominis* muscle. This muscle is commonly used to determine colour, as it is external and thus easily reached; it is known to be representative of the colour of the whole carcase (Quilichini 1987; Becherel 1992).

Pigmentation was expressed on a standard scale based on three components: L, a and b. L is a gradient of luminosity ranging from 0 (black) to 100 per cent (white); a and b are gradients of coloration ranging from 0 to 100 per cent, from green to red (a), and from blue to yellow (b), respectively.

Statistical analysis

For each observation session (n = 17 scans), all behavioural records were pooled by calf and then analysed. Data that fitted a Gaussian distribution were analysed by ANOVA, while those that did not fit a normal distribution (behavioural variables, final PCV and plasma iron concentrations) were analysed by non-parametric Mann-Whitney U tests. Qualitative values were analysed using chi-square tests.

Results

Behaviour

There was no significant difference between groups in the time (mean ± SEM per cent of observations) calves spent standing (17.7 ± 5.2, 17.7 ± 3.8, and 20.5 ± 7.1 for G0, G10 and G25 respectively). Some activities were essentially restricted to a lying position (chewing), while others were predominant when calves were standing (tongue playing, manipulating objects). Neither the mean level of total activities (25%) nor of grooming (3%) were significantly influenced by treatment. At 6, 8, and 10 weeks, there was strong evidence for a decrease in chewing activities when calves in groups G10 and G25 were supplied with pellets ($P < 0.01$, Figure 1). This activity, however, did not seem to be related to rumination behaviour: no cycles of chewing starting with regurgitation and ending with swallowing were observed. The frequencies of manipulating objects and tongue playing did not appear to be consistently influenced by additional pellets (see Figures 2 and 3).

Haematology

Haemoglobin concentrations were higher in calves in G25 than those in G0 ($P < 0.05$, Table 2). Except for WBC, which was lower in G25 compared with other groups ($P < 0.05$), all other blood parameters were unaffected by intake of pellets.

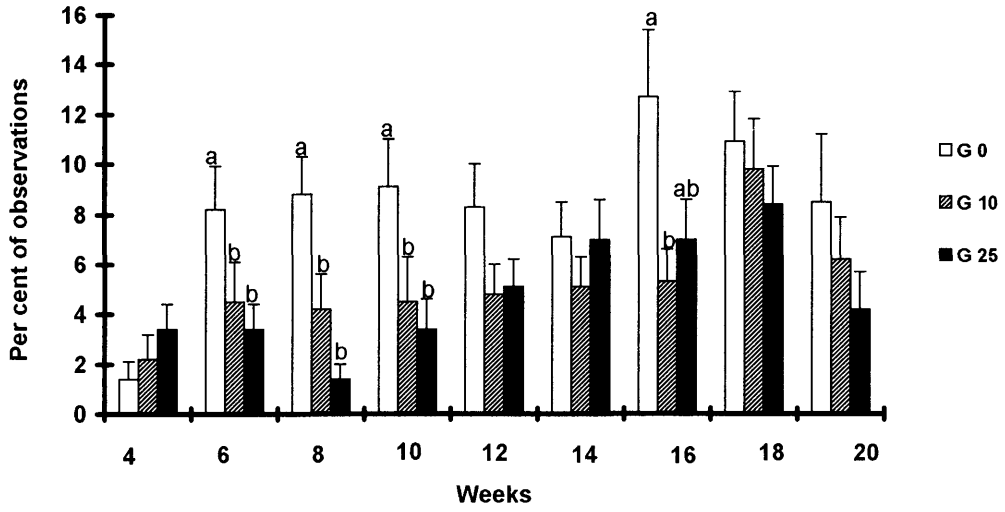

Figure 1 Frequency of chewing behaviour as the percentage of total behavioural observations in a lying position. (Significant differences within age-groups are indicated by a,b for $P < 0.01$.)

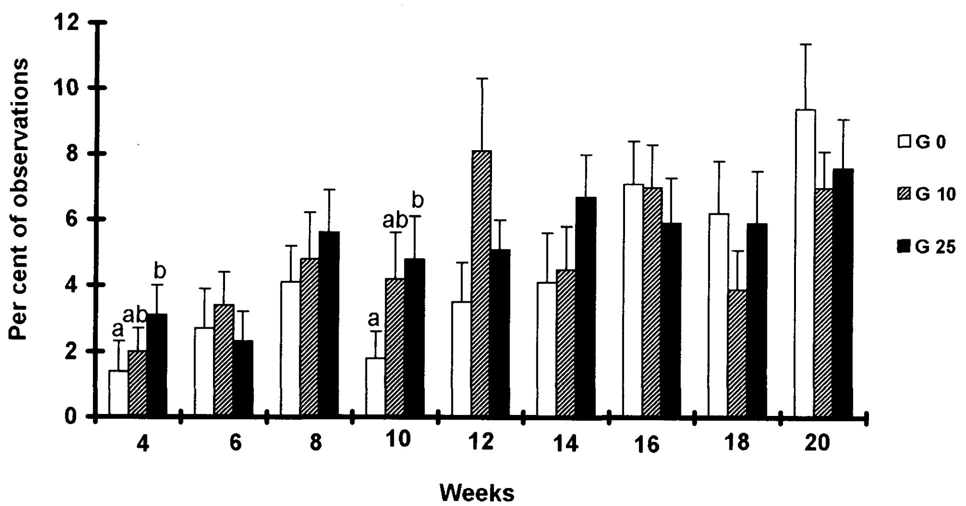

Figure 2 Frequency of manipulating objects (licking stalls) as the percentage of total behavioural observations in a standing position. (Significant differences within age-groups are indicated by a,b for $P < 0.05$.)

Table 2 Haematological values (mean ± SEM) in 20-week-old calves fed an all-liquid diet (G0), or supplemented with 10kg (G10) or 25kg (G25) of dry feed.

Haematological parameter	G0 n = 20	G10 n = 21	G25 n = 20
Haemoglobin (g 100ml^{-1})	6.5 ± 0.8^{a}	6.8 ± 0.6^{ab}	7.3 ± 1.1^{b}
PCV (l l^{-1})	0.22 ± 0.03	0.23 ± 0.03	0.24 ± 0.04
RBC (10^{6} mm^{-3})	10.8 ± 1.1	10.1 ± 1.4	10.4 ± 1.1
WBC (10^{3} mm^{-3})	8.9 ± 1.4^{a}	9.9 ± 2.2^{a}	7.4 ± 1.4^{b}
Iron (mg l^{-1})	0.40 ± 0.19	0.47 ± 0.36	0.39 ± 0.09

Means within a row lacking a common superscript are significantly different ($P < 0.05$).

Forestomach characteristics

As the intake of pellets increased, there was strong evidence ($P < 0.001$) for an increase in reticulo-rumen weights and for a reduction in hairball presence ($P < 0.001$, Table 3). In addition, the ruminal mucosa became darker (ie L values decreased) as pellet supplies increased ($P < 0.001$). The papillae (which were essentially observed only in groups G10 and G25) were significantly longer in G25 than in G10 (Table 3).

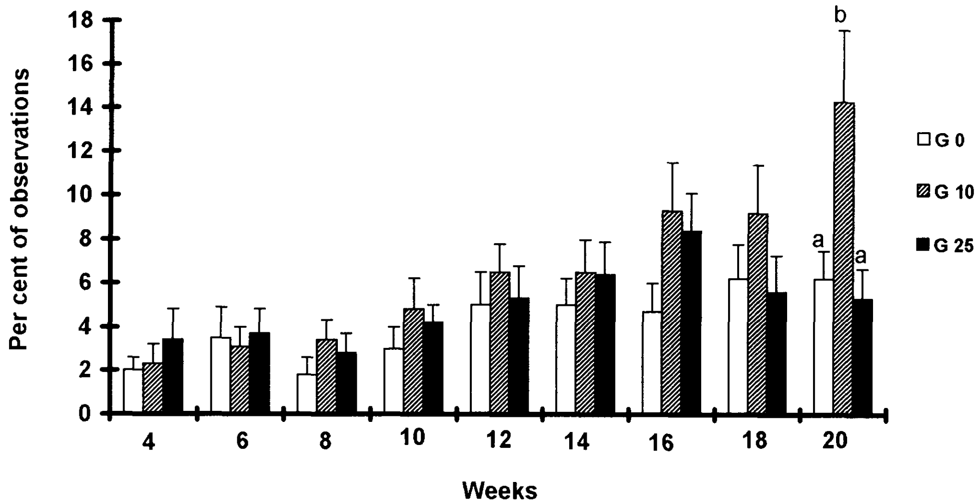

Figure 3 Frequency of tongue playing as the percentage of total behavioural observations in a standing position. (Significant differences within age-groups are indicated by a,b for $P < 0.05$.)

Table 3 Forestomach characteristics in 20-week-old calves fed an all-liquid diet (G0), or supplemented with 10kg (G10) or 25kg (G25) of dry feed. (Mean ± SEM, unless otherwise stated.)

Characteristic	G0 n = 20	G10 n = 21	G25 n = 20
Weight of reticulo-rumen (g)	2313 ± 237[a]	2579 ± 369[a]	3120 ± 480[b]
Hairballs			
Number of calves with hairballs	17[a]	4[b]	2[b]
Number of hairballs ≥ 4 cm	5.1 ± 5.3[a]	3.0 ± 2.4[ab]	1.5 ± 0.5[b]
Mean weight (g)	1109 ± 502[a]	470 ± 243[b]	605 ± 92[b]
Pigmentation of ruminal mucosa[1]			
L	51.4 ± 7.6[a]	47.4 ± 9.6[ab]	44.1 ± 7.4[b]
a	3.2 ± 1.4[a]	3.4 ± 1.5[a]	4.8 ± 1.4[b]
b	12.6 ± 2.3[a]	12.4 ± 2.4[a]	13.9 ± 3.4[a]
Papillar length[2]			
Number of scores in classes 2 + 3	0[a]	6[b]	14[c]
Number of scores in class 3	0[a]	0[a]	6[b]
Papillar density[2]			
Number of scores in classes 2 + 3	4[a]	18[b]	19[b]
Number of scores in class 3	3[a]	7[b]	8[b]

[1] See text for full description of pigmentation scales.
[2] Class scores ranged from 0 (absence) to 3 (long or high), see text for full details.
Means within a row lacking a common superscript are significantly different ($P < 0.001$ for all cases except for L, where $P < 0.05$).

Performance

An increase in carcase weight and daily weight gain was observed in G25 compared with G0 ($P < 0.01$). The pigmentation of carcases was slightly darker in G25 than in G0 and G10 (Table 4).

Table 4 Performance and carcase pigmentation in 20-week-old calves fed an all-liquid diet (G0), or supplemented with 10kg (G10), or 25 kg (G25) of dry feed (mean ± SEM).

	G0 n = 20	G10 n = 20	G25 n = 20
Daily weight gain (g day^{-1})	1066 ± 78[a]	1104 ± 94[a]	1166 ± 53[b]
Carcase weight (kg)	121.9 ± 6.9[a]	124.8 ± 11.2[ab]	129.8 ± 5.8[b]
Pigmentation[1]*:*			
L	50.8 ± 2.4[ab]	52.2 ± 2.5[a]	49.5 ± 2.0[b]
a	9.5 ± 1.7	10.6 ± 2.1	9.5 ± 2.0
b	4.5 ± 1.5	4.9 ± 1.9	4.4 ± .9

[1] See text, for full description of the pigmentation scales.
Means within a row lacking a common superscript are significantly different ($P < 0.01$).

Health

Mortality and morbidity were very low and independent of treatments: one G0 calf died during the first week after unsuccessful treatment for respiratory disease, and one G25 carcase was eliminated after slaughter for signs of pneumonia. The frequency of slight abomasal erosions, was not significantly different between groups, occurring in 20 per cent of G0, 30 per cent of G10 and 40 per cent of G25 calves, respectively.

Discussion

Even when the calves were in a lying position, true rumination was not observed, and only chewing activities were evidenced. As this latter behaviour decreased when calves were given additional pellets, chewing cannot be considered as pseudo-rumination; it is more likely that it represents a non-nutritive oral activity restrained, to some extent, by dry feed. Frequencies of chewing (Figure 1) and tongue playing (Figure 3) increased in G25 from 8 weeks until 18 and 16 weeks respectively, and declined thereafter. The reason for these latter reductions is unclear but might correspond to the end of the progressive increases in dry feed supplies (Table 1). The frequency of tongue playing was not influenced in a statistically significant manner by the addition of pellets. These results can be related to those of Kooijman *et al* (1991) who, comparing straw pellets and hay, demonstrated that only roughage given on an *ad libitum* basis reduced the occurrence of abnormal oral behaviour.

Manipulating objects (ie licking stalls) increased with age. Up to 14 weeks of age, its frequency increased (or tended to increase) when calves received pellets (Figure 2) but levels remained low (6%–8% of total activities) when compared with the results of other authors: 20 per cent of total activities in individual crates (Morisse *et al* 1996), and 40 per cent of total activities in collective pens (Kooijman *et al* 1991). In concordance with the observations of Veissier *et al* (1996), licking objects could be considered as redirected normal feeding activities, such as food nibbling or sucking.

Additional iron from the pellets (180mg kg^{-1}) explains the linear progression in haemoglobin concentrations in G10 and G25 (Table 2) and the darker pigmentation of G25 carcases (Table 4). Nevertheless, haemoglobin levels and subsequent pigmentation of carcases remained within the standards aimed for by French producers. Of the three treatments, only G25 was in conformity with the new standard for haemoglobin concentrations of 4.5 mmol l^{-1} (equivalent to 7.25g $100ml^{-1}$) recently proposed by Council Directive 97/2/EC (1997) laying down minimum standards for the protection of veal calves.

The basis for the slight reduction in WBC observed in G25 is unclear and cannot be related to the health of the animals, which remained excellent throughout the fattening period as far as their clinical aspect, appetite and performance were concerned.

A clear progression in ruminal development was observed when dry feed was provided (Table 3). No true rumination was observed but several characteristics of the rumens attested to the presence and development of different ruminal functions under these conditions:

i) a darkening of the mucosa. This observation suggests the production of volatile fatty acids, as reported by Morisse *et al* (1992);

ii) an increase of the presence of papillae. In calves fed an all-liquid diet, the ruminal mucosa was completely bare and smooth, while it became rougher when dry feed was added, as a consequence of the presence of many small papillae (2–3 mm in length);

iii) a marked reduction in the number of hairballs. Hairballs were observed in 85 per cent (17/20) of the G0 calves. This accords with the results of previous studies showing the presence of hairballs in 80–90 per cent of calves fed an all-liquid milk replacer (Morisse *et al* 1996). The drastic reduction in the number of hairballs observed with dry feed in this study cannot be explained by a reduction of grooming activity, as levels were similar in all treatments. Therefore, we suggest that a continuous elimination of ingested hair may have been induced by improved ruminal motility. A similar development of the reticulo-rumen and a reduction in the number of hairballs was previously described by Toullec (1991).

Supplying a total of 10kg of dry feed per calf was not sufficient to increase daily weight gain and final carcase weight over the 20-week period, whereas supplying 25kg improved daily gain by 9 per cent and carcase weight by 6.5 per cent.

Health was excellent throughout the fattening period. No sign of bloating was observed, in contrast with results of van de Braak and Mol (1991). This difference probably arose because these authors supplemented calves with 300g of all-straw pellets from 6 weeks of age, while in the present study, dry feed (straw-cereal pellets) was only added very progressively (Table 1). Only slight abomasal erosions were observed. Our results are not consistent with the findings of Welchman and Baust (1987) who reported ulcers in calves fed an all-liquid diet and with or without free access to straw from racks, with frequencies of 97 per cent and 66 per cent respectively. Their conclusion was that the consumption of straw was associated with an increased incidence of ulcerations. The differences between these studies could be explained as follows:

i) feeding young calves with straw in shoots without free access to water was a possible cause of stomach irritation and disturbance;

ii) in our study, the pelleted dry feed was mainly made of cereals with only small amounts of straw (see earlier for details of pellet chemical composition);

iii) the formulation of milk replacers has progressed since 1987.

Conclusions and animal welfare implications

Supplying veal calves with a total of 10kg or 25kg of straw-cereal pellets did not induce real rumination behaviour; it reduced the frequency of chewing but had no effect on the frequencies of tongue playing or licking stalls. Significant development of the rumen, pigmentation of the ruminal mucosa, and an increase in carcase weight and haemoglobin concentration, were observed in calves receiving 25kg of dry feed.

In both groups supplied with dry feed, development of papillae on the ruminal mucosa was observed, while the presence of hairballs was clearly reduced. No significant abomasal lesions were observed in any group.

Supplying calves with straw-cereal pellets meets the SVC's criticisms concerning physiological impairments observed in veal calves fed a strict all-liquid diet. Nevertheless, further investigations would be necessary in order to determine the exact composition of pelleted dry feed necessary for inducing full rumination behaviour.

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