POSSIBLE EXPLOITATION OF BODY COMPOSITION-NUTRITION INTERRELATIONSHIPS FOR EARLY WEANING OF CALVES

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SUMMARY

The possibility is discussed of inducing high proportions of body fat during the milk feeding period to facilitate early weaning direct to pasture without the use of expensive meal supplements. The mobilization of body fat may satisfy the energy demands of good growth rates while solid food intake develops.

INTRODUCTION

Percival (1952-3) reported an experiment aimed at determining the dietary fat requirement of the milk-fed Jersey calf. Isocaloric quantities of liquid containing 1, 3, or 5% milkfat were offered for eight weeks at which time calves were weaned on to pasture only. Growth rates, although unaffected by treatment in the milk feeding period (Table 1), were positively related to previous fat intake in the 10-week post-weaning period. An hypothesis to explain the causes of this differential growth in the post-weaning period is that the milk diets affected body fat content such that calves on the 5% and 1% fat diets had the greatest and least amounts of fat in their bodies available for mobilization after weaning when solid food intake was inadequate, and that the magnitude of these reserves was reflected in growth rates. This hypothesis depends on: (1) that differences in diet as employed by Percival will affect body fat content in the proposed manner and (2) that young ruminants can mobilize fat in the period following weaning and so compensate for a low energy intake

TABLE 1: EXPERIMENTAL RESULTS FROM PERCIVAL (1952-3)

Diet	*5% Fat*	*3% Fat*	*1% Fat*
Published data			
Liveweight gain (g/day):			
0-8 wk	458	470	470
8-18 wk	400	322	291
Milkfat fed (kg)	10.4	6.4	2.7
Calculated data			
Energy intake (MJ/day)	13	13	13
Protein intake (g/day)	131	197	252

during this period. Evidence in support of these conditions will be discussed. Should it be possible to manipulate the body composition of the calf in this manner and subsequently utilize the fat as an energy source to maintain high growth rates in the post-weaning period, then it may be possible also to obtain high growth rates by calves early weaned to pasture without the use of expensive meal supplements.

BODY COMPOSITION — DIET INTERRELATIONSHIPS

Two recent experiments involving milk-fed Friesian calves provide data on the relationship between diet and body composition.

EXPERIMENT 1

Table 2 and Fig. 1 present, respectively, diet composition and body fat contents of calves from a study of protein requirements (Donnelly and Hutton, 1976a, b). Each of the diets was fed to groups of three Friesian calves at a high (H) level (21.6 ± 1.0 MJ/day) and at a low (L) level (17.4 ± 0.8 MJ/day). These intakes were sufficient for liveweight gains of 830 and 610 g/day, respectively. Body fat content decreased with increasing protein

TABLE 2: CHEMICAL COMPOSITIONS (g/100 g DM) OF THE SIX DIETS

Component	*1*	*2*	*3*	*4*	*5*	*6*
Protein	15.7	18.1	21.8	25.4	29.6	31.5
Fat	22.0	24.2	24.2	23.1	18.9	18.3
Protein: energy (energy basis)	0.18	0.21	0.26	0.29	0.35	0.36

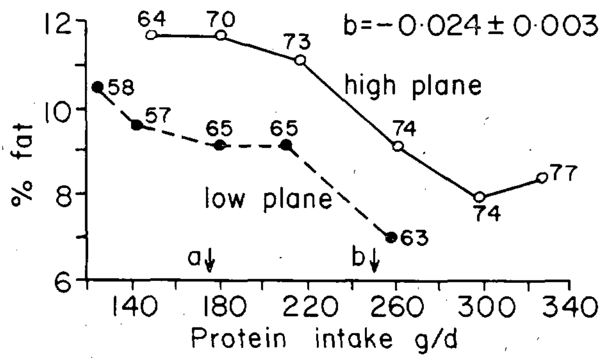

FIG. 1: *Relationships of body fat content to protein intake (o——o high plane; ●——● low plane; figures adjacent to points are group mean digesta-free body weights kg).*

TABLE 3: RESULTS FROM EXPERIMENT 2 (Donnelly, unpubl.)

Ration	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Chemical composition (g/100 g):												
Protein ($N \times 6.38$)	26.3	26.1	27.4	29.5	31.8	29.9	18.6	20.9	22.0	22.9	22.1	21.8
Fat	12.2	15.4	18.0	23.3	28.4	32.2	23.7	27.2	32.1	36.6	39.0	39.2
Lactose	55.9	52.6	48.7	40.9	33.9	31.3	53.7	47.7	41.5	35.9	34.3	34.1
Fat:carbohydrate ratio (energy basis)	1:1.98	1:1.48	1:1.2	1:0.77	1:0.52	1:0.42	1:1.0	1:0.77	1:0.56	1:0.42	1:0.38	1:0.38
Digesta-free body weight (DFBW) gain (g/d)			569 ± 53						598 ± 57 *[a]			
Fat content % of DFBW			5.9 ± 0.8						9.8 ± 1.2 ***[a]			
Fat content % of DFBW gain			9.7 ± 2.0						19.1 ± 2.1 ***[a]			

[a] The means for diets 1-6 and 7-12 differ significantly. *$P < 0.05$, ***$P < 0.001$.

intake and liveweight. The decreases in body fat continued beyond the minimum protein intakes supporting maximum liveweight gains (arrowed points a and b for H and L groups, respectively). The difference between feeding levels in body fat content (2.23 ± 0.30%) indicates the effect of energy — in this case associated also with a difference in body weight (9.1 ± 1.0 kg).

EXPERIMENT 2

This comparative slaughter experiment (Donnelly, unpubl.) was designed to investigate the effects of variations in the proportion of energy derived from fat and carbohydrate on growth and body composition. The essential details for diet composition and growth results are presented in Table 3. The protein:energy ratios for diets 1 to 6 were adequate (0.32) while those for diets 7 to 12 were inadequate (0.23) for maximum protein retention. Groups of four Friesian calves were offered each diet for 49 days. For the calves offered diets 1 to 6, mean daily energy and protein intakes were respectively 18.7 ± 0.2 MJ and 244 ± 11 g; for those fed diets 7 to 12, respective intakes were 21.8 ± 0.6 MJ and 196 ± 8 g. Compared with groups 1 to 6, the bodies and gains of groups 7 to 12 contained much higher proportions of fat. This resulted from the combined effects of a difference in level of feeding and an adequate versus an inadequate protein: energy ratio. The effects of fat:carbohydrate ratio on growth and body fat content were small ($P < 0.10$) and occurred in groups 1 to 6 only. The association was of increasing weight gain and decreasing fat content (of the body weight gain), as an increasing proportion of the calories was derived from carbohydrate.

These two experiments clearly indicate a marked effect of dietary protein:energy ratio on the body composition of the young calf but the effect of fat:carbohydrate ratio is small and then only when protein intake is not limiting growth.

In relation to Percival's experiment (Table 1) it was calculated that calves receiving the 5% fat diet were mildly protein-deficient for maximum growth; therefore energy otherwise available for this would have been retained as fat. The groups receiving the 3% and 1% fat diets consumed respectively about 50% and 100% more protein than required for maximum growth. This excess would have caused increased heat production (Donnelly and Hutton, 1976a; van Es *et al.*, 1969) and a decrease in the energy available for fat deposition. These effects of protein-energy imbalance would have resulted in the body fat content of the three groups being of the relative order 5% fat group > 3% fat group

> 1% fat group. Any effects of dietary fat intake *per se* on body fat content in Percival's study would have been small but additive to the trends resulting from protein-energy balance.

Mobilization of Fat

Since there are no relevant data from experiments with calves, results from early weaning studies with lambs will be presented to illustrate the manner in which young ruminants can mobilize fat to maintain the availability of energy and compensate for low food intake in the post-weaning period.

Working with lambs weaned at 3.5 weeks and slaughtered 3 weeks later, Mitchell (1970) reported that some lambs were in negative energy balance while they had gained empty body weight. Fennessy *et al.* (1972) suggested from an examination of non-esterified fatty acid levels in blood that early weaned lambs mobilized fat in response to a low energy intake in the post-weaning period. Subsequently, when slaughtered at a later date, such lambs were considerably leaner than unweaned control lambs (Fennessy, 1971; McConnell, 1972). The net effect was that, despite body weight gains being similar for weaned and unweaned controls (15 kg over 9 weeks), weaned lambs had energy retentions of only about 70% of that of unweaned controls. The relationships between net fat and protein retention

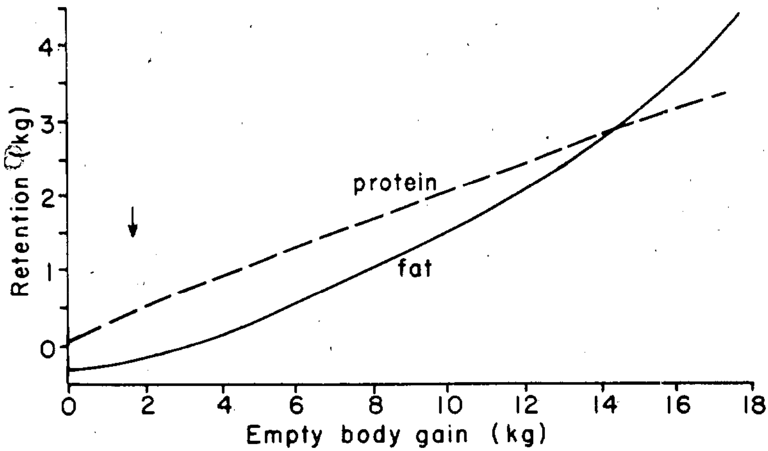

FIG. 2: *Relationships between net fat and protein retention and body weight gain in early weaned lambs slaughtered 2-10 weeks after weaning (from Fennessy, 1971; McConnell, 1972). (The arrow indicates the point of zero energy balance.)*

and body weight gain in lambs weaned at 26 days of age and slaughtered 2-10 weeks later are presented in Fig. 2. It is apparent that lambs were in negative energy balance until they had gained about 1.6 kg empty body weight (EBW) after weaning. Thus these lambs were able to grow at high rates (240 g EBW/day) with lower rates of both energy intake and energy retention compared with unweaned controls.

DISCUSSION

It is the basis of this hypothesis that Percival's recorded differences in post-weaning growth rate resulted from the effects of milk composition on body fat content and subsequent mobilization of this when pasture intake was inadequate. It is well established that early-weaned calves cannot eat as much dry matter in the form of grass as concentrate-meal (Byford, 1973). Such differences in intake are reflected in growth rates and it is suggested that, if milk replacer protein content and feeding level were manipulated to increase body fat deposition, then it might be possible to early wean calves to pasture only with reliance being placed upon mobilization of these "energy reserves" to support growth rates nearer those observed when early weaning to meal and pasture (680 g/day, Gleeson, 1971; 580 g/day, Byford, 1973; 700 g/day, Donnelly, 1977) than when early weaning to pasture only (370 g/day, Gleeson, 1971; 320 g/day, Byford, 1973; 463 g/day, Donnelly, 1977).

ACKNOWLEDGEMENTS

Staff of the Nutrition and Biometrics Sections, Ruakura Animal Research Station, and of the Animal Science Department, Lincoln College.

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