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Effects of energy concentration and feeding level on growth and efficiency of beef steers

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The growth and efficiency of feed utilization of Simmentaler steers were studied on three dietary energy concentrations and three feeding levels. Energy concentration was varied through concentrate:roughage ratios, 80:20, 50:50 and 20:80, respectively, while the feeding levels were calculated as 94 (high), 84 (medium) and 75% (low) of the *ad libitum* ME intake. Gains differed significantly to highly significantly between energy concentrations and between feeding levels. Efficiency of feed utilization in terms of kg DM/kg empty body gain, kg empty body gain/100 MJ ME and MJ empty body energy/100 MJ ME differed significantly to highly significantly between energy concentrations but not significantly between feeding levels. The energy content of empty body gain as well as the subcutaneous fraction of carcass gain differed significantly between the 80:20, 50:50 and 20:80 concentrate:roughage ratios, but not significantly between feeding levels.

Die groei en doeltreffendheid van voerverbruik van Simmentalerosse is bestudeer aan die hand van drie dieet-energiekonsentrasies en drie voedingspeile. Energiekonsentrasie is gevarieer deur kragvoer:ruvoerverhouding, naamlik 80:20, 50:50 en 20:80 te varieer, terwyl die drie voedingspeile bereken is as 94 (hoog), 84 (medium) en 75% (laag) van die *ad libitum* ME inname. Groeitempo het betekenisvol tot hoogs betekenisvol tussen energiekonsentrasies en tussen voedingspeile verskil. Doeltreffendheid van voerverbruik in terme van kg DM/kg leë massatoename, kg leë massatoename/100 MJ ME en MJ leë liggaamsenergie/100 MJ ME het betekenisvol tot hoogs betekenisvol tussen energiekonsentrasies verskil maar nie betekenisvol tussen voedingspeile nie. Die energiewaarde van leë massatoename asook die onderhuidse vetfraksie van karkastoename het betekenisvol tussen 80:20, 50:50 en 20:80 kragvoer : ruvoerverhoudings verskil, maar dit het nie betekenisvol tussen voedingspeile verskil nie.

Keywords: Dietary energy concentration, feeding level, efficiency of growth, composition of gain, beef steers

Introduction

Blaxter (1964) stated: '.... if animals of the same size are given the same diet *ad libitum* the animal which eats the most is the most efficient converter'. This suggests that in general, the higher the intake the higher the efficiency. Yet, more and more studies question this generalization. Andersen (1975) and Meissner, Hofmeyr & Roux (1977) showed similar efficiencies at lower levels of intake in the ruminant. Meissner & Roux (unpublished) showed the contrary, although the differences between *ad libitum* and 70% of *ad libitum* intake were practically negligible. Many other reports also showed the contrary, but some of these (eg. Newland, Byers & Reed, 1979; Byers, 1980) varied energy intake by manipulating dietary energy concentration thereby altering the fermentation substrate and possibly the site of digestion.

This study addresses the question in beef steers using three dietary energy concentrations, each fed at three feeding levels. These were standardized between dietary energy concentrations on the basis of approximately equal ME intake.

Materials and Methods

Sixty-three Simmentaler weaner steers of *ca.* 210 kg initial live mass were allocated at random to one of three dietary energy concentrations and one of three feeding levels according to a factorial design. The dietary energy concentrations were respectively 80:20, 50:50 and 20:80 of a concentrate:roughage mixture supplied in pelleted form. The three feeding levels, designated high, medium and low, were calculated in terms of proportions of the rate constant in the growth model proposed by Roux (1976) and had the further distinction that all high levels, all medium levels and all low levels constituted similar ME intakes. The dietary ingredients and composition are shown in Table 1. Intake and live mass were recorded weekly and body composition, in terms of chemically determined constituents and constituents of the consumable carcass, was determined at the slaughter masses of 245 (1), 350 (1), 410 (1), 490 (2) and 550 kg (2). The figures in brackets indicate the number of steers per slaughter mass. Digestibility of the diets was determined *in vivo* just prior to slaughter.

Table 1 Composition of diets[ab]

A Concentrate part (kg/1000 kg)	
Maize meal	849
Fish meal	40
Sunflower oilcake meal	40
Urea	13
Molasses	36
Limestone	9
Salt	12
Commercial mixture of minerals and vitamins	1
B. Roughage part (kg/1000 kg)	
Lucerne hay	477
Eragrostis curvula hay	477
Monosodium phosphate	10
Molasses	36

[a] Mixtures: A and B were mixed in proportions of respectively 80:20, 50:50 and 20:80 and pelleted.

[b] In addition to their daily allowances of pellets the steers also received a 10% allowance of wheat straw milled through a 25 mm screen.

Results and Discussion

The results were tested by means of a two-way analysis of variance and covariance procedure on the parameters of the equations applicable in the growth model. Table 2 shows the calculated figures of growth data in accordance with the suggestions of the statistical tests.

The digestibility of energy differed highly significantly ($P<0{,}01$) between dietary energy concentrations but not significantly between feeding levels. Two factors might be involved in explaining the non significant feeding level effects. Unpublished work from this laboratory shows that in the long term the rumen 'adapts' to lower than *ad libitum* levels of intake by shrinking which leads to similar retention times of digesta to those found at *ad libitum* intake and consequently to similar *in vivo* digestibilities. On the other hand, individual variation in digestibilty is quite substantial and might obscure feeding level effects.

Intake of ME (0,82 DE), as intended, differed highly significantly ($P<0{,}01$) between feeding levels but not between the dietary energy concentrations. Empty body gain differed significantly ($P<0{,}05$) to highly significantly ($P<0{,}01$) between feeding levels and between dietary energy concentrations, while the efficiency of utilization of ME for gain only differed significantly ($P<0{,}05$) to highly

Table 2 Growth and efficiency data between 220 and 550 kg live mass

	Concentrate:roughage ratio								
	80:20			50:50			20:80		
Variable measured	H	M	L	H	M	L	H	M	L
Time taken (days)	385^{a}	440^{c}	509^{e}	420^{b}	462^{d}	512^{e}	540^{f}	588^{g}	653^{h}
Digestible energy (MJ/kg)	$14,0^{a}$	$13,8^{a}$	$13,7^{a}$	$12,6^{b}$	$12,6^{b}$	$12,7^{b}$	$11,7^{c}$	$11,5^{c}$	$11,6^{c}$
ME intake (MJ/day)	65^{a}	57^{b}	50^{c}	64^{a}	58^{b}	52^{c}	65^{a}	59^{b}	52^{c}
*ME intake as % of calculated *ad libitum*	94	83	72	93	84	75	94	86	75
DM intake (kg/day)	5,7	5,0	4,5	6,2	5,6	5,0	6,8	6,3	$5,5^{a}$
Empty body gain (kg/day)	$0,78^{a}$	$0,69^{b}$	$0,60^{d}$	$0,70^{b}$	$0,65^{c}$	$0,59^{d}$	$0,53^{e}$	$0,49^{f}$	$0,45^{g}$
Gain in empty body energy (MJ/day)	10^{a}	$9,1^{b}$	$8,2^{c}$	$9,1^{b}$	$8,2^{c}$	$7,4^{d}$	$6,1^{e}$	$5,6^{f}$	$5,1^{g}$
Energy in empty body gain (MJ/kg)	$12,8^{a}$	$13,1^{a}$	$13,7^{a}$	$13,0^{a}$	$12,6^{a}$	$12,5^{a}$	$11,5^{b}$	$11,4^{b}$	$11,3^{b}$
Subcutaneous fat in carcass gain (g/kg)	68^{a}	67^{a}	68^{a}	66^{a}	66^{a}	64^{a}	29^{b}	28^{b}	28^{b}
kg DM/kg empty body gain	$7,3^{a}$	$7,2^{a}$	$7,5^{a}$	$8,9^{b}$	$8,6^{b}$	$8,5^{b}$	$12,8^{c}$	$12,9^{c}$	$12,2^{c}$
kg empty body gain/100 MJ ME	$1,20^{a}$	$1,21^{a}$	$1,20^{a}$	$1,09^{b}$	$1,12^{b}$	$1,13^{b}$	$0,82^{c}$	$0,83^{c}$	$0,87^{c}$
MJ empty body energy/100 MJ ME	$15,4^{a}$	$16,0^{a}$	$16,4^{a}$	$14,2^{b}$	$14,1^{b}$	$14,2^{b}$	$9,38^{c}$	$9,49^{c}$	$9,81^{c}$

*Calculated from a previous experiment

a–d Figures in the same line bearing the same superscript letter do not differ at the 5% level of probability.

significantly ($P<0,01$) between dietary energy concentrations.

The non-significant difference between feeding levels would be in accordance with the findings of Andersen (1975) and Meissner *et al.* (1977). It is generally accepted that differences in efficiency are a function of the end-products of fermentation in the rumen in addition to small contributions from the small intestine (Orskov, 1978). The present results suggest that within the limits of this experiment feeding level did not affect the proportions of end-products produced from the same substrate. One could have expected such an effect since different feeding levels can lead to different microbial growth rates associated with different retention times of ruminal digesta (Harrison & McAllan, 1980). A shift in proportions of volatile fattty acids associated with feeding level has indeed been reported in the literature (Eadie & Mann, 1970; Sutton, Broster, Schuller, Smith & Napper, 1977), although results from this laboratory could not substantiate this (Pienaar, unpublished).

On the other hand, a shift in end-products of fermentation from one substrate to another, could probably explain some of the differences in efficiency between the different dietary energy concentrations. However, from the available evidence, if the diet changes from a 50:50 concentrate: roughage ratio to an 80:20 ratio (Annison & Armstrong, 1970; Sutton, 1976; Sutton *et al.*, 1977) one would have expected a similar or greater production in the amount of absorbed nutrients which yield glucose or glucose precursers in comparison to those which cannot (Orskov, 1978), than when it changes from a 20:80 to a 50:50 ratio. In the present study the difference between the 20:80 concentrate:roughage ratio and the 50:50 ratio was 25% but only 7% between the 50:50 and the 80:20 ratios (Table 2). This indicates that reasons other than those associated with the end-products of fermentation are probably more important in explaining the efficiency differences encountered.

The composition of gain (only energy is shown) differed significantly ($P<0,05$) between dietary energy concentrations (80:20, 50:50 and 20:80) but not significantly between feeding levels. Although not significant, the energy in empty body gain was 4% higher for the 80:20 treatment when compared with the 50:50 treatment, while for the 20:80 treatment 14% more energy was retained. The deposition of subcutaneous fat on the carcass showed a similar pattern.

One feature in common with all studies where efficiency was not altered by feeding level within a particular dietary energy concentration, was that intake was studied between *ad libitum* and about 70% of *ad libitum*. It could be postulated that the relative stability of efficiency within these limits could be a function of an alteration in basal metabolic rate or a change in proportions of fat and protein deposited. In the study by Meissner *et al.* (1977) and that of Andersen (1975) this explanation applied, but in the present study the composition of gain was not altered. The composition of gain was, however, altered between dietary energy concentrations, although only between the 20:80 treatment and the other two. The fact that the 80:20 and 50:50 treatments did not differ significantly in composition of gain can be explained by their relatively small differences in efficiency of ME utilization.

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