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Energy and Nitrogen Metabolism in Lambs During Feed Restriction and Realimentation

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ABSTRACT

Eighteen crossbred Swifter (Flemish ♀ X Texel ♂) male lambs, born in March 1997 and weaned at the age of approximately 3 months, were used to quantify effects of feed quality restriction and realimentation on changes in energy and nitrogen metabolism. The ration consisted of grass straw (17 MJ of GE and 46 g CP per kg DM) on an *ad libitum* basis and 35 $g.kg^{-.75}d^{-1}$ mixed concentrates (16.5 MJ of GE and 173 g CP per kg DM). At the age of approximately 3.5 months, the animals were randomly divided into six blocks, based on live weight, according to a randomized complete block design. Within each block, the animals were randomly assigned to two restricted treatments (R1 and R2) and a control treatment. Treatments R1 and R2 were subjected to feed quality restriction by withholding concentrate for 3 and 4.5 months, respectively. A modified linear model was developed to study the effects of restriction and realimentation. The comparison between treatments was made by analyzing the data of R1 and R2 animals as deviations from the control animal in each block. During the restriction period, restricted animals lost weight and showed a negative EB and NB, whereas their intake from low-quality roughage significantly ($P < 0.001$) increased. After realimentation, the R1 and R2 animals grew significantly ($P < 0.001$) faster than the C animals. The realimented animals persisted in ingesting more ($P < 0.001$) low-quality roughage and their EB and NB were greater ($P < 0.001$) than those of C animals. The R2 animals needed a longer period of realimentation because of a longer period of restriction. The expression of compensatory growth was mainly related to a sustained higher ($P < 0.001$) grass straw (low-quality roughage) intake during realimentation periods, and greater ($P < 0.001$) efficiency of metabolizable energy intake. The maintenance requirement of realimented animals was lower ($P < 0.001$) only during the initial stages of realimentation compared with controls.

Keywords: Energy metabolism, Feed restriction, Metabolizability, Nitrogen metabolism, Realimentation.

INTRODUCTION

There is an abundance of seemingly conflicting research results (Butler-Hogg and Tulloh, 1982; Ryan *et al.,* 1993) in the field of compensatory growth. In most of the studies, experimental animals were assigned to feed quantity restriction in which animals were imposed to eat a limited amount of feed. On the other hand, published results on the effects of feed quality restriction in sheep are sparse. In feed quality restriction, animals always have access to low-quality feed. Compensatory growth may be associated with lower maintenance requirements during the recovery period, an increase in growth efficiency, an increase in feed intake and changes in body composition and the contents of the digestive tract. An increase in intake of realimented sheep has been reported in some studies (Graham and Searle, 1979). In contrast, Hogg (1977) found no differences in the feed intake of realimented

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animals and their controls. According to ARC (1980), the maintenance requirements for metabolizable energy (ME) in sheep amounts to 420 to 450 kJ.kg$^{-.75}$.d^{-1}, whereas sheep subjected to feed restriction require a ME intake of 340 kJ.kg$^{-.75}$.d^{-1} at zero energy balance (Graham and Searle, 1979). After realimentation, the reduced maintenance requirements temporarily resulted in a comparatively higher energy for gain. The efficiency of ME for maintenance and growth is related to the ME intake level and metabolizability (ME/gross energy [GE]) of the feed. The efficiency of energy deposition may change during compensatory growth. The efficiency of ME utilization increases with increasing metabolizability of energy. In many parts of the world, ruminant production systems mainly depend on the natural vegetation of the ranges and farmlands. Periods of drought are interspersed with periods of rainfall, making forage availability very unpredictable. Seasonal variations cause periodic live weight loss and gain in grazing animals. Ruminant production systems often face a prolonged dry season where available feed cannot meet their requirements. Kamalzadeh *et al.* (1997) showed that after realimentation, the sheep maintained at the same live weight in three months feed quality restriction, grew faster than controls and have reached the same live weight as controls with total lower ($P< 0.05$) feed consumption. Extending the duration of restriction may result in a higher growth rate after realimentation. The present study was designed as follows: (1) to evaluate the effects of a longer period of feed quality restriction on energy metabolism and nitrogen retention in immature sheep, and (2) to study the expression of compensatory growth in relation to changes in feed intake, maintenance energy requirements and feed efficiency.

MATERIALS AND METHODS

Animals and Housing

Eighteen crossbred Swifter (Flemish ♀ X Texel ♂) male lambs, born in March 1997 were randomly selected from a flock. Average birth weight was 4 kg and average live weight at weaning (approximately 3 months old) was 30 kg. The experiment started at an age of approximately 3.5 months and an average live weight of approximately 34 kg. Animals were allocated to six blocks, each containing three near identical lambs, based on initial live weight, according to a randomized complete block design. Within each block, the animals were then randomly assigned to three treatments: control (C); 3 months period of restriction (R1); and 4.5 months period of restriction (R2). The C group received low quality roughage on an *ad libitum* basis and a concentrate supplement. Only the R1 animals, for a period of three months (between age 3.5 to 6.5 months), and the R2 animals, for a period of 4.5 months (between age 3.5 to 8 months), were allowed to consume low quality roughage on an *ad libitum* basis including a mineral supplement (1 g.kg$^{-.75}$.d^{-1}), but no concentrate.

The low quality roughage consisted of grass (*Festuca arundinacea*) straw. The grass straw was chopped to reduce selection by animals. The grass straw contained 17 MJ of GE and 46 g analyzed crude protein (CP) per kg dry matter (DM). To ensure an *ad libitum* feeding regime, the animals fed to a level of 100 g of grass straw per kg metabolic weight per day (2 times maintenance). The concentrate contained 16.5 MJ of GE and 173 g analyzed CP per kg DM, was offered at 35 g.kg$^{-.75}$.d^{-1}. The composition of

Table 1. Dry matter (DM), organic matter (OM), crude protein (CP), ash and gross energy (GE) contents of straw and of concentrate.

	Straw	Concentrate
DM (g.kg^{-1})	875	869
OM (g.kg^{-1} DM)	923	924
CP (g.kg^{-1} DM)	46	173
Ash (g.kg^{-1} DM)	88	78
GE (MJ.kg^{-1} DM)	17	16.5

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the diets is presented in Table 1. The concentrate consisted of a ground and pelleted mixture of sugar beet pulp, potato protein, a mineral mixture of mervit 318 produced at ILOB(Instituut voor Landbouwkundig Onderzoek van Biochemische Production, Wageningen, The Netherlands), vitamins A and D and trace elements, $NaH_2PO_4.2H_2O$, $FeSO_4.7H_2O$, and $MgSO_4.7H_2O$ (Table 2). Grass straw was offered twice a day at 07.00 and 16.00. Concentrates were also offered twice a day at 07.30 and 16.30. Concentrates were eaten completely at all times by all animals. Grass straw residues were collected daily prior to the morning feeding. All lambs were treated with IVOMEC (MSD, Haarlem, The Netherlands) against internal parasites. Environmental temperature was kept constant at 20°C. Relative humidity was maintained at approximately 70%. The day length during the experiment was set at 12 h from 07.00 to 19.00.

Table 2. Composition of concentrate ($g.kg^{-1}$).

Sugar beet pulp	870
Potato protein	100
Mineral mixture (mervit 318, vitamin A, D and trace elements)	14.3
$NaH_2PO_4.2H_2O$	9.35
$Fe\ SO_4.7H_2O$	0.15
$Mg\ SO_4.7H_2O$	6.2
Total	1000

Measurements

The duration of the experiment was 10 months. During the experiment, seven successive balance trials were conducted. Each balance trial had duration of three weeks and between trials, for a period of 3 weeks, animals were placed in ground pens which were bedded with sawdust to allow them more space and to reduce the risk of hoof problems. During the trials, animals were individually housed in metabolism cages. Prior to the measurements, animals were allowed to adapt to the cages for a period of 11 days. Then, every lamb had a period of 10 collection days (three days in a metabolism cage, seven days in respiration chamber). During each balance trial, feed refusal, faeces and urine were collected daily, accumulated for each lamb and sampled.

In each balance trial, energy balance (EB) and nitrogen balance (NB) were assessed. All the lambs were weighed once every two weeks. The feed offered was adjusted once every two weeks on the basis of metabolic weight. Daily feed intake for each lamb was recorded. The collected samples of feed, refusals and faeces were analyzed for DM, ash, N, and energy content. Urine was analyzed for N and energy content. The DM content of the offered feeds, refusals and faeces was determined by drying representative sub-samples to constant weight at 103°C and organic matter (OM) was calculated as weight loss of the same sub-samples during ashing at 550°C for 3 h. The N content of the feeds, refusals, faeces and urine was determined according to Kjeldahl method (AOAC, 1975). Gross energy (GE) values were determined using an adiabatic bomb calorimeter. Digestible energy (DE) and ME intake and energy metabolizability (ME/GE) per lamb were determined from the energy contents of feed eaten, faeces, urine and methane production. The heat production (HP) of each lamb was determined daily from continuous measurements (every 3 min) of CO_2, CH_4 and O_2 exchange (Brouwer, 1965) in 24 h cycles. By subtracting the amounts of N in the feed residue, faeces, urine and ammonia in the air from N in the feed, NB was calculated. From data on ME and HP the EB per lamb was calculated (EB = ME – HP), (Brouwer, 1965). The quantity of protein and fat stored in the body can be estimated from the carbon and nitrogen balance. These were estimated in the experiment (by using a respiration chamber) in which the amounts of C and N entering and leaving the body were measured. By difference the amount of C and N retained in the body was calculated (Brouwer, 1965). From the EB and energy in protein (calculated as 23.7 x 6.25 x NB), the fat gain (g/day) was calculated as ((EB - energy in protein)/39.8) (Brouwer, 1965). The mean caloric value of

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retained fat and protein was assumed to be 39.8 kJ/g and 23.7 kJ/g, respectively (ARC, 1982). The value 6.25 was used for the conversion of N to protein.

Statistical Analysis

According to the experimental block design, comparisons were made within blocks by analyzing the observations of the restricted animals as deviations from the control animal in each block. In this way, the block effects were removed from the data, and only the effects of restriction and realimentation are left. Because restriction and realimentation are events in time, the analysis is concentrated on the effects in time. The following model is used:

$$y = a_0 + \Delta_{a0} + [(a_1 + \Delta_{a1}) - (a_0 + \Delta_{a0}) + (b_1 + \Delta_{b1})\, t_r]\, s \qquad [1]$$

In which:

y = deviation of an R1 or R2 observation at different ages for various measurements,

a_0= constant level during the restriction period,

Δ_{a0}= difference between groups R1 and R2 for a_0,

a_1 = constant level during the realimentation period,

Δ_{a1}= difference between groups R1 and R2 for a_1,

t_r = weeks after start of realimentation,

b_1= regression during the realimentation period,

Δ_{b1}= difference between groups R1 and R2 for b_1,

s = has a value of 0 during restriction, and 1 during realimentation.

The parameters in Equation 1 are tested in

Table 3. Means of live weight, feed and N intakes, N losses, N balance (NB), daily weight, protein and fat gain, intake of GE, DE and ME, energy losses, energy balance (EB), and metabolizability of energy (ME/GE) in control (C) animals at different stages of the experiment.

Agd (months)	3.5[a]	6.5[b]	8[c]	14[d]
Live weight (kg)	34.6	44.3	49.3	73
Feed intake ($g.kg^{-75}$/ d^{-1}				
Straw	31.5	30.5	30.3	28.6
Concentrate	35	35	35	35
Nitrogen	0.98	1.02	1.02	0.94
N-losses ($g.kg^{-75}.d^{-1}$)				
Facece	0.46	0.48	0.48	0.43
Urine	0.32	0.33	0.32	0.34
NB ($g.kg^{-75}. d^{-1}$)	0.20	0.21	0.22	0.17
Gain (g/day)				
Weight	81.4	87.8	94.9	115.4
Protein	17	23	25	26
Fat	12	14	15	16
Energy intake ($kJ.kg^{-75}.d^{-1}$)				
GE	1028	1056	1078	1043
DE	630	642	643	620
ME	540	545	553	533
Energy losses ($kJ.kg^{-75}. d^{-1}$)				
HP	476	483	502	483
Faeces	398	414	435	423
Urine	20	20	21	22
Methane	70	78	69	65
EB ($kJ.kg^{-75}. d^{-1}$)	64	62	51	50
Metabolizability	0.53	0.53	0.52	0.51

[a, b, c, d] Age at different stages of the experiment.

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Table 4. Estimates and standard errors of the parameters for model [1][1], for the observations of restricted animals as deviations from the control animal.

Measure (y)	a_0[c]	SE	a_1[c]	SE	b_1[c,e]	SE
Feed intake ($g.kg^{-.75}.d^{-1}$)						
Straw	15.4, 12.7[2]	1.7	6.3	0.98	-	-
Nitrogen	-0.66	0.02	0.05	0.01	-	-
N-losses ($g.kg^{-.75}.d^{-1}$)						
Faeces	-0.12	0.16	0.01[d], 0.03[2]	0.01	-	-
Urine	-0.11	0.01	-0.11	0.01	0.003	0.001
NB	-0.4	0.02	0.16	0.02	-0.003	0.001
Gain (g/day)						
Weight	-108.7	8.6	81.8	5.6	-	-
Protein	-37.2	1.8	8.2	1.1	-	-
Fat	-33.5	6.0	15.9	3.7	-	-
Energy intake ($kJ.kg^{-.75}.d^{-1}$)						
GE	-308.9, 350.2[2]	24.5	56.8	14.4	-	-
DE	-333.6	13.1	60.0	8.1	-	-
ME	-296.7, 324.2[2]	15.6	47.8	9.2	-	-
Energy losses ($kJ.kg^{-.75}.d^{-1}$)						
HP	-149.8	7.4	-33.8	8.7	1.8	0.49
Faeces	-46.1	11.8	-18.2[**]	7.3	-	-
Urine	-4.8	0.61	-2.2	0.37	-	-
Methane	-29.5	3.2	18.4	3.7	-0.6[**]	0.21
EB	-147.6	12.6	85.0	14.9	-1.5[*]	0.85
Metabolizability	-0.15	0.01	0.05	0.01	-	-

[1] For explanation of parameters and variables see Eq.[1] in text.
[2] Different estimates for R1 and R2.
[c] If the significant level is not indicated, estimate is highly significant different from 0 ($P < 0.001$).
[*] Estimate is significantly different from 0 ($P < 0.05$).
[**] Estimate is significantly different from 0 ($P < 0.01$).
[d] Estimate is not significantly different from 0 ($P > 0.05$).
[e] The unit is the unit of measure (y) per week.

a step-wise manner, using the NLREG program (Sherrod, 1992), by leaving out at each step non-significant ($P > 0.05$) parameters. The final model therefore contains only parameters, which differ significantly from zero.

RESULTS

Means of live weight (kg) and the values for C animals based on metabolic weight for feed consumption, N intake, N losses in faeces and urine and NB, the values based on g/day for daily weight, protein and fat gain, and the means based on $kJ.kg^{-.75}.d^{-1}$ for energy intake (GE, DE and ME), energy losses in faeces, urine, and methane, HP, EB and metabolizability (ME/GE) are all given in Table 3. These data are presented for different stages of the experiment. Equation 1 was fitted to the observations of the restricted animals as deviations from the control animal in each block. Estimates of the parameters for fitted curves are presented in Table 4. The relationship between NB and age during whole experiment is presented in Figure 1. The means for restricted animals in different stage of experiment can be calculated by adding the estimates in Table 4 to the data of C animals given in Table 3. For example, the estimated mean value for GE in R1 animals at the onset of realimentation (at the age of 6.5 months) is 1056 - 308.9 = 747.1, and at the end of experiment (at the age of 14 months) is 1043 + 56.8 = 1099.8,

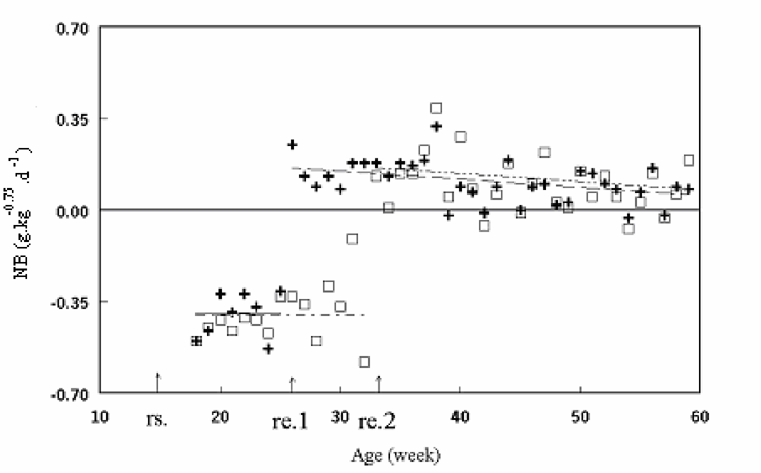

Figure 1. Differences for nitrogen balance (NB) of R1 and R2 animals with C animals from the start to the end of experiment. (+) R1, and (□) R2; Regression lines: (— —), (—·—·)during restriction. (——), (—··—··) during realimentation; rs = age at the start of restriction periods; re.1 and re.2 = ages at the start of realimentation periods for R1 and R2 animals, respectively.

the GE of C animals at the age of 6.5 months being 1056 and, at the age of 14 months, 1043.

Effect of Restriction

During the restriction period, restricted animals lost weight and showed a negative NB, whereas their low-quality roughage intake increased significantly ($P < 0.001$) compared to C animals (Table 4).The energy intake of restricted animals decreased ($P < 0.001$) and EB became negative. The restricted animals lost protein and fat tissues, whereas, the energy losses through faeces, urine, methane and heat decreased ($P < 0.001$) compared to C animals. The metabolizability of energy for restricted animals was lower ($P< 0.001$), and maintenance energy requirements for ME intake reduced to about 340 kJ.kg$^{-.75}$.d^{-1}, compared with C animals (Figure 2).

Increasing the duration of restriction from 3 to 4.5 months did not have significant effects on metabolizability, NB, EB and the level of energy losses through methane, urine and heat. However, the amount of straw and GE intake ($P < 0.1$) and ME intake ($P < 0.08$) of R2 animals tended to be lower, compared to R1 animals.

Effect of Realimentation

After realimentation, the R1 and R2 animals, with the grass straw supplemented by concentrates, grew significantly faster ($P < 0.001$) than the C animals (Table 4). The realimented animals persisted in ingesting more ($P < 0.001$) low-quality roughage and showed consistently greater values for energy (GE, DE and ME) intake, N intake, metabolizability of energy, daily weight gain, and protein and fat gain compared to C animals. From the onset of realimentation until the end of experiment, the NB and EB of realimented animals were greater ($P < 0.001$) than those of C animals, however, with decreasing slopes. In realimented animals, N and energy losses through faeces and urine were consistently lower ($P < 0.001$), whereas, energy loss through methane was consistently higher ($P < 0.001$) compared to C animals (Table 4). The realimented animals had a lower ($P < 0.001$) HP at the initial stages of realimentation. The HP of realimented animals increased at

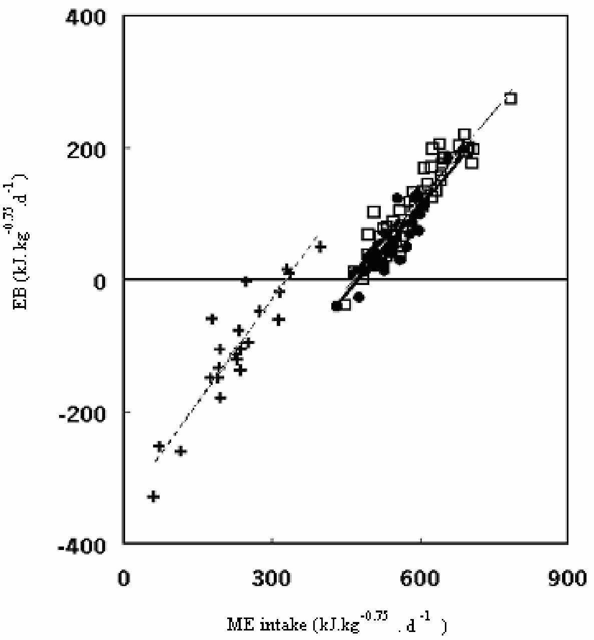

Figure 2. The relationship between energy balance (EB) and metabolizable energy (ME) intake; (+) restricted, (•) control (□) realimented. Regression lines; (·····) restricted, (—) control, (-----) realimented.

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the latter stages of the realimentation period (Table 4), and resulted in an increased maintenance energy requirement. The estimated parameter (Table 4) shows that increasing the duration of feed restriction did not have significant effects during compensatory gain. However, R2 animals had higher ($P < 0.05$) faecal N losses compared to R1 animals, in general, R2 animals showed the same pattern as R1 animals.

DISCUSSION

Part of the compensatory growth was caused by a sustained increase in fibrous feed intake. An increase in intake for realimented animals has been reported in other studies with sheep (Graham & Searle, 1979). In the study of Butler-Hogg and Tulloh (1982), in contrast, realimented sheep had significantly lower intake than the controls for the first 10 kg of live weight after a period of feed quantity restriction. Ryan *et al.* (1993) also reported a lower intake during the first three months of realimentation for both sheep and cattle. These latter findings are not supported by the present results; this is most likely because a different type of feed restriction was imposed. They restricted the animals by reducing the quantity of feed offered. The present experiment showed that the higher intake of low-quality roughage by realimented animals was related to the adaptation of these animals during restriction.

The C animals showed a value of about 480 kJ.kg$^{-.75}$.d^{-1} for maintenance requirement of ME intake. Graham and Searle (1979) reported a value of 470 kJ.kg$^{-.75}$.d^{-1} for sheep, whereas ARC (1980) proposed a range of 420-450 kJ.kg$^{-.75}$.d^{-1}. These findings are not completely in line with our results, most likely because of a different method of estimation. Their results are based on the data of fasting heat production, whereas the observations of the present study are in sheep which managed to keep at maintenance level and always had access to low-quality feed. However, they lost about 12% of their initial live weight at the end of the restriction period. During restriction, maintenance requirements of restricted animals decreased by about 29 % compared to C animals, to an amount of 340 $kJ.kg^{-.75}.d^{-1}$ ME intake (Figure 2). Graham and Searle (1979) also reported a value of about 340 $kJ.kg^{-.75}.d^{-1}$ ME intake for sheep when fed at zero energy retention. The increased HP of animals during the latter stages of the realimentation period points to an increased energy requirement for maintenance. However, they had higher ($P < 0.001$) ME intake at the same level of HP compared to C animals (Table 4). This indicates that more energy was available for growth.

Our results show that after realimentation, metabolizability increased, implying an increased efficiency of ME utilization. The metabolizability values obtained in this experiment for C and realimented animals corresponded well with the range (0.45 to 0.6) proposed by ARC (1980) and Oosting *et al.* (1993) when sheep were given *ad libitum* access to feed. Metabolizability of C animals reduced by ageing animals (Table 3), but in contrast to that, metabolizability of realimented animals at the same chronological age was higher ($P < 0.001$) than C animals (Table 4). This is probably because during restriction, the growth of animals was delayed and therefore, at the time of realimentation, these animals were in a younger physiological state than the C animals.

Losses of energy through faeces, methane and urinary excretion relative to metabolic weight, decreased in animals under restriction. This is probably caused by a low level of N intake and decreased urinary urea N excretion of these animals. Nitrogen retention in restricted sheep was negative, presumably due to less nitrogen in their feed, decreased energy intake and N losses (Table 4). The sustained decrease in energy and N losses especially through urine and faeces, during realimentation, indicates that efficiency of feed utilization in realimented animals was higher than in the controls. This was probably caused by physiological adaptation of R1 and R2 animals during restriction, which maintained during realimentation.

During restriction, the fat and protein gains of R1 and R2 animals were negative. These animals used body tissues to attain maintenance requirements and survival. The higher protein and fat gains of realimented animals was a reflection of depletion of these tissues during restriction. At the time this experiment was terminated, R1 animals fully compensated and reached to the same live weight as C animals (72.5, se=1.94 *vs.* 73.1, se=2.47; n=12). The R2 animals did not have higher intake and gain than R1 animals during realimentation. Because of a longer period of restriction, it seemed that they needed a longer period of realimentation to reach the same live weight as C and R1 animals. This finding does not confirm the data of Graham and Searle (1979), who reported a consistently higher growth rate when sheep were maintained at the same live weight for six months compared to the sheep that were maintained for four months.

The expression of compensatory growth can be partly explained by the increased ME intake. The present study shows that the increased ME intake is related to a distinctly higher low-quality roughage intake during restriction, which forms the foundation of a sustained increased low-quality roughage intake during realimentation. A small part of the compensatory growth is caused by lower energy maintenance requirements of realimented animals. The improved metabolizability of energy and sustained lower losses of N and energy indicate that realimented animals utilize their feed more efficiently than the controls, which can probably be contributed to an improved digestibility of the low-quality feed organic matter intake. Extending the period of restriction (more than 3 months) caused lower growth rate in immature sheep, which is not advisable.

IMPLICATIONS

Small ruminants' production systems in most parts of the world, particularly in developing countries, mainly depend on natural vegetation of the range and farmlands. Seasonal variations in feed quantity and quality cause periods of live weight loss and gain in grazing animals. The availability of supplements is low and they often have to be purchased at high prices. When integrating the effect of compensatory growth into feeding strategies, the efficiency of the available feeds is increased.

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متابوليسم انرژي و ازت در بره‌ها طي دوره محدوديت خوراكي و دوره تغذيه مجدد

ع. كمالزاده

چكيده

براي تعيين ميزان آثار محدوديت كيفي خوراك و تعليف مجدد بر تغييرات در متابوليسم انرژي و ازت, ۱۸ رأس بره نر از نژاد دو رگ سويفتر (تلاقي ماده‌هاي نژاد فلاميش و نرهاي نژاد تكسل) كه در ماه مارس ۱۹۹۷ متولد و در سن حدود سه ماهگي از شير گرفته شده بودند مورد استفاده قرار گرفتند. جيره دام‌ها از كاه علف كه داراي ۱۷ مگاژول انرژي خام و ۴۶ گرم پروتئين خام و يك تركيب كنسانتره كه داراي ۱۶/۵ مگاژول انرژي خام و ۱۷۳ گرم

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پروتئین خام در هر کیلوگرم ماده خشک بودند تشکیل شده بود. کاه علف به صورت آزاد و کنسانتره به مقدار ۳۵ گرم به ازاي هر کیلوگرم وزن متابولیکي در اختیار دام‌ها قرار گرفت. در سن حدود ۳/۵ ماهگي، دام‌ها به طور تصادفي و براساس وزن زنده در قالب طرح بلوک‌هاي کاملا" تصادفي به شش بلوك تقسیم شدند. در داخل هر بلوك دام‌ها بطور تصادفي به دو تیمار محدودیت خوراکي (R1 و R2) و یک تیمار کنترل اختصاص داده شدند. کنسانتره از جیره دو گروه R1 و R2 از آغاز دوره آزمایش به ترتیب به مدت ۳ و ۴/۵ ماه حذف گردید. یک مدل خطي تغییر داده شده براي مطالعه آثار محدودیت خوراکي و تعلیف مجدد طراحي شد. مقایسه بین تیمارها براساس اختلاف موجود بین اعداد و ارقام مربوط به دام‌ها در هر بلوك در گروههاي محدودیت خوراکي با گروه کنترل انجام گرفت. در طي دوره محدودیت، دامها در گروههاي R1 و R2 کاهش وزن نشان دادند و تعادل انرژي و ازت آنها بطور معني‌داري (P< ۰/۰۰۱) منفي شد، در حالي که مصرف کاه آنها بطور معني‌داري (P< ۰/۰۰۱) افزایش یافت. پس از تعلیف مجدد، دام‌ها در گروههاي R1 و R2 داراي رشد سریعتري (P< ۰/۰۰۱) نسبت به دام‌هاي گروه کنترل بودند. افزایش مصرف کاه آنها در دوره تعلیف مجدد ادامه داشت و تعادل انرژي و ازت در آنها بطور معني‌داري (P< ۰/۰۰۱) بیشتر بود. ظهور رشد جبراني در دام‌ها بطور عمده به علت مصرف مداوم بیشتر کاه (خوراك کم کیفیت) در دوره تعلیف مجدد و همچنین بازدهي بیشتر مصرف انرژي قابل سوخت و ساز (متابولیسمي) بود. میزان احتیاجات نگهداري دامهایي که تعلیف مجدد شدند در مقایسه با دامهاي کنترل فقط طي هفته‌هاي اول بعد از رفع محدودیت خوراکي کمتر بود.

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