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Energy Balance in Faunated and Defaunated Sheep on a Ration High in Concentrate to Roughage (Good Quality) Ratio

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Abstract: Five faunated and five defaunated sheep were fed diet containing 70:30 concentrate to roughage (oat hay) ratio and energy balances were determined by carbon and nitrogen balance method.Intake and nutritive value of the diet did not differ between faunated and defaunated sheep. Loss of carbon in urine and methane as percent of intake was significantly ($p<0.01$) less in defaunated sheep but energy balance and efficiency of utilisation of ME for maintenance was similar in both faunated and defaunated animals. The energy cost per g protein and fat synthesis in defaunated sheep was 13.9 and 12.3 kcal ME, respectively. It was inferred that high concentrate to roughage ratio and maintenance type roughage like oat hay in ration of defaunated Muzaffarnagari sheep does not yield any additional benefit from energetic point of view, compared to faunated sheep.

Key words: Carbon-nitrogen balance, sheep, defaunation, high concentrate ration, protein and fat synthesis

Introduction

Manipulation of rumen function through the removal of ciliate population (defaunation) appears to have considerable potential in improving ruminant productivity under certain feeding situations (Bird and Leng, 1985). Heat production is affected by defaunation which may be significantly lower (Kreuzer, *et a.*, 1986; Eadie and Gill, 1971; Itabashi *et al.*, 1984) or higher (Whitelaw *et a.l*, 1984) in defaunated sheep as compared to normal animals affecting energy utilisation. The consequent effect of diet induced thermogenesis on carbon; nitrogen and energy balance is little studied. We have earlier reported (Chandramoni *et al.*, 1999) that higher concentrate to roughage ratio in diet of sheep is beneficial to achieve retention of more protein and energy with less methane emission. In this investigation the same technique (C:N balance) have been used to determine the energy balance in two groups, faunated and defaunated, of Muzaffarnagari sheep fed on diet with 30:70 roughage to concentrate ratio.

Materials and Methods

Ten healthy male Muzaffarnagari sheep of about 6-8 months of age were divided into two groups of five each. The animals were dewormed before the start of experiment. One group of sheep was defaunated chemically using a solution of sodium lauryl sulphate at the dose rate of 9-g/100 kg body weight orally by stomach tube for three consecutive days. Before the first dose, 24-hrs fasting was done but water was given *ad libitum*. After 8 hrs of first dose, only 33% of the normal requirement of energy was offered through concentrate. The treatment with sodium lauryl sulphate was repeated two times at intervals of 24 and 48 h from first dose. The presence of protozoa in the rumen was checked every week. The animals were housed in two cemented sheds, which were well ventilated with individual feeding and watering arrangement. Defaunated sheep were kept in a separate shed.

Animals were fed on diet with 30:70 roughage: concentrate ratio as per NRC (1985) at maintenance levels. Oat hay was the roughage used. Concentrate mixture (Crude protein 11.7%, gross energy 4.37 Mcal/kg, DM) contained maize 93, deoiled groundnut cake 3.5, Wheat bran 3.5 parts, respectively. To every 100 kg concentrate mixture 2 kg mineral mixture and 1 kg common salt were added. Animals were shifted to metabolic crate and were adapted for 3 days. Metabolic trial of seven days was conducted after preliminary feeding of a month. During the last two days of the trial, a complete energy balance study was done in an open circuit respiration chamber described by Khan and Joshi (1983). Chamber was maintained at 20-25°C with a relative humidity of 65%. Carbon-dioxide measurement was conducted using modified Sonden apparatus with 100 ml burette. Measurement of methane was done by an infrared gas analyser (Analytical Development Co.Ltd., Hoddesdon, England, Model 300). The estimation of gross energy (GE) of samples was done by Gallenkamp adiabatic bomb calorimeter (CBA 301 series) as per procedure of Gallenkamp manual. Estimation of carbon content of feed, faeces and urine was done by adopting sodalime (self-indicating granule) absorption method given by van Es as described earlier (Chandramoni *et al.*, 1999).

Carbon content of carbon dioxide and methane produced was calculated from the values obtained in respiration calorimetry using factors recommended by Brouwer (1965).

Nitrogen in the samples was analysed by Kjeldahl's method, fat by extracting with petroleum ether (Lab con co.) and crude fibre by successively boiling with dilute acid and alkali.

Estimation of energy balance (EB) was made by the formula of Brouwer (1965) i.e. EB (kcal/d) = 12.387 C - 4.632 N, where C is carbon balance (g) and N is nitrogen balance (g). Body energy content was determined by assuming value of 5.32 kcal /g for protein 9.37 kcal/g for fat. Statistical analysis was done as per Snedecor and Cochran (1967).

Results and Discussion

Chemical composition of oat hay and concentrate mixture used is given elsewhere (Chandramoni *et al.*, 1999) and daily

Table 1: Daily intake of feeds (DM basis) and nutritive value of rations in faunated and defaunated sheep

Particulars	Faunated	Defaunated	SEM
Live weight,W, (kg)	48.1	51.2	1.63
Metabolic bodyweight (kgW $^{0.75}$)	18.2	19.1	0.66
Feed and nutrient intake (g/d)			
Concentrate mixture	840.8	892.4	28.64
Oat hay	263.6	294.1	26.57
Total intake	1104.4	1186.5	29.95
Intake (g/kg $W^{0.75}$)	60.68	62.1	1.31
Intake (kg/100kg W)	2.3	2.3	0.16
DP intake (g/d)	78.9	86.7	4.17
DP intake (g/kg$W^{0.75}$)	4.3	4.5	0.16
TDN intake (g/d)	743.0	791.8	23.35
TDN intake (g /kg$W^{0.75}$)	40.8	41.4	0.71
Nutritive value			
DP (%)	7.23	7.28	0.25
TDN(%)	68.2	66.7	0.86
DE (Mcal/kg DM)	3.00	2.68	0.08
ME (Mcal/kg DM)	2.71	2.45	0.08

Table 2: Carbon (C) and Nitrogen (N) balances (g/d) in faunated and defaunated sheep

Particulars	Faunated	Defaunated	SEM
C Intake	417.0	447.9	12.9
Faecal-C*	127.7	170.1	7.46
Urinary-C	10.2	9.6	0.35
Carbon dioxide-C*	223.3	216.8	6.5
Methane-C*	10.0	7.03	0.54
Total C balance	45.8	44.4	12.42
Losses of C as % of total intake			
Fecal-C	30.6	38.0	1.61
Urinary-C**	2.4	2.1	0.04
Methane-C**	2.4	1.6	0.13
Carbon dioxide-C*	53.5	48.6	1.75
N-Intake	19.6	20.9	0.55
Fecal-N	6.8	7.1	0.40
Urinary-N	10.5	11.0	0.66
Total N balance	2.3	2.8	0.30
N-Balance (mg/kg$^{0.75}$)	125.3	141.6	14.89
N retained as % of intake	11.7	12.8	1.10
N retained as % of absorbed-N	18.5	19.8	2.3

*P < 0.05, **P< 0.01

Table 3: Daily energy balance and heat production in faunated and defaunated sheep by carbon nitrogen balance.

Particulars	Faunated	Defaunated	SEM
Protein deposited (g)	14.4	17.5	1.87
Fat deposited (g)	51.2	47.37	15.60
Energy stored as protein (kcal/d)	76.6	93.1	9.08
Energy stored as fat (kcal/d)	480.1	443.9	146.17
Total energy retained (kcal/d)	556.7	537.0	152.81
Heat Production			
kcal/d	2375.1	2381.8	61.35
kcal / kg $W^{0.75}$ /d	130.5	124.7	4.25
Efficiency of ME utilisation for maintenance	51.3	54.7	4.20

intake of these by faunated and defaunated sheep and nutritive value of composite rations is given in Table 1. Digestibility, intake of digestible nutrients and energy (DE and ME) were almost similar in both faunated and defaunated groups resulting in similar nutritive value of composite rations. Similar observation was reported by Rowe *et al.* (1985) in defaunated wethers. This may be due to maintenance level of feeding and quality of roughage (oat hay) used in the experiment.

Carbon and nitrogen balance data obtained in faunated and defaunated groups is presented in Table 2. Fecal carbon was significantly higher ($P<0.05$) and methane carbon was significantly lower ($P<0.05$) in defaunated sheep. However, intake of carbon and carbon loss as CO_2 did not differ between the groups resulting in similar carbon balance. On the other hand, nitrogen balance data show that nitrogen intake and outgo did not differ significantly ($p<0.05$) between groups. No significant difference in the loss of carbon in urine may be due to similar intake of digestible energy. It has been found (Kishan *et al.*, 1986) that level of energy influence the excretion of carbon and nitrogen in the urine and that urinary carbon is positively ($P<0.01$) co-related with DE intake. On the other hand, Khan *et al.* (1986) and Ghosh (1990) reported that intake and excretion of carbon in faeces was dependent on energy intake but urinary, CH_4 and CO_2-C outgo were not affected by energy intake in male buffaloes and crossbred cattle, respectively. In this study, total methane - C as well as methane - C loss as percent of total C intake was significantly low due to lower methane production in defaunated sheep. This is because defaunation reduces methanogenesis to the tune of 30-45% (Jouany *et al.*, 1988). Protozoal activity results in hydrogen gas production and it is used for methane production by methanogenic bacteria (Hungate, 1967) which has got ectosymbiotic relationship with rumen ciliate protozoa (Stumm *et al.*, 1982; Krumholtz *et al.*, 1983). In defaunated sheep, methanogenic bacteria loose their symbiotic partners resulting in reduced methane production.

The loss of carbon as carbon dioxide in defaunated sheep was less (6%) as compared to faunated sheep, which may be due to combined effect of reduced tissue metabolism of host (Kreuzer *et al.*, 1986) and higher carbon dioxide production in the rumen of defaunated sheep (Rowe *et al.*, 1985).

The data on energy retention and heat production as determined by carbon and nitrogen balance method is given in Table 3. It is evident that there was no difference in heat production and energy retention between two groups of sheep. Using FHP value of 53.5 kcal/kg $W^{0.75}$ of sheep (Chandramoni *et al.*, 2000) the efficiency of utilisation of ME for maintenance was estimated as ME intake- (HP-FHP)/ME intake which was found to be 0.513 and 0.547 in faunated and defaunated sheep, respectively. In defaunated sheep, ME for production (ME_p) separated from ME for maintenance (ME_m) was regressed on energy retained as protein (ER_p) and fat (ER_f), which yielded the following equation.

$Me_p = 2.51\ ER_p + 1.31\ ER_f \quad p<0.01 \quad r^2 = 0.67$

This gave the efficiency of ME utilisation for protein and fat synthesis, which was 39.8 and 76.3 per cent, respectively. Thus ME required per g of protein and fat synthesis was 13.9 and 12.3 kcal/g. Energetic cost of protein and fat synthesis (per g) in faunated sheep based on 12 observations in the same breed of sheep (Chandramoni *et al.*, 1999) was 14.38 and 11.71 kcal ME, respectively which was similar to defaunated sheep in this study.

It is evident from the present study that high level of concentrate to roughage ratio and good quality roughage like oat hay in ration of defaunated sheep does not yield any additional benefit from energetic point of view compared to faunated sheep because there is no significant positive effect of defaunation on carbon and nitrogen balance i.e. energy balance and efficiency of energy utilisation.

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