
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

ENERGY COST OF PROTEIN DEPOSITION IN THE PRE-RUMINANT AND YOUNG RUMINANT LAMB

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SUMMARY

Comparative slaughter data for 105 young lambs fed milk or milk plus pasture diets and for 48 early weaned lambs fed pasture or lucerne were used to estimate the ME cost of fat and protein deposition by multiple regression analysis. The cost of fat deposition did not differ between diets and averaged 34 ± 9 kJ ME/g fat. The ME cost of protein deposition was almost three times greater on the herbage diets (142 ± 25 kJ ME/g protein) than on the milk based diets (51 ± 10 kJ ME/g protein). The majority of early weaned lambs were in negative energy balance, losing fat but still gaining protein. High estimates of maintenance and low estimates of K_m (50%) were obtained for these lambs by using regressions of energy gain or log heat production on ME intake, because in these methods the ME cost of protein deposition appears as part of the maintenance requirement. Multiple regression analysis separated these two processes. For the milk diets and herbage diets K_m was approximately 80 and 70%, while K_g was 70-80 and 30%, respectively.

INTRODUCTION

The efficiency of utilization of metabolizable energy (ME) for gain in the milk-fed lamb is 70 to 80% (Walker and Jagusch, 1969; Jagusch and Mitchell, 1971), while that in older ruminant lambs is 20 to 50% depending on diet quality (Rattray *et al.*, 1973a, b). While the energy cost of fat deposition appears similar in pre-ruminant and older ruminant lambs fed herbage (43 to 63 kJ ME/g fat) the energy cost of protein deposition appears to be markedly different (30 to 36 *vs.* 114 to 225 kJ ME/g protein) (Kielanowski, 1965; Walker and Norton, 1971; Rattray and Joyce, 1976).

In an attempt to clarify this issue, data were analysed from several comparative slaughter experiments where lambs were fed either milk as a sole diet; milk plus pasture; ryegrass-white clover pasture; or lucerne.

EXPERIMENTAL

Data were obtained from previously reported comparative slaughter trials summarized in Table 1.

TABLE 1: SUMMARY OF EXPERIMENTS

Trial Report	*Initial Age (days)*	*Days on Feed*	*No. Lambs*	*Breed-cross*	*Diet*	*Group No.*
Jagusch and Mitchell, 1971	2	21	11	Dorset Down × Romney	Ewe's milk	1
Jagusch, 1968	7	14-56	68	Dorset Horn × Border Leicester-Merino	Reconstituted cow's milk	2
Joyce and Rattray, 1970	1	70	36	Southdown × Romney and Hampshire × Romney	Ewe's milk and pasture	3
Fennessy *et al.*, 1972	24-52	14-56	24	Dorset Down × Romney	Pasture	4
Fennessy *et al.*, 1972	24-52	14-56	24	Dorset Down × Romney	Lucerne	5

TABLE 2: DAILY METABOLIZABLE ENERGY INTAKES, ENERGY RETENTION, FAT DEPOSITION AND PROTEIN DEPOSITIONS
(Mean with range in parentheses)

Group No.	*ME Intake* ($kJ/kg\ W^{0.75}$)	*Energy Retention* ($kJ/kg\ W^{0.75}$)	*Fat Deposition* ($g/kg\ W^{0.75}$)	*Protein Deposition* ($g/kg\ W^{0.75}$)
1	816 (452-1181)	163 (— 142-+ 419)	1.0 (— 3.7-+ 5.0)	5.3 (— 0.6-+ 10.0)
2	850 (297-1679)	301 (— 59-+ 821)	5.5 (— 3.9-+ 13.7)	4.5 (— 2.7-+ 13.8)
3	917 (544-1172)	234 (+ 126-+ 410)	3.2 (+ 0.9-+ 6.9)	4.7 (+ 2.8-+ 9.4)
4	620 (155-1365)	— 54 (— 427-+ 205)	— 2.0 (— 9.3-+ 4.6)	1.0 (— 1.6-+ 3.5)
5	762 (218-1700)	— 21 (— 285-+ 263)	— 1.1 (— 8.1-+ 4.8)	1.4 (— 2.1-+ 3.3)

The procedure used by Rattray and Joyce (1976) was used to obtain estimates of the ME cost of fat (F) and protein (P) deposition (g/kg $W^{0.75}$) by a multiple regression of these on ME intake (kJ ME/kg $W^{0.75}$).

Estimates of maintenance were obtained from the above method (*i.e.*, from the intercept), and also by the two methods used by Rattray *et al.* (1973b). Efficiencies of utilization of ME for maintenance (K_m) and gain (K_g) were obtained by the procedures used by Rattray *et al.* (1973a, b).

RESULTS AND DISCUSSION

Table 2 contains the mean daily ME intake, energy retention, fat deposition and protein deposition, together with their ranges.

The partial regression coefficients and correlation coefficients from the multiple regression analysis are shown in Table 3. A ridge trace (Hoerl and Kennard, 1970) showed that all the regression coefficients were stable. The inclusion of negative fat or protein deposition did not alter the coefficients. The coefficients for fat deposition did not differ significantly between diets and a pooled within-group regression (for groups 1 to 4) yielded a partial coefficient for rat synthesis of 34 ± 9 kJ ME/g fat. There were highly significant differences among the partial regression coefficients for protein deposition between the milk and herbage diets. Pooled within-group regressions gave estimates for protein deposition of 51 ± 10 and 142 ± 25 kJ ME/g protein, respectively. These estimates are similar to those obtained by Kielanowski (1965) and Walker and Norton (1971) for young milk-fed lambs, and by Rattray and Joyce (1976) with older lambs fed herbage diets. The high ME cost of protein deposition in the ruminant is most probably associated with inefficiencies in rumen function, poor utilization of the end-products of ruminant digestion, solubility of dietary protein, and possibly a limitation or imbalances in essential amino acids finally reaching the intestine (Rattray and Joyce, 1976; Walker, 1974; Sniffen *et al.*, 1974). Group 3 had functional rumens by approximately 21 days (Joyce and Rattray, 1970) but presumably because they obtained sufficient metabolites and essential amino acids from the milk (70% of MEI) no depression of efficiency occurred.

The estimated maintenance requirements are shown in Table 4. In contrast to groups 3, 4, and 5, all three methods gave similar results for groups 1 and 2. The discrepancies in group 3 are due to the extrapolation beyond the data. The "classical" approaches

TABLE 3: PARTIAL REGRESSION COEFFICIENTS ($\pm S_b$) AND CORRELATION COEFFICIENTS

Group No.	*Diet*	*Fat Deposition (kJ ME/g fat)*	*Protein Deposition (kJ ME/g protein)*	R^a	r^b	r^c	r^d
1	Milk	43 ± 12**	35 ± 12*	0.99	0.94	0.97	0.97
2	Milk	33 ± 5***	53 ± 5***	0.97	0.88	0.95	0.93
3	Milk + Pasture	24 ± 9*	54 ± 16**	0.70	0.56	0.47	0.63
4	Pasture	35 ± 16*	135 ± 42**	0.76	0.61	0.48	0.69
5	Lucerne	23 ± 15NS	145 ± 32***	0.80	0.52	0.45	0.77

[a] Multiple correlation coefficient.
[b] Correlation coefficient between fat and protein.
[c] Correlation coefficient between fat and MEI
[d] Correlation coefficient between protein and MEI

TABLE 4: ESTIMATED MAINTENANCE REQUIREMENTS ($kJ\ ME/kg\ W^{0.75}$)

	Method of Estimation (Y vs. X)[a]		
	1	*2*	*3*
Group	*Log HP vs. MEI*	*EG vs. MEI*	*MEI vs. F + P*
1	611	607	590
2	435	419	419
3	461	389	590
4	724	791	553
5	745	833	582

[a] Method 1 where MEI = HP; Method 2 where EG = 0; Method 3 where F and P = 0.
HP = Heat production. MEI = ME intake. EG = Energy gain.

(methods 1 and 2) gave extremely high estimates for groups 4 and 5. This is because the majority of animals in these groups were losing fat and were in negative energy balance while still depositing protein. The estimates of maintenance based on energy gain (methods 1 and 2) would not be corrected for the high cost of protein deposition; however, the multiple regression technique separates the two processes. Although in the milk-fed group 1 many of the animals were losing fat, a similar elevation of maintenance did not occur because protein deposition was a very much more efficient process.

The estimates of maintenance obtained by multiple regression for the New Zealand experiments with Romney-cross sheep are quite consistent, and group 2 could differ from these because of environmental, or breed differences.

The K_m and K_g values for the diets are shown in Table 5. K_m depends greatly on the maintenance value used. For the lambs

TABLE 5: EFFICIENCY OF UTILIZATION OF ME FOR MAINTENANCE (K_m) AND GAIN (K_g)

Group No.	*Diet*	K_m[a]%	K_m[b]%	K_g
1	Milk	81	83	77 ± 4
2	Milk	82	84	69 ± 2
3	Milk pasture + grass	—[c]	—[c]	68[d] ± 3
4	Pasture	51	70	32 ± 8
5	Lucerne	50	68	29 + 7

[a] Maintenance taken as a mean of methods 1 and 2 (Table 4).
[b] Maintenance from method 3 (Table 4).
[c] Insufficient range to estimate FHP reliably.
[d] Confined regression through maintenance (method 3, Table 4).

fed pasture and lucerne, the estimates of maintenance calculated from methods 1 and 2 (Table 4) gave K_m values of approximately 50%, but by using maintenance estimated from method 3 (Table 4) K_m was approximately 70%. These estimates of K_m (70-80%) and K_g for the milk diets are similar to others reported (Walker and Norton, 1971; Rattray *et al.*, 1973a, b; Walker, 1974). However, the K_g for the herbage diets is considerably lower than would be expected from such high quality diets (Rattray *et al.*, 1973a). This is because of the weaning check or because even at relatively high intakes these early weaned lambs were depositing mainly protein, while in older lambs simultaneous deposition of fat and protein usually occurs at similar intakes. In the early weaned lamb, the relatively high maintenance requirements and physiological drive for protein deposition, with its associated high ME requirements, will often exceed the ME intake. This leads to fat mobilization. In older lambs approaching maturity the slowing of metabolic rate and protein gain allows energy surpluses for storage as adipose depots.

ACKNOWLEDGEMENT

The authors are grateful to D. M. Duganzich for running the ridge traces.

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