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

Relationships between insulin-glucose status and carcass fat in lambs

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ABSTRACT

Two experiments investigated relationships between biochemical measurements and carcass fat in lambs. In the first, artificially reared Dorset lambs, weaned at 5 (early) or 13 (late) weeks were slaughtered at 5, 9 and 13 weeks for carcass fat determination. In the second experiment, 330 Coopworth male lambs (entire and castrate), were weaned at 9 weeks of age and slaughtered at 21 weeks.

At 9 and 13 weeks of age early weaned lambs which had lower carcass weights had significantly lower glucose and insulin levels, and less internal and carcass fat than milk fed lambs. In the second experiment at similar carcass weights entire lambs were leaner than castrates and had lower blood glucose.

In contrast to results in the first experiment, lambs grown to slaughter under a uniform dietary regime in the second showed a negative correlation between insulin and fat measurements. It is suggested that insulin is an important regulator of fat deposition in the milk fed lamb but its exact role in the ruminant lamb remains unclear.

Keywords Insulin; glucose; carcass fat; lamb; glucose tolerance; weaning age; milk-fed lamb

INTRODUCTION

A positive association between blood insulin and glucose levels and rate of fat deposition has been found in indoor trials with lambs offered either a milk or grass diet (Chambers and Bickerstaffe, 1982) or by altering the rumen fermentation pattern (Abdul-Razzaq and Bickerstaffe, 1983). Generally, elevation of blood insulin by continual feeding of milk or by establishing a propionic rumen fermentation pattern has been associated with increases in blood glucose and fat deposition.

There is no information on these relationships under pasture grazing. This paper investigates the association between insulin, glucose and carcass fat deposition, firstly in lambs reared under different dietary regimes (i.e., early *v* late weaning) and secondly, in entire or castrated male lambs reared under a uniform dietary regime.

MATERIALS AND METHODS

In the first experiment (Expt. A), 40 Dorset lambs were artificially reared as outlined by Smith and Geenty (1983). Lambs were weaned at 5 (early) or 13 (late) weeks of age and slaughtered at 5, 9 and 13 weeks to determine carcass weight and fat content. Weekly blood samples were collected for insulin and glucose determination and before slaughter a glucose tolerance test (Munro, 1982) was performed.

In the second experiment (Expt. B), 330 Coopworth entire or castrated male lambs were weaned onto pasture at 9 weeks of age and slaughtered at 21 weeks at a local freezing works. Carcass weight, kidney fat and GR measurement were recorded. The day before slaughter a blood sample was taken for insulin and glucose analysis.

RESULTS

Results of blood measurements in Expt A are given in Table 1. Early weaned lambs had significantly lower

TABLE 1 Blood glucose (mg%), insulin (μU/ml) and glucose tolerance (T ½ min) of early and late weaned lambs at 6, 9 and 13 weeks of age. (Expt. A).

	Age	Early weaned	Late weaned	SED	Sig
Blood glucose	6	61.35	70.85	3.16	**
	9	45.35	58.50	4.29	**
	13	38.76	51.96	2.36	**
Plasma insulin	6	3.09	14.7	3.27	**
	9	2.27	10.01	2.54	**
	13	3.50	11.93	2.19	**
Glucose tolerance	6	26.1			
	9	64.8	40.6	10.70	*
	13	95.0	40.7	12.23	**

blood glucose and insulin levels than did later weaned lambs and required a longer time to clear exogenous glucose from their blood.

Carcass weights and fat measurements (Table 2) were markedly lower in early compared with late weaned lambs, slaughtered at 9 and 13 weeks of age.

TABLE 2 Carcass weight (kg) and fat content of early and late weaned lambs slaughtered at 5, 9 and 13 weeks of age (Expt. A).

	Age	Early weaned	Late weaned
Carcass weight	5	7.33	
	9	7.42	11.39
	13	9.00	15.60
Carcass fat (% of carcass)	5	15.6	
	9	10.48	16.96
	13	11.89	22.79
Internal fat[a] (g)	5	186	
	9	82	345
	13	128	809

[a] Kidney plus omental fat.

In Expt B, entire lambs had slightly heavier carcasses and significantly less kidney fat, lower GR measurement and lower blood glucose compared with castrates, but there was no difference in insulin levels (Table 3).

TABLE 3 Effect of sex on carcass weight (kg), blood insulin (μU/ml), glucose (mg %), kidney fat (g) and GR measurement (mm) (Expt. B).

	Entire	Castrate	SED	Sig
Carcass weight	13.34	13.18	0.237	ns
Blood glucose	44.22	45.79	0.533	**
Blood insulin	4.82	4.75	0.330	ns
Kidney fat	118.1	125.7	5.82	**
GR measurement	5.61	6.14	0.262	ns

At constant carcass weight within sex, blood insulin levels were negatively correlated with fat measurements but blood glucose showed no correlation. Regression coefficients were:

(a) blood insulin on kidney fat -3.16 ± 0.86*** ($R^2 = 0.042$)

(b) blood insulin on GR measurement -0.096 ± 0.035 ** ($R^2 = 0.024$)

DISCUSSION

Results in Expt A are consistent with findings in indoor trials where milk-fed (semi-ruminant) compared with grass-fed (ruminant) lambs have maintained elevated blood glucose and insulin levels (Chambers and Bickerstaffe, 1982; Munro, 1982). In the milk-fed lamb dietary carbohydrate (lactose), which is readily absorbed directly by the small intestine, maintains the high glucose level (levels normally associated with non-ruminants) which stimulates insulin release (Bassett, 1974). Since insulin stimulates fat deposition Yang and Baldwin, 1973) it would be expected that increased circulating insulin levels would be associated with increased rates of fat deposition. Despite differences in carcass weight between early and late weaned lambs, percentage of carcass fat was greater in the latter. Fat mobilisation (Fennessy *et al.*, 1972) during the growth check may have contributed to the lower levels of carcass fat in early weaned lambs. The curvilinear relationship between carcass fat and live weight (Searle and Griffiths, 1976) may also confound the differences in fat concentration. In previous weaning age experiments at Templeton with the same breed, carcass fat has been significantly lower in lambs weaned at 4 compared to 18 weeks of age when adjusted to the same carcass weight (Geenty, 1980). Similar results have been reported by Kellaway (1973) and Searle and Griffiths (1976).

Results of the glucose tolerance tests indicate that insulin secretion is markedly different in the milk-fed compared with pasture-fed lambs. Circulating levels of insulin have been shown to increase up to 8-fold following ingestion of milk (Munro, 1982). It is therefore possible that continual ingestion of milk in the suckling lamb which maintains high levels of insulin, stimulates fat deposition at a faster rate than in the early weaned lamb whose pancreas is less responsive to insulin stimulus.

The results in Expt B showed an expected tendency for entires to be leaner than castrates (Everitt and Jury, 1966) and this was associated with lower blood glucose but no difference in insulin. In contrast to results between groups in Expt A, however, an increase in blood insulin was associated with a decrease in measurements of fatness within treatments in Expt B. Although this relationship was highly significant it only accounted for a small proportion (2 to 4%) of the variation in fat measurements. Previous differences shown in fat deposition between milk and grass fed lambs have been clearly associated with dietary induced differences in blood glucose and insulin levels. In the ruminant, however, nearly all glucose is endogenously synthesised (Lindsay, 1979) and relatively constant glucose levels present little variation in stimulus of insulin secretion.

CONCLUSIONS

These results show that lambs with continual access to milk maintain some non-ruminant physiological characteristics, namely, elevated blood glucose and insulin levels and a greater pancreatic response to stimuli. Associated with this is an increased rate of fat deposition and it is suggested that insulin is one of the important regulatory factors.

In the ruminant lamb there is clearly a different release pattern of insulin secretion. However, more detailed examination of the insulin release and mode of action (e.g., glucose tolerance or insulin resistance tests) will give more information on the role of insulin in the regulation of fat deposition.

ACKNOWLEDGEMENTS

The authors are grateful to D. O'Connell and M. Smith for field assistance and Anna Nicoll, Diane Strode and P. Sadgrove for laboratory analyses.

REFERENCES

Abdul-Rassaq H. A.; Bickerstaffe R. 1983. Effect of manipulating rumen volatile fatty acids on blood glucose urea and insulin levels in growing lambs. *Proceedings of the Nutrition Society of New Zealand 1983*. (In press).

Bassett J. M. 1974. Early changes in plasma insulin and growth hormone levels after feeding in lambs and adult sheep. *Australian journal of biological science* **27:** 157-166.

Chambers J. A. N.; Bickerstaffe R. 1982. Glucose and insulin levels in milk and grass fed lambs. Symposium on regulation of carbohydrate and lipid metabolism. University of Otago, 1982.

Everitt G. C.; Jury K. E. 1966. Effect of sex and gonadectomy on the growth and development of Southdown × Romney cross lambs. Part II. Effects on carcass grades, measurements and chemical composition. *Journal of agricultural science* **66:** 15-27.

Fennessy P. F.; Woodlock M. R.; Jagusch K. T. 1972. The effect of early weaning on the concentrations of non-esterified fatty acids and glucose in the plasma of lambs. *New Zealand journal of agricultural research* **15:** 802-807.

Geenty K. G. 1980. Influence of weaning age, management and slaughter age on export lamb carcass production and slipe wool weights. *New Zealand journal of agricultural research* **23:** 433-440.

Kellaway R. C. 1973. The effects of plane of nutrition, genotype and sex on growth, body composition and wool production in grazing sheep. *Journal of agricultural science, Cambridge* **80:** 17-29.

Lindsay D. B. 1979. Metabolism in the whole animal. *The proceedings of the Nutrition Society* **38:** 295-301.

Munro J. M. 1982. Factors influencing insulin yield and secretion from the ovine pancreas. PhD thesis, Lincoln College, Canterbury, 1982.

Searle T. W.; Griffiths D. N. 1976. The body composition of growing sheep during milk feeding and the effect on composition of weaning at various body weights. *Journal of agricultural science, Cambridge* **86:** 483-493.

Smith M. C.; Geenty K. G. 1983. A low cost method of artificially rearing lambs at pasture. *Proceedings of the New Zealand Society of Animal Production* **43:** 43-44.

Yang Y. T.: Baldwin R. L. 1973. Preparation and metabolism of isolated cells from bovine adipose tissue. *Journal of dairy science* **56:** 350-365.