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

Characterisation of the insulin status of lambs and consequences for carcass composition

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ABSTRACT

The nutritional treatment of lambs influences the extent of carcass fat deposition. Suckled lambs deposit more fat than weaned lambs with associated increases in plasma glucose and insulin levels. To investigate the mechanisms involved, groups of lambs with different insulin profiles were created, either nutritionally or by infusing insulin, and the effect on carcass composition determined. Border Leicester x Dorset lambs were either weaned at 5 weeks of age or remained suckling with access to grass. Twenty four lambs were slaughtered at 12 weeks of age, the remaining lambs were slaughtered at 23 weeks of age. A subset of both weaned and suckled lambs were treated with exogenous insulin from 5 weeks until slaughter. Insulin status was assessed by the glucose tolerance test and by the response of plasma glucose to injected insulin. The prolonged suckling of lambs increased carcass fatness and decreased carcass protein compared to early weaned lambs. Infusing insulin decreased carcass fatness and increased carcass protein. The alterations in carcass composition were associated with changes in the sensitivity of peripheral tissues to insulin.

Keywords Lamb, glucose tolerance, insulin sensitivity, fat, protein, body composition.

INTRODUCTION

The nutritional treatment of lambs influences the extent of fat deposition. Suckled lambs deposit more fat than weaned counterparts, in association with increased plasma levels of glucose and insulin (Chambers, 1984). Altered insulin profiles and sensitivity to insulin are features of clinical forms of obesity (Olefsky, 1975) and a number of acquired and genetic animal models of obesity (Soll *et al.*, 1976). This study investigates the possibility that the differences in carcass composition between suckled and weaned lambs can be attributed to differences in the sensitivity of peripheral tissues to insulin. Groups of lambs with different insulin profiles were created, either nutritionally or by infusing exogenous insulin, and the effects on carcass composition determined.

MATERIALS AND METHODS

At 5 weeks of age, 48 Border Leicester x Dorset wether lambs were allocated into four treatment groups in a 2 x 2 factorial design. Half the lambs were weaned, the remaining lambs continued suckling with access to pasture. A subset of both the weaned and suckled lambs were treated with exogenous insulin. Lambs were slaughtered at either 12 or 23 weeks of age. Only data from the 23 week slaughter group are presented here. This group consisted of: weaned lambs(n=8); weaned lambs treated with insulin(n=4); suckled lambs(n=8) and suckled lambs treated with insulin(n=4). The insulin treated lambs were initially injected daily with insulin (Monotard, Novo) between 5 and 12 weeks and were subsequently infused with insulin (Velosulin, Nordisk) into the jugular vein using backmounted infusion pumps until slaughter. Dose rates for insulin are shown in Figure 1. Each week the animals were weighed and blood samples taken for the determination of glucose, insulin and urea. Glucose tolerance was measured in the week preceding slaughter using a single intravenous injection of glucose (0.4 g/kg body weight). Blood samples were collected at 0, 10, 15, 20, 25, 30, 40, 50, 60, 90 and 120 minutes following the injection of glucose. Insulin sensitivity was also measured in the week prior to slaughter by injecting insulin (Porcine, regular, 0.47 I.U./kg body weight $^{0.75}$) and collecting blood samples at 0, 10, 20, 30, 40, 50, 60, 75, 90, 120, 150, 180 and 240 minutes after the injection of insulin.

Plasma glucose was determined by the method of Lever (1977) on an Autoanalyser II (Technicon Instruments, Tarrytown, NY 10591, USA). Plasma insulin was determined as immunoreactive insulin using a modification of the RIA procedure of Albano and Ekins (1970). Carcasses were retained at slaughter for chemical analysis of fat and protein content.

RESULTS

The T-half value is the time taken to clear half the increase in plasma glucose resulting from a glucose injection. The amount of insulin released after a glucose injection was estimated by measuring the area underneath a graph of plasma insulin concentration versus time after injection. The T-half values for glucose clearance and the insulin released during preslaughter glucose tolerance tests at 23 weeks are shown in Table 1. The T-half value for the suckled lambs was significantly higher than the weaned animals. Differences between the infused and control (untreated) lambs were not significant. Insulin release was greater in suckled lambs than in weaned lambs. Infused lambs secreted less insulin than the control lambs. These differences in insulin secretion were not significant.

TABLE 1 Parameters derived from glucose tolerance and insulin sensitivity tests in 23 week old lambs

Treatment	T-half (min)	Insulin Release clearance (mU/ml.min)	Glucose (mg/dl/min)
Weaned	70	4313	1.37
Suckled	96	4577	1.27
Control	80	4786	1.51
Infused	87	3787	0.98

T-half	Rearing,	P<0.01
Clearance	Infusion,	P<0.005

Glucose clearance, calculated from the rate of glucose disappearance during the first 20 min following an injection of insulin, was significantly lower in the insulin infused animals than in the controls. There was no difference between rates of glucose clearance for weaned and suckled lambs.

TABLE 2 Carcass fat and protein content of lambs slaughtered at 23 weeks of age (Covariate : empty body weight)

Treatment	% of Carcass	
	Fat	Protein
Weaned	26.8	15.8
Suckled	34.4	14.3
Control	31.1	14.9
Infused	29.6	15.4

Fat	Rearing,	P<0.001
	Infusion,	P=0.07
Protein	Rearing,	P<0.001
	Infusion,	P=0.01

The chemical composition of the carcasses are presented in Table 2. Data for all lambs was corrected to the same empty body weight. Suckled lambs had significantly greater amounts of carcass fat than the weaned animals. Infusing exogenous insulin significantly reduced carcass fat compared to the control lambs.

Weaned animals had significantly higher levels of carcass protein than the suckled lambs. Carcass protein was significantly higher in the insulin infused compared with the control lambs.

DISCUSSION

An increase in the T-half value indicates a decrease in the sensitivity of peripheral tissues to insulin or a reduced pancreatic secretion of insulin. In this experiment the similar insulin secretion rates in the weaned and suckled lambs suggest that the difference in T-half between these two groups reflects differences in the responsiveness of peripheral tissues to insulin.

Accordingly the rate of decline of plasma glucose after an insulin injection was lower in the suckled than the weaned lambs. The decrease in peripheral insulin sensitivity in suckled lambs was associated with increased carcass fatness at the expense of carcass protein.

The insulin infused lambs cleared glucose more slowly after a glucose challenge than controls, possibly due to the decreased insulin release in these lambs. Lower peripheral sensitivity to insulin was indicated in the infused lambs by slower glucose clearance after an insulin challenge. This lower responsiveness to insulin was associated with increased carcass protein content and decreased carcass fatness.

That is, the effects at carcass level of lowered sensitivity to insulin depended on whether the decreased responsiveness to insulin was achieved by prolonged suckling or by treatment with exogenous insulin.

The consequences of altered sensitivity to insulin at the level of adipose and muscle tissue are not predictable as not all insulin-mediated processes are sensitive to insulin to the same extent (Le Marchand *et al.*, 1977). Sensitivity of the various processes may be manipulated to partition nutrients between fat and protein synthetic pathways. The shift between fat deposition and fat mobilisation at the onset of lactation, for instance, is achieved by changes in sensitivity between the adipose and mammary tissues (Flint, 1982). Shunting of nutrients between processes may also be controlled at the post-receptor level.

Decreasing the fat content of meat has been a priority for both health and aesthetic reasons. Early weaning of lambs and the infusion of exogenous insulin has achieved this objective. Further studies are required to delineate the mechanisms involved.

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