
VOLUME 62 2002

BRIEF COMMUNICATION: Effect of early life diet on lamb growth and organ development

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Keywords: lamb; milk; pellet; growth; maintenance

Introduction

Neonate lambs are pre-ruminants until approximately 3 – 4 weeks of age (Treacher & Caja 2002) and therefore their dam's milk is key to their survival and growth. During this period, their digestive system is relatively immature. Attempts have been made to evaluate the effects of early weaning on lamb growth performance with few data available at ages earlier than 4 weeks (Brown 1964; Large 1965; Walker & Hunt 1981; Lane et al. 1986). These early studies show that lambs can be weaned at two to three weeks of age, however, they often result in growth rate checks. These findings suggest lambs require liquid diet for a minimum of two to three weeks. Nevertheless, rumen development is essential to enable lambs continue a normal growth trajectory when milk consumption ceases (Poe et al. 1969). Our objective was to examine the impacts on lamb growth and organ development when pellets are added to the milk diet of lambs in very early post birth life. Furthermore, lamb growth rates have improved by 50 g/day since the 1980s (Bray 2004). This may imply that the efficiency of lambs in utilising energy in their diet for growth and maintenance has altered. Thus, in addition to the growth performance, the utilisation of metabolisable energy (ME) in the diet for maintenance and growth was also examined.

Materials and Methods

The study and animal handling procedures were approved by the Massey University Animal Ethics Committee.

Animals, measurement and diet

Sixteen male Suffolk lambs were allowed to suckle their dams for two days post-partum before being separated from their dams and housed in individual indoor pens bedded with rubber mats. The lambs were randomly assigned to one of two feeding groups (n=8 per group). One group received milk replacer only (MO) by bottle feeding, while the second group received the same amount of milk replacer in addition to *ad libitum* access to pellets (MP). Liquid milk replacer (Milligans Feed Ltd, Oamaru, New Zealand) was prepared daily with water at 40^{O}C in a ratio of 1 part milk replacer to 6 parts water. The quantity of milk replacer fed was adjusted as lambs grew and the frequency of feeding also depended on the lamb's age; the initial amount of milk powder was 120 g/day which was gradually increased to 210 g/day over the 60 day study period. The composition of milk replacer is presented in Table 1. Lamb Start Mix and Performance Pellets (Reliance Feeds, Canterbury, New Zealand) were offered to MP lambs from 2 to 18 days of age and from 19 days of age until the end of the study respectively (see Table 1). Milk and pellet intake were recorded daily. Lambs were weighed at the start of the study and then every three days thereafter until slaughter at 60 ± 1 days of age.

Table 1 Composition of milk replacer, start mix and performance pellets as fed to lambs.

Chemical composition	Diet		
	Milk replacer	Start mix[1]	Performance pellets[1]
Dry matter (%)	96.3	88.7	88.8
Ash (%)	5.8	7.9	9.4
Protein (%)	24.4	16.9	17.5
Fat (%)	26.6	1.4	4.4
Lactose (%)	38	-	-
Minerals (%)	6	-	-
GE[2] (kJ/g)	22.5	15.3	15.4
Starch (%)	-	36.4	34.7
NDF[3] (%)	-	13.8	14.3
ADF[4] (%)	-	4.8	5.1
Lignin (%)	-	0.8	0.9

[1]Composed of barley, soya bean meal, canola, peas, wheat, maize, oats, molasses, vegetable oil, grass seed meal, minerals, vitamins, prebiotics and essential oils; [2]Gross energy; [3]Neutral detergent fibre; [4]Acid detergent fibre.

Slaughter

Lambs were weighed after being fasted overnight, slaughtered (60 days of age) by captive bolt and exsanguination, skinned, eviscerated and carcass parameters were measured. Weights of the head, skin and feet (HSF), hot carcass and all internal organs were recorded. The stomach and intestines were weighed before and after removal of contents to determine gut fill. Weights of the liver and kidney were also recorded.

Table 2 The effects of feeding treatments, milk only (MO) vs milk + pellets (MP) on growth performance, carcass and organ weights of lambs used in the study.

	Treatment		P-value
Growth performance	MO (n = 8)	MP (n = 7)	
Initial LW[1], kg	6.12 ± 0.30	6.11 ± 0.32	0.97
Final LW, kg	13.67 ± 0.77	18.68 ± 0.82	<0.01
Mean DM[2] intake (milk), kg	10.66 ± 1.01	10.44 ± 1.09	0.19
Mean DM intake (pellet), kg	-	7.52 ± 1.07	-
Total ME[3] intake, MJ	226 .6 ± 14.19	326.2 ± 15.17	<0.01
ADG[4], g/day	126.25 ± 14.29	211.14 ± 15.28	<0.01
LWG[5], kg	7.54 ± 0.85	12.57 ± 0.91	<0.01
EFF[6]	0.71 ± 0.02	0.70 ± 0.02	0.93
Carcass and organs weights			
Hot carcass weight (HCW), kg	7.46 ± 0.35	9.35± 0.38	<0.01
Empty body weight (EBW)	12.89 ± 0.68	16.48± 0.72	<0.01
Dressing %	54.54 ± 0.47	50.21 ± 0.50	<0.01
HSF[7], kg	2.75 0.15	3.43 0.16	0.02
Total organ weight, kg	1.72 ± 0.15	2.64 ± 0.16	0.001
Stomach[8], kg	0.22 ± 0.04	0.51 ± 0.04	<0.01
Intestines, kg	0.63 ± 0.06	0.91 ± 0.07	0.01
Liver, kg	187.25 ± 29.09	321± 31.097	0.01
Kidney, kg	66.75 ± 6.02	79.43 ± 6.44	0.17
Carcass and organs, % of EBW			
HCW, %	57.81 ± 0.48	56.90 ± 0.52	0.22
HSF, %	21.36 ± 0.25	20.85 ± 0.27	0.19
Total organ weight, %	13.42 ± 0.53	15.36 ± 0.56	0.03
Stomach, %	1.68 ± 0.16	3.04 ± 0.17	<0.001
Intestines, %	4.95 ± 0.41	5.46 ± 0.44	0.99
Liver, %	1.46 ± 0.11	1.90 ± 0.12	0.02
Kidney, %	0.52 ± 0.05	0.49 ± 0.06	0.61

[1]Liveweight; [2]Dry matter; [3]Metabolisable energy; [4]Average daily gain; [5]Live weight gain [6]Efficiency of feed utilisation [7]Head, skin and feet; [8]All four stomach compartments

Calculations and statistical analysis

Total metabolisable energy (ME) intake was calculated as the sum of ME in milk and pellets (for MP lambs). ME intake was calculated as 0.91 x gross energy (GE) intake (Roy 1980) for milk and 13.5 and 13.9 MJ/kg dry matter (DM) intake Start Mix and Performance pellets, respectively. Empty body weight (EBW) was obtained by deducting the weight of the digesta from the fasted live weight and the efficiency of feed utilisation (EFF) was calculated as average daily gain (ADG) divided by absolute daily DM intake.

The measured parameters for growth performance, carcass and organ weights were analysed using the generalised linear model procedure (Proc GLM) in SAS (2013) with the fixed effect of feeding group. To derive the ME requirement for maintenance and growth, a model was fitted to the individual data set for all lambs (21 per lamb; n = 315) with feeding group as a fixed effect; metabolic live weight ($LW^{0.75}$) and live weight gain (LWG) as covariates and the interactions to test the homogeneity of the covariates and lambs within the feeding groups as a random effect.

Results and discussion

The range of values for intakes, growth rates and efficiencies are presented in Table 2. One lamb from the MP group died as result of a rupture in the abomasum and was excluded from the study. Mean milk powder intake of lambs during the study (60 ± 1days) was not different ($P > 0.05$) for the two groups; 11.07 kg ± 0.11 vs 10.84 kg ± 0.11 for MO and MP respectively. The mean pellet intake of MP lambs for the duration of the trial was 125.33 g DM/day. Studies on artificial rearing have generally reported that the intake of solid feed before 21 days is negligible (Owen et al. 1969; Walker & Hunt 1981; Lane et al. 1986) particularly when milk was offered concurrently (Walker & Hunt 1981). In the present study some MP lambs started nibbling at the pellets as early as 3 days of age (although milk was fed to appetite) and by 9 days of age all lambs were observed to be consuming pellets with intakes ranging from 13.32 g to 63.28 g DM/day.

Addition of pellets to the diet of MP lambs had a significant effect on their LW, empty body weight (EBW), LWG and the hot carcass weights of the lambs (Table 2). Final LW, LWG and EBW were greater ($P < 0.05$) in MP lambs than in MO lambs which were not unexpected. The efficiency of feed utilisation (EFF) was similar ($P > 0.05$) between the two feeding groups. As a percentage of EBW, no differences ($P > 0.05$) were observed in the hot carcass weight, HSF, intestines and kidney among the two treatments, whereas the total internal organ weight, stomach and liver sizes were greater ($P < 0.05$) in MP lambs. The findings concur with those of Hamada et al. (1976) and Potchoiba et al. (1990) who demonstrated that growth of internal organs relative to body weight in goat kids was stimulated only during the period of solid feed intake. Histological studies are currently being conducted on lamb stomachs to examine development. By offering *ad libitum* cereal based pellets from 4 days of age, Muir et al. (2002) successfully weaned Friesian bull calves at 5 weeks of age. Thus introduction of pellets early in life may offer the opportunity of early weaning in lambs.

The maintenance and growth energy requirement for the two feeding groups over the experimental period were:

MO group: ME intake = 1.09 + 0.35 (± 0.03) $LW^{0.75}$ + 6.80 (± 0.44) LWG

MP group: ME intake = 1.09 + 0.52 (± 0.03) $LW^{0.75}$ + 6.80 (± 0.44) LWG

The value for maintenance requirement (0.35MJ/kg $LW^{0.75}$/day) for MO lambs was within the range reported previously for indoor fed lambs (0.339 – 0.47MJ/kg $LW^{0.75}$) (Walker & Norton 1971; Thomson et al. 1979); whilst that obtained for MP lambs (0.52 MJ/kg $LW^{0.75}$/day) was higher ($P < 0.01$) than the values for milk fed lambs but almost identical to the value obtained by Nicol & Brookes (2007) (0.5 MJ/kg $LW^{0.75}$) for ram lambs on pasture. There was no interaction effect between LWG and feeding groups; thus the ME value (6.80 MJ/kg LWG/day) obtained for growth was the same ($P > 0.05$) for both groups.

Conclusion

Pellet consumption started earlier than previously reported suggesting it may be possible for lamb rumen development to begin at a very early age, which may allow for early weaning. As expected, feeding the pellets in addition to milk replacer resulted in greater lamb growth, carcass and organ weights than feeding milk replacer only. However, there was no difference in the efficiency of feed utilisation between lamb groups. Metabolisable energy requirement for maintenance was higher in lambs fed milk and pellets than in the milk only fed lambs; ME requirement for growth on the other hand, was the same for both groups.

Acknowledgements

The authors gratefully acknowledge the National Research Centre for Growth and Development (Gravida) and Massey University for funding this research.

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