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Effects of dietary protein and energy intake on growth, body composition and nutrient utilisation in lambs reared artificially with milk replacers and pellet feeds

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ABSTRACT

A growth simulation model demonstrated that the ratio between crude protein (CP) and metabolisable energy (ME) intake (CP:ME) of lambs reared artificially with milk replacers and pellets feed did not adequately match their requirements and this mismatch would limit their growth in early life. The aim of this study was to test the effect of a modelled ratio between CP and ME intake on growth, body composition and nutrient utilization. A total of 28 Romney twin-born male lambs were allocated to a randomized 2 × 2 factorial design with seven lambs per treatment. Treatments consisted of two protein levels in iso-energetic milk replacer (normal CP:ME milk [NM] and high CP:ME milk [HM]) fed as a proportion of the lamb's live weight (LW) and two protein levels in iso-energetic pellets (low-CP:ME pellets [LP] and high CP:ME pellets [HP]) fed *ad libitum*; resulting in four experimental groups (NMLP, NMHP, HMLP, HMHP). This design resulted in lambs having different CP intake to ME intake ratio during the experiment. Lambs were kept indoors in individual pens. Five lambs from each treatment were placed in metabolic cages at 9 kg and 16 kg live weight (LW) for 4 d to allow for total fecal and urine collection. All lambs were slaughtered at 18 kg LW. The weights and chemical composition of the carcass, organs, head and skin were determined. Lambs fed HM had greater ($P < 0.01$) CP intake, daily gain, gain to feed ratio and greater liver and kidney weights than lambs fed NM. Pellet treatment had no effect ($P > 0.05$) on any of the intake or growth measurements. Pellet intake was low and contributed only to 20% of the CP intake and 18% of the ME intake. Deposition of protein and water in the carcass, organs, and empty bodies were greater ($P < 0.01$) in HM than in NM lambs. Fat deposition and energy retention in carcass, organs, and empty bodies were greater ($P < 0.05$) in NM than in HM lambs. Pellet treatment had no effect ($P > 0.05$) on protein, fat and water deposition rates. A maximum protein deposition rate of 43 g per day was measured for lambs having a CP:ME intake ratio in excess of 14.2. In conclusion, increasing the CP:ME ratio of milk replacer is a way of improving lean growth rates in pre-weaned lambs.

Abbreviations: Ad, daily ash deposition rate; ADF, acid detergent fibre; ADG, average daily gain; BL, Basal group; CP, crude protein; DE, digestible energy; DM, dry matter; DN, digestible nitrogen; EBW, empty body weight; Fd, daily fat deposition rate; GE, gross energy; HM, high protein milk; HP, high protein pellet; LP, low protein pellet; LW, live weight; ME, metabolisable energy; MPC, milk protein concentrate; MR, milk replacer; N, nitrogen; NDF, neutral detergent fibre; NM, normal milk; Pd, daily protein deposition rate; RN, retained nitrogen; Wd, daily water deposition rate

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1. Introduction

One of the aims of the New Zealand sheep industry is to improve live weight (LW) gain of pre-weaned lambs and consequently, the total weaning weight of lambs per ewe (Morris and Kenyon, 2014). However, improving LW gain in animals does not necessarily result in an increase in lean tissue deposition as the gain may be deposited as fat (Stobo et al., 1966). Since Sheep farmers in New Zealand are paid premiums for the production of lean lamb carcasses (Schreurs, 2012) the emphasis should shift from maximizing daily gain to increasing lean tissue growth.

Altering dietary composition is one approach to improve feed efficiency in pre-weaned ruminants. Increasing crude protein (CP) content of milk replacers (MR), and thus the corresponding protein to energy ratio can increase both live weight gain and protein deposition in lambs (Jagusch et al., 1970; Norton et al., 1970) and calves (Diaz et al., 2001; Blome et al., 2003). Likewise, offering low-protein solid feed to veal calves has been shown to reduce urinary nitrogen (N) excretion and improve N utilization for protein gain (Berends et al., 2012). However, there is no information on the effect of altering both MR and solid feed composition on the growth, body composition, and N utilization in lambs pre-weaning.

A simulation model derived in a recent study (Danso et al., 2016) showed that the CP to metabolisable energy (ME) intake ratio needed to meet a lamb's growth requirement decreased curvilinearly from a value of 13.1 at 5 kg LW to 10.0 at 30 kg LW. Given that the CP to ME ratio is approximatively 11 in ewe's milk (Paten et al., 2013) and 16–20 for New Zealand pastures (Brookes and Nicol, 2007), these CP to ME ratios do not match the young lamb's nutritional requirements. This likely limits growth in early life, while protein intake is wasted later as pasture intake increases and milk intake decreases.The aim of this study was to investigate the effect of different CP to ME intake ratio on growth, body composition, and nutrient utilisation during artificial rearing. This was achieved by feeding pre-weaned lambs, milk replacers and pellet feeds with different CP:ME ratios.

2. Materials and methods

The study was conducted at Massey University 5 km South of Palmerston North, New Zealand during the months of September to December 2015. The study and animal handling procedures were approved by the Massey University Animal Ethics Committee (MUAEC 15/54).

2.1. Experimental design, animals and management

Thirty-two sets of Romney twin lambs with at least one male born to mixed aged ewe were selected at birth for the present study. Lambs were allowed to suckle from their dam for 1 d post-partum before one male lamb per litter was removed for the study. The remaining lamb within the litter grazed with their dam on a rye-grass white clover pasture. Four lambs (5.2 kg ± SD 0.26 kg) were slaughtered 1 d post-partumto provide baseline (BL) body composition data. The remaining 28 male lambs were moved indoors, kept in single pens and hand-reared. The floor space of the pens measured 1.94 m^2 and the average minimum and maximum room temperature recorded over the study period were 14 °C and 24 °C, respectively. The 28 lambs were randomly allocated to a 2 × 2 factorial design with seven lambs per group. Treatments consisted of two CP:ME ratio in iso-energetic Milk Replacers (MR): normal CP:ME milk [NM; Milligans Feed Ltd, Oamaru, New Zealand] and high CP:ME milk [HM] and two CP:ME ratio in iso-energetic pellets:low CP:ME pellets [LP] and high- CP:ME pellets [HP]; … The HM consisted on an as-is basis of 800 g/kg NM and 200 g/kg milk protein concentrate ([MPC]; Fonterra, Palmerston North, New Zealand) and contained 312 g/kg crude protein. Liquid MR (NM or HM) was prepared daily with warm tap water at 30 °C at a ratio (w/w) of 1 part MR to 4 parts water to give 196 g of dry matter (DM) per kg milk replacer as fed. The quantity of MR given (on an as is basis) and the frequency of feeding were adjusted as lambs grew and aged. Lambs were bottle fed milk (MR plus water) five times daily totaling 150 g/kg LW in the first 14 d. From day 15, bottle feeding was reduced to four times totaling 100 g/kg LW until the end of the study. This resulted in an average initial amount of milk powder (on a as is basis) being 175 g/d at 5 kg LW which gradually increased to 360 g/d at 18 kg LW (end of the study). The quantity of milk fed per kg LW was reduced to encourage greater pellet consumption. The LP pellets mix consisted of 555 g/kg barley, 348 g/kg broll (bran/pollard mix) 68 g/kg soy bean meal and 30 g/kg molasses. The HP pellets mix consisted of 395 g/kg barley, 356 g/kg broll (bran/pollard mix) 218 g/kg soy bean meal and 30 g/kg molasses. All lambs had *ad libitum* access to pellets in feeder from day one until the end of the study. Milk intake and pellet intake were recorded daily as the daily amount offered, minus the amount refused. Lambs were weighed at the start of the study and then twiceweekly before the first feeding of the day and MR allowance was adjusted accordingly. There was either a 3 day or a 4 day gap between weekly weighing (3 + 4 = 7 day = one week). Water was available at all time.

2.2. Digestion and metabolism trial

A nutrient balance study was conducted to determine energy and N utiliation in a subset of lambs The same 20 randomly chosen lambs (n = 5 per treatment group) were temporarily moved from their single pen to metabolic cages at an average LW of 9.06 kg (period one) and 16.30 kg LW (period two), and feed as usual. The metabolic crates had a mesh floor with a funnel tray underneath and were 94 cm long, 52 cm wide and 70 cm high. Total faeces were collected over a 4 day period, weighed and pooled together within lamb, for each time period. Faecal samples were then sub-sampled, freeze-dried, ground, and stored until being chemical analysed. The funnel tray underneath the crate allowed for urine collection into a plastic bucket. Each day, 0.2 g of Potassium dichromate ($K_2Cr_2O_7$) was put into the collection bucket to inhibit growth of bacteria and enzymatic processes that cause loss of N (Diaz et al., 2001). For each period of the digestibility study, the total urine per lamb was collected, measured daily over the 4-d period, pooled together, sub-sampled, frozen and stored at −20 °C for further analysis.