Performance, carcass traits and costs of Suffolk lambs finishing systems with early weaning and controlled suckling

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ABSTRACT

The performance, carcass traits and finishing costs of Suffolk lambs were evaluated in three systems: (1) lambs weaned with 22 kg of body weight (BW) and supplemented with concentrate on pasture until slaughter; (2) lambs weaned with 22 kg BW and fed in feedlot until slaughter; (3) lambs maintained in controlled nursing after 22 kg BW and creep fed in feedlot until slaughter. Average daily gain (ADG) was 224 g/d for lambs weaned and supplemented with concentrate on pasture, 386 g/d for lambs weaned in feedlot and 481 g/d for lambs under controlled nursing. Empty body weight and visceral fat deposition were highest in lambs from feedlot systems. Carcass weights and carcass yields were highest for lambs in controlled nursing. Finishing total costs were highest in controlled nursing and lowest in the system with weaning in feedlot. High concentrate diet associated with controlled nursing in feedlot allowed lambs to reach the growth potential and carcasses with higher weights, higher yields and higher fat content. After weaning, lambs in feedlot fed with high concentrate diet had higher weight gain than lambs supplemented with concentrate on pasture. Carcasses produced under these two systems presented the same characteristics. The system with weaning in feedlot showed the lowest cost per kg carcass.

Key words: average daily gain, carcass weight, concentrate supplementation, cost per kg carcass, finishing period.

RESUMO

Desempenho, características de carcaça e custos da terminação de cordeiros Suffolk em sistemas com desmame precoce e amamentação controlada

O objetivo deste trabalho foi avaliar o desempenho, as características de carcaça e os custos da terminação de cordeiros Suffolk em três sistemas: (1) cordeiros desmamados com 22 kg de peso corporal (PC) e mantidos em pastagem com suplementação concentrada até o abate; (2) cordeiros desmamados com 22 kg de PC e confinados até o abate; (3) cordeiros mantidos em amamentação controlada após atingirem 22 kg de PC e confinados com alimentação em *creep feeding* até o abate. Os valores de ganho médio diário (GMD) foram 224 g/dia para os cordeiros desmamados e suplementados em pastagem; 386 g/dia para os cordeiros desmamados e confinados, e 481 g/dia para os cordeiros mantidos em amamentação controlada. O peso de corpo vazio e a deposição de gordura visceral foram maiores em

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cordeiros mantidos nos sistemas em confinamento. Os pesos e rendimentos de carcaça foram superiores para os cordeiros mantidos em amamentação controlada. O custo total de terminação foi maior neste sistema e menor no sistema com desmame em confinamento. A oferta de dieta com alta proporção de concentrado associado à amamentação controlada em confinamento permitiu que os cordeiros atingissem o potencial de ganho de peso, determinando a produção de carcaças com peso, rendimento e teor de gordura elevados. Após o desmame, cordeiros confinados e alimentados com alta proporção de concentrado na dieta apresentaram maior ganho de peso que os suplementados com concentrado em pastagem. As carcaças produzidas nesses dois sistemas apresentaram as mesmas características. O sistema com desmame em confinamento apresentou menor custo/kg de carcaça produzida.

Palavras-chave: custo por kg de carcaça, ganho médio diário, peso de carcaça, suplementação concentrada, período de terminação.

INTRODUCTION

Early weaning associated with improved nutritional status in the post-weaning period is a strategy used in lamb finishing. High protein and energy concentrate content for grazing lambs and diets with high concentrate for feedlot lambs can ensure the intake of high-quality food after weaning. Lambs moderately supplemented with concentrate (2% of body weight - BW) on good quality pastures feature 150 to 200 g/day of weight gain (Carvalho *et al*., 2007; Ribeiro, 2010; Fernandes *et al*., 2011). Lambs fed diets with high concentrate content (above 300 g/kg of dry matter - DM), in confinement, may have weight gains from 350 to 450 g/day (Poli *et al*., 2008; Ribeiro *et al*., 2009).

Another strategy is the provision of diets with high concentrate for unweaned lambs, which is denominated creep feeding. In this condition, feedlot lambs show weight gains above 400 g/day. These animals can gain weight above 400 g/day in confinement (Garcia *et al*., 2003). However, ewes under continued breastfeeding, as in creep feeding, may have greater loss of body condition and late return to postpartum estrus. In this case, the controlled or interrupted suckling, in which the lambs have access to breastfeeding at predetermined periods of the day, makes early return to postpartum estrus, ensuring greater efficiency to the production system (Assis *et al*., 2011).

Carcass traits are influenced by breed, weight, age at slaughter and characteristics of the diet supplied to the lambs. Carcasses with satisfactory traits to the Brazilian consumers have been obtained with slaughtering of lambs at 36 kg BW, between 90 and 120 days of age (Monteiro *et al*., 2009). The concentrate content of the diet affects the level of energy intake by the lambs and, also, the weight, yield and fat content of the carcass. WThese traits are higher in carcasses of lambs supplemented with moderate to high levels of concentrate on pasture (Carvalho *et al*., 2007; Ribeiro, 2010; Fernandes *et al*., 2011), lambs fed diets with high concentrate content in feedlot, and also those unweaned until slaughter (Fernandes *et al*., 2008; Ribeiro *et al*., 2009).

In this context, the aim of this study was to evaluate the performance, carcass traits and the finishing costs of Suffolk lambs in systems with early weaning and concentrate supplementation on pasture or high quality diet in confinement, from weaning to slaughter, and in system with controlled suckling and high quality diet in feedlot until slaughter.

MATERIALS AND METHODS

The experiment was carried out between September/ 2006 and January/2007, at the Laboratory of Production and Research on Sheep and Goats (LAPOC), Universidade Federal do Paraná (UFPR), Pinhais - PR.

Three finishing systems were compared: (1) lambs weaned at 22 kg BW and kept on pasture with concentrate supplementation until slaughter; (2) lambs weaned at 22 kg BW and fed in feedlot until slaughter; and (3) lambs kept under controlled suckling after reaching 22 kg BW and creep fed in feedlot.

The experiment was arranged in a completely randomized design with three treatments and six replications. Eighteen non-castrated male lambs of Suffolk breed were distributed uniformly in the finishing systems based on BW and type of birth (three single lambs and three twin lambs). After birth, the lambs remained with the ewes in a slatted-floor pen, and from 21 days of age were supplemented with protein-energy concentrate (DM = 878.7 g/kg of natural matter – NM; crude protein - CP = 227.7 g/kg DM; metabolizable energy - ME = 3.05 Mcal/kg DM) in 1.85% BW in DM/day.

The period of adaptation to finishing systems began when the lambs reached 30 days of age on average. From this age, the lambs of the system on pasture were kept with ewes on annual ryegrass (*Lolium multiflorum* Lam) overseeded on Tifton-85 (*Cynodon* spp.) and creep fed on protein-energy concentrate in 1.85% of BW in DM/ day. The lambs of feedlot systems remained with ewes in the slatted-floor pen and were fed diet containing 500 g/kg DM of protein-energy concentrate and 500 g/kg DM of corn silage (DM = 270.4 g/kg NM; CP = 83.3 g/ kg DM; ME = 2.52 Mcal/kg DM) *ad libitum* in creep feeding. The experiment started when the lambs reached 22.2 ± 0.7 kg BW and 52 ± 2 days of age (mean ± standard error - SE).

In the system on pasture the grazing method was continuous grazing with variable stocking, in which test lambs remained in the pasture and extra lambs were used to adjust the stocking rate, using the "put and take" technique (Mott and Lucas, 1952). The adjustments were made every 21 days, to ensure a minimum leaf mass of 1000 kg DM/ha without limiting herbage intake (Rattray *et al*., 1987). The supplementation with protein-energy concentrate was maintained at 1.85% BW, in DM/day, and provided once daily (9:00 am).

In the feedlot system, lambs were fed diet containing 600 g/kg DM of protein-energy concentrate and 400 g/kg DM of corn silage, keeping the leftovers at 10% of the amount provided daily to not limit feed intake. The total amount of feed was split into two feedings per day (9:00 am and 4:00 pm) and provided on the post-weaning period to weaned lambs and in creep feeders to lambs under controlled suckling. The diet was formulated to meet the nutritional requirements of weaned lambs with moderate growth potential (200 to 345 g/day; NRC, 1985).

In the system with controlled suckling , the ewes were separated from lambs every day for 6 hours (8:30 am to 2:30 pm), and kept on limpograss pasture. Ewes were kept with the lambs on the remaining of day, and before and after the grazing period were fed, feeding on a diet containing 400 g/kg DM of energy concentrate (DM = 881.3 g/kg NM; CP = 158.4 g/kg DM; ME = 3.21 Mcal/kg DM) and 600 g/kg DM of corn silage. This diet was provided to meet 80% of the daily requirement of DM intake in lactation (NRC, 1985). The diet was split into two feedings daily (8:00 am and 4:00 pm) and provided in feeders maintained 50 cm over the ground to avoid the access of lambs to the feeding.

The adjustment of diets provided in feedlot and the amount of concentrate provided on pasture were performed every 14 days, based on animals weight measurements carried out after fasting for 16 hours.

The protein-energy concentrate was composed, on NM basis, by 310 g/kg of soybean meal, 510 g/kg of ground corn grain, 150 g/kg of wheat bran, 20 g/kg of mineral supplement (Ovinophós®), 5 g/kg of limestone and 5 g/kg of sodium chloride. The energy concentrate was composed, on NM basis, by 150 g/kg of soybean meal, 600 g/kg of ground corn grain, 200 g/kg wheat bran and 20 g/kg of mineral supplement (Ovinophós®), 20 g/ kg of limestone 10 g/kg of sodium chloride.

Parasitological monitoring was performed every 14 days. The degree of anemia was assessed by the Famacha® method (Molento *et al*., 2004) and the number of eggs per gram of feces (EPG) by the modified McMaster technique (Gordon and Whitlock, 1939). Anthelmintic drugs (Moxidectin 0.2% - 1 mL/50 kg BW; and Nitroxynil 34% - 1 mL/25 kg BW) were administered to animals with Famacha degree equal or higher than 3 and/or equal or higher than 700 EPG.

The average daily gain (ADG) of lambs was calculated on the basis of the post-fasting weights obtained every 14 days. The individual ADG was calculated by linear regression of the BW as a function of the age of the lambs in the weighing dates. The regression equation model corresponded to $Y_i = \beta_0 + \beta_1 X$, where Y_i = body weight (kg) at age *i*; β_0 = intercept of the regression; β_1 = average daily gain (kg/day); and X = age (days). The coefficient of determination (R^2) of the regression equations was 0.9813 and indicated that the growth pattern of the lambs in finishing systems was normal, and that the method used to calculate of ADG was suitable to evaluate the animal performance.

In the system with controlled suckling, the ewes were weighed after 16 hours fasting at the beginning (EW_I) and the end (EW_F) of the experiment. The ADG was calculated by subtracting EW_I from the EW_F and dividing the result by the number of days of the experiment.

Lambs were slaughtered when reaching 36 kg BW, after 16 hours fasting (SW). The slaughter procedure consisted in electric stunning (8 seconds, 220 V) followed by bleeding performed by the section of the jugular veins and carotid arteries. The lambs were then skinned and gutted. The weight of gastrointestinal contents (GC) (full minus empty gastrointestinal tract) was calculated to determine the empty body weight (EBW = SW - GC). Visceral fat (omental, mesenteric and perirenal) was separated and weighed.

After dressing, the carcasses were weighed to register the hot carcass weight (HCW), hanged by tarsometatarsal joints on 17-cm meat hooks, cooled in a chill-room at 5 ºC for 24 hours and weighed again to obtain the weight of the cold carcass weight (CCW). The biological yield (BY = (HCW/EBW) x 100), hot carcass yield (HCY = (HCW/ SW) x 100), cold or commercial carcass yield (CCY = (CCW/ SW) x 100) and the cooling losses (LC = [(HCW - CCW)/ HCW] x 100) were determined.

The cost analysis of lamb finishing in the three systems was performed considering a farm similar to LAPOC-UFPR.

The analysis was performed in a spreadsheet elaborated with the experimental data and the prices found at ANUALPEC (2012), in the list of prices paid for the product in May/2013 and published by SEAB-PR (2013). Prices were obtained by budget when not available in these sources.

In the spreadsheet, costs of maintenance and depreciation of facilities (1), and machinery and equipment (2), labor (3), technical assistance (4), implantation and fertilization of pastures (5), feeding (6), animal health care (7), energy (8), transportation and slaughter of lambs (9) and taxes related to revenue from the sale of frozen meat on the farm (10) were calculated. The fixed cost included the sum of items 1, 2, 3, 4 and 9; the variable cost corresponded to the sum of items 5, 6, 7, 8 and 10; and the total production cost was obtained by the sum of the fixed and variable costs. The cost calculation was adjusted to the period of finishing in each system and the results were expressed as annual costs (R$/year).

Production modules of 100 male lambs for slaughter were simulated in order to allow the comparison of the production costs of each finishing system. The cost per kg of carcass produced (R$/kg) was calculated dividing the total production cost (R$/year) by the amount of carcass produced (kg/year).

Data of performance and carcass traits were subjected to analysis of variance by the general linear model (GLM) for completely randomized designs. The means that showed significant difference among treatments were compared by Tukey test at 5% significance. The costs of finishing systems were compared by descriptive analysis. Statistical analysis was performed using the software Statistical Analysis System version 8.2 (SAS, 2001).

RESULTS AND DISCUSSION

The lamb weights at the beginning of the experiment and at slaughter did not differ ($P>0.05$) among the finishing systems (Table 1). The homogeneity and low variation (low SE values) of these variables were determined by the strict control of the individual weights at the beginning of the experiment and at slaughter. The mean weight of lambs at slaughter corresponded to 36.7 ± 0.3 kg (mean ± SE) (Table 1).

The system with controlled suckling had the highest ADG ($P < 0.05$) with 481 g/day (Table 1). Compared to the system with weaning in feedlot, the controlled suckling increased the lambs ADG by 95 g/day. The presence of the ewes (lambs' mothers) in the production system and the breastfeeding are important factors to decrease stress, improve nutritional status and promote the development of lambs (Poli *et al*., 2008; Ribeiro *et al*., 2009).

Milk is an important source of nutrients and contributes effectively to lamb growth until 60 days of age, but above that age milk is still part of the diet of suckling lambs (Silva *et al*., 2010). Therefore, the presence of the ewe and controlled suckling allowed lambs in feedlock to reach high performance.

The ADG of lambs in controlled suckling was higher than that reported by Garcia *et al*. (2003) and Almeida Júnior *et al*. (2004), who observed in creep-fed Suffolk lambs maximum values of 408 and 396 g/day, respectively. In these studies, lambs were fed *ad libitum* diets with high concentrate (850 g/kg DM) and levels of CP and ME close to 200 g/kg and 2.90 Mcal/kg DM, respectively.

Compared with the controlled nursing, the lower ADG reported by Garcia *et al*. (2003) and Almeida Júnior *et al*. (2004) for creep-fed lambs may be related to the nutritional status and, consequently, to the ewes' milk production. These ewes remained on pastures with low supply of poor quality forage and were supplemented with Tifton-85 hay *ad libitum* and concentrate at 1% BW/day (Garcia *et al*., 2003) or only with concentrate at 0.8% BW/day (Almeida Júnior *et al*., 2004). The ewes in the system with controlled suckling were fed diet containing high concentrate (1.5% BW/day) and good quality corn silage.

In addition to the forage consumed on the pasture during the day, the diet fed in feedlot fully supplied the requirements of CP and ME intake of ewes during lactation (NRC, 1985). The ewes ADG was 71 g/day, which was 96 g/day higher than the minimum limit of the performance range expected for lactating ewes (-25 g/day; NRC, 1985). Under these conditions, the potential of milk production of the ewes may have been reached, favoring the high performance of lambs in the system with controlled suckling.

Although the ADG was higher in the system with controlled suckling, the lambs were slaughtered with similar age ($P > 0.05$) to the lambs in the system with weaning in feedlot (Table 1). The difference between these two systems for the slaughter age of lambs was approximately 14 days.

Weaned lambs in feedlot had ADG (367 g/day) lower than that reported by Poli *et al*. (2008) and close to that obtained by Ribeiro *et al*. (2009) for Suffolk lambs produced under similar conditions of the present study, which were 437 and 369 g/day, respectively. The superiority of the ADG reported by Poli *et al*. (2008) is explained by the better quality of the diet fed to the lambs, which contained 400 g/kg DM of concentrate, 600 g/kg DM of alfalfa hay, and levels of 192 g/kg DM CP and 2.44 Mcal/kg DM ME in the total diet. The diets used by Ribeiro *et al*. (2009) and in this study had average levels of 145 g/kg DM of CP and 2.66 Mcal/kg DM of ME, which may explain the close values of ADG recorded for weaned lambs in feedlot of both studies.

Lambs weaned and supplemented on pasture had lower ADG (224 g/day) (P <0.05) and, therefore, higher slaughter age (116 days) (P <0.05) than lambs in feedlot (Table 1). Probably the lower dietary energy density and higher energy expenditure with grazing determined the lower ADG of lambs on pasture.

In the feedlot system, the lambs were daily fed concentrate at 2.62% BW in DM, which corresponded to 780 g DM/animal/day, while the lambs kept on pasture were supplemented with 470 g DM/animal/day of concentrate. Thus, the concentrate intake by the grazing lambs was 310 g DM/animal/day lower than by the feedlot lambs, which represented a reduction of 0.95 Mcal/day of ME by the first ones. In this condition, there may be a decrease in the amount of propionate produced by rumen fermentation, which is the main short chain fatty acid used for energy production of (Baldwin *et al*. 2004). Therefore, the efficiency of dietary energy use may have been lower in lambs kept on pasture.

The energy spent on grazing also decreased the efficiency of dietary energy use by lambs kept on pasture. Sheep under grazing condition spend 30% more energy than those kept in feedlot, because of the energy expenditure on grazing activity (Caton and Dhuyvetter, 1997).

The occurrence of parasitic infections also affected the performance of lambs kept on pasture. An average of 2200 EPG was recorded for these animals and only 100 EPG for lambs in feedlot. Parasitic infection is one of the main factors that cause decrease in performance of sheep raised on pasture, especially in young animals, due to their high susceptibility (Miller and Horohov, 2006). High level of parasitic infection led to increased in the nutritional requirements of lambs kept on pasture, because in parasitized animals the priorities for the distribution of nutrients in the body are oriented, for the recovery of damages caused by the parasites (Roy *et al*., 2003).

Despite the low efficiency of dietary energy use and high parasitic infection, the performance of lambs weaned and supplemented on pasture was satisfactory. These animals showed higher ADG than the minimum expected for lambs raised on pasture after weaning, which is 200 g/day (Kenyon and Webby, 2007). Supply of concentrate to lambs and pasture management directed to the maintenance of high leaf mass (1076 kg DM/ha on average) were determinant for obtaining ADG above 200 g/day.

The ADG of lambs weaned and supplemented on pasture was higher than that observed in studies with Suffolk lambs, which were supplemented with the same amount of protein-energy concentrate after weaning (Ribeiro, 2010; Fernandes *et al*., 2011). Evaluating the performance of lambs supplemented with concentrate and annual grazing ryegrass, Ribeiro (2010) recorded ADG of 151 g/day in non-castrated male lambs slaughtered at 32 kg BW and with 137 days of age. Fernandes *et al*. (2011) recorded ADG of 191 g/day for ram lambs supplemented with concentrate on Tifton-85 pasture and slaughtered at 34 kg BW and 136 days of age.

The EBW was similar (P > 0.05) between lambs finished in the feedlot systems, with mean of 31.9 kg (Table 2). Lambs kept on pasture had EBW (29.8 kg) lower (P < 0.05) than lambs in feedlot. Despite the differences in EBW, the bBY did not differ (P > 0.05) among the finishing systems and showed mean of 55.4% (Table 2).

The EBWt is influenced by the gastrointestinal tract weight, which varies with diet characteristics, especially by the concentrate content in it (Medeiros *et al*., 2009). Weaned lambs kept on pasture showed weight of GC weight similar (P > 0.05) to the weaned lambs in feedlot, with mean of 6.15 kg (Table 2). The GC weight of lambs under controlled suckling was lower (P < 0.05) than weaned lambs and corresponded to 4.5 kg. The higher GC weight in weaned lambs indicates that these animals consumed a larger amount of roughage than those kept in controlled suckling. In animals that consume large quantities of roughage, the rumen retention time is longer

Table 1. Means and standard error (M ± SE) for performance traits of Suffolk lambs in three finishing systems

Variables	Systems			P-value
	Weaning and supplementation on pasture	Weaning and feedlot	Controlled suckling and feedlot	
BWI (kg)	23.2 ± 1.0	21.8 ± 0.8	21.4 ± 1.7	0.5226
SW (kg)	36.1 ± 0.2	37.2 ± 0.4	37.0 ± 0.6	0.1623
ADG (g/day)	224 ± 15 c	386 ± 21 b	481 ± 18 a	0.0000
PExp (days)	57 ± 4 a	41 ± 3 b	32 ± 4 b	0.0015
SA (days)	116 ± 5 a	92 ± 4 b	78 ± 4 b	0.0002

BWI = initial body weight; SW = body weight at slaughter; ADG = average daily gain; PExp = experimental period; SA = slaughter age. Means followed by different lowercase letters in the same row are significantly different by the Tukey test (P < 0.05).

(Van Soest, 1994). Moreover, the difference between the GC weight of weaned lambs and those in controlled suckling was 1.45 kg, which represents the compensation of absence of milk in the diet by the increase in intake of solid feed by weaned lambs.

The differences observed in EBW are not only related to the GC weight, but also with the lambs body composition. The highest EBW of feedlot lambs indicate a greater deposition of muscle and adipose tissues in these animals compared to the lambs kept on pasture. This is confirmed by the higher HCW (1.1 to 2.4 kg heavier) and higher VF (mean 226.5 g higher) of feedlot lambs in relation to those kept on pasture (Table 2).

Compared to the weaned lambs, those kept in controlled suckling had higher ($P < 0.05$) weight and yield of hot and cold carcass (Table 2). These traits were similar ($P > 0.05$) between weaned lambs kept in feedlot and those kept on pasture. In lambs under controlled suckling, the highest carcass weights before and after cooling (18.5 and 18.2 kg, respectively) are related to increased fat deposition, which also determined high yield of hot and cold carcasses (50 and 49.2%, respectively). Bueno *et al*. (2000) reported increased yield before and after cooling with increasing carcass weight and found positive correlation between weight ($r = 0.84$) and yield ($r = 0.60$) of cold carcass with the percentage of fat in carcasses of Suffolk lambs slaughtered with 20 to 40 kg BW.

In addition to promoting weight gain, systems without weaning have allowed the production of heavier carcasses with higher yields and higher fat content than the systems with weaning. In lambs slaughtered with 32 to 34 kg of BW, carcasses weighing 1.6 to 2.3 kg higher and yields from 4.3 to 5.3% greater have been observed in unweaned lambs in comparison with weaned ones (Fernandes *et al*., 2008; Ribeiro *et al*., 2009). Under controlled suckling, the carcasses were on average 1.9 kg heavier and 4.7% had higher yields than in systems with weaning (Table 2). Thus, the controlled suckling has similar response to continuous suckling and allows the production of heavy carcasses with high fat content.

Carcasses obtained in the systems with weaning had mean weights of 16.7 and 16.2 kg for HCW and CCW, and 45.5 and 44.3% for HCY and CCY, respectively (Table 2). In this condition, the decision to finish weaned lambs with concentrate supplementation on pasture or in feedlot should be made considering the availability of facilities on the farm for the implementation of these systems, the cost of labor and feeding and time for finishing lambs.

The CL did not differ ($P > 0.05$) among the systems evaluated (Table 2). However, the losses by cooling of carcasses obtained in the feedlot systems were on average 2% lower than those from pasture system (3.2%). This difference indicates that the carcasses of feedlots lambs had greater fat deposition than those of lambs kept on pasture, because CL are lower in carcasses with higher fat content (Bueno *et al*., 2000). However, CL remained below the maximum acceptable (3-4%) in all finishing systems, indicating that the carcasses showed satisfactory fat cover (Almeida Júnior *et al*., 2004).

The VF deposition in lambs kept on pasture (513 g) was lower ($P < 0.05$) than in feedlot lambs, which were similar ($P > 0.05$) between them (average 740 g, Table 2). The percentage of deposited VF in relation to the SW was 1.4% for lambs on pasture and 2% for feedlot lambs, respectively. The higher energy intake from diet and less energy expenditure with physical activity determined greater VF deposition in feedlot lambs.

Table 2. Means and standard error (M ± SE) for post-slaughter body traits, carcass traits, gastrointestinal content and visceral fat deposition in Suffolk lambs in three finishing systems

Variables	Systems			P-value
	Weaning and supplementation on pasture	Weaning and feedlot	Controlled suckling and feedlot	
EBW (kg)	29.8 ± 0.5 b	31.2 ± 0.1 a	32.5 ± 0.4 a	0.0007
BY (%)	54.1 ± 0.8	55.1 ± 1.0	56.9 ± 0.7	0.1023
HCW (kg)	16.1 ± 0.3 b	17.2 ± 0.3 b	18.5 ± 0.4 a	0.0004
HCY (%)	44.7 ± 0.6 b	46.3 ± 1.1 b	50.0 ± 1.1 a	0.0042
CCW (kg)	15.6 ± 0.3 b	16.8 ± 0.3 b	18.2 ± 0.4 a	0.0003
CCY (%)	43.3 ± 0.6 b	45.3 ± 1.1 b	49.2 ± 1.1 a	0.0027
CL (%)	3.2 ± 0.6	2.3 ± 0.1	1.7 ± 0.3	0.0857
GC (kg)	6.3 ± 0.4 a	6.0 ± 0.3 a	4.5 ± 0.3 b	0.0151
VF (g)	513 ± 39 b	738 ± 53 a	741 ± 86 a	0.0224

EBW = empty body weight; BY = true or biological yield; HCW = hot carcass weight; HCY = hot carcass yield; CCW = cold carcass weight; CCY = cold carcass yield; CL = losses BY cooling; GC = gastrointestinal content; VF = visceral fat.

Means followed by different lowercase letters in the same row are significantly different by the Tukey test ($P < 0.05$).

The total finishing cost was higher in the system with controlled suckling and lower in the system with weaning in feedlot (Table 3). The total finishing cost in the system with weaning on pasture was 10.5% (R$ 2,553.96) higher than in the system with weaning on feedlot. The highest costs with maintenance and depreciation of facilities, temporary labor, animal health care, energy and the cost of establishment and fertilization of Annual Ryegrass pasture determined the higher total finishing cost in the system with weaning on pasture in relation to the system with weaning on feedlot (Table 3).

Considering the cost actually paid by the farmer, the costs of permanent labor and technical assistance had the greatest impact on the total finishing cost in the three systems (Table 3). These items accounted for 19.5 to 25% and 11-13% of the total finishing cost respectively, and are among the components that have the greatest influence on the total cost of sheep meat production (Barros *et al*., 2009a; 2009b). The cost of temporary labor was proportional to the finishing period in each system, and was higher in the system with weaning on pasture and lower in the system with controlled suckling. In these systems, the cost of temporary labor corresponded to 6.3 and 3.0% and in the system with weaning in feedlot corresponded to 5.0% of the total finishing cost.

The cost of feeding the lambs was highest in the system with weaning in confinement and lowest in the system with weaning on pasture (Table 3). This item represented 7.1, 11.2 and 6.8% of the total finishing cost in systems with weaning on pasture, weaning in feedlot and controlled suckling, respectively. However, other costs related to the lambs feeding must be considered in the system with weaning on pasture, such as the cost of pasture fertilization and establishment of annual ryegrass, which represented 5.7% of the total finishing cost; and in the system with controlled suckling with the cost of feeding ewes and fertilization of Hemarthria, which represented 6.0 and 4.3% of the total finishing cost, respectively. Therefore, costs related directly or indirectly to the feeding of lambs in the systems with weaning on pasture and with controlled suckling represented 12.8 and 17.1% of the total finishing cost, respectively.

The lowest cost/kg of produced carcass was recorded in the system with weaning in feedlot (R$ 14.44/kg) and the highest cost/kg in the system with weaning on pasture (R$ 17.19/kg, Table 3). In addition to the highest costs compared with the system with weaning in feedlot, the longest time for finishing the lambs determined the increase in the cost/kg of carcass produced by R$ 2.75 in the system with weaning on pasture. Although carcasses obtained from these systems have similar CCW (Table 2),

Table 3. Costs and amount of carcass produced for 100 non-castrated male lambs of Suffolk breed in three finishing systems

Item	Systems		
	Weaning and supplementation on pasture	Weaning and feedlot	Controlled suckling and feedlot
Facilities (R$/year) [1]	4,188.96	2,832.68	5,806.59
Machinery and equipment (R$/year) [1]	3,797.59	3,921.93	4,058.26
Permanent labor (R$/year)	6,044.88	6,044.88	6,044.88
Temporary labor (R$/year)	1,676.92	1,206.21	941.43
Technical assistance (R$/year)	2,990.89	2,990.89	3,987.85
Transport and slaughter (R$/year)	1,700.00	1,700.00	1,700.00
Pastures (R$/year) [2]	1,538.77	0.00	1,334.80
Feeding of ewes (R$/year)	0.00	0.00	1,858.41
Feeding of lambs (R$/year)	1,891.31	2,728.00	2,107.58
Health of ewes (R$/year) [3]	0.00	0.00	23.87
Health of lambs (R$/year) [3]	94.53	20.88	14.22
Energy (R$/year) [4]	564.24	309.45	382.64
Taxes (R$/year)	2,329.87	2,509.08	2,718.17
Fixed cost (R$/year) [5]	20,399.24	18,696.59	22,539.01
Variable cost (R$/year) [6]	6,418.72	5,567.41	8,439.69
Total finishing cost (R$/year) [7]	26,817.96	24,264.00	30,978.70
Carcass produced (kg) [8]	1,560.00	1,680.00	1,820.00
Cost/kg carcass produced (R$/kg) [9]	17.19	14.44	17.02

[1]Maintenance and depreciation; [2]Establishment and fertilization; [3]Application of anthelmintic; [4]Electricity, fuel for machinery and equipment; [5]Sum of the items facilities until transport and slaughter; [6]Sum of the items pastures until taxes; [7]Sum of fixed and variable costs; [8]Cold carcass weight multiplied by the number of slaughtered lambs; [9]Ratio between total finishing cost and total amount of carcass produced.

the amount of carcass produced with the finishing of 100 lambs in the weaning in confinement was 120 kg higher than that produced in the system with weaning on pasture (Table 3). Considering the CCW obtained in the system with weaning on pasture (15.6 kg), it is possible to produce about eight carcasses more in the system of weaning in feedlot with the lowest finishing cost.

The cost/kg of produced carcass in the system with controlled suckling (R$ 17.02/kg) was R$ 2.58 higher than the system with weaning in feedlot and R$ 0.17 lower than the system with weaning on pasture (Table 3). Although the total finishing cost has been greater in the controlled suckling, the shortest time for finishing the lambs and the highest CCW obtained in this system allowed that the cost/kg of produced carcass had an intermediate position relative to the other systems. The amount of carcass produced in the system with controlled suckling was 200 kg higher than in the systems with weaning (average of 1620 kg vs. 1820 kg).

CONCLUSIONS

The combination of high concentrate diet with the practice of controlled suckling in feedlot allows the lambs to express their potential for weight gain, reaching the slaughter weight in shorter time and producing heavier and high-fat carcasses.

The finishing of weaned lambs with concentrate supplementation on pasture or with high concentrate diet in feedlot results in the production of similar carcasses. However, the finishing on feedlot determines higher weight gain for the lambs, reducing the time to reach slaughter weight.

The costs of labor and technical assistance and those related to lambs feeding, the finishing period and the final weight of the carcasses have strong influence on the total finishing cost. The system with weaning in feedlot showed the greatest balance among these factors, with lowest cost per kg/carcass produced.

REFERENCES

Almeida Jr GA, Costa C, Monteiro ALG, Garcia CA, Munari DP & Neres MA (2004) Desempenho, características de carcaça e resultado econômico de cordeiros criados em *creep feeding* com silagem de grãos úmidos de milho. Revista Brasileira de Zootecnia, 33:1048-1059.

ANUALPEC (2012) Pecuária de corte (Custos) In: Anuário da Pecuária Brasileira – ANUALPEC. São Paulo, FNP. p.161-220.

Assis RM, Pérez JRO, Souza JC, Leite RF & Carvalho JRR (2011) Influência do manejo de mamada sobre o retorno ao estro em ovelhas no pós-parto. Ciência e Agrotecnologia, 35:1009-1016.

Baldwin RL, McLeod KR, Klotz JL & Heitmann RN (2004) Rumen development, intestinal growth and hepatic metabolism in the pre- and postweaning ruminant. Journal of Dairy Science, 87:55-65.

Barros CS, Monteiro ALG, Poli CHEC, Fernandes MAM, Almeida R & Fernandes SR (2009a) Resultado econômico da produção de ovinos para carne em pasto de azevém e confinamento. Acta Scientiarum Animal Sciences, 31:77-85.

Barros CS, Monteiro ALG, Poli CHEC, Dittrich JR, Canziani JRF & Fernandes MAM (2009b) Rentabilidade da produção de ovinos de corte em pastagem e em confinamento. Revista Brasileira de Zootecnia, 38:2270-2279.

Bueno MS, Cunha EA, Santos LE, Roda DS & Leinz FF (2000) Características de carcaça de cordeiros Suffolk abatidos em diferentes idades. Revista Brasileira de Zootecnia, 29:1803-1810.

Carvalho S, Brochier MA, Pivato J, Teixeira RC & Kieling R (2007) Ganho de peso, características da carcaça e componentes não-carcaça de cordeiros da raça Texel terminados em diferentes sistemas alimentares. Ciência Rural, 37:821-827.

Caton JS & Dhuyvetter DV (1997) Influence of energy supplementation on grazing ruminants: requirements and responses. Journal of Animal Science, 75:533-542.

Fernandes MAM, Monteiro ALG, Poli CHEC, Barros CS, Ribeiro TMD & Silva ALP (2008) Características das carcaças e componentes do peso vivo de cordeiros terminados em pastagem ou confinamento. Acta Scientiarum Animal Sciences, 30:75-81.

Fernandes SR, Monteiro ALG, Silva CJA, Silva MGB, Rossi Junior P, Souza DF, Salgado JÁ & Hentz, F (2011) Desmame precoce e a suplementação concentrada no peso ao abate e nas características de carcaça de cordeiros terminados em pastagem. Revista Brasileira de Saúde e Produção Animal, 12:527-537.

Garcia CA, Costa C, Monteiro ALG, Neres MA & Rosa GJM (2003) Níveis de energia no desempenho e características da carcaça de cordeiros alimentados em *creep feeding*. Revista Brasileira de Zootecnia, 32:1371-1379.

Gordon HM & Whitlock HV (1939) A new technique for counting nematode eggs in sheep faeces. Journal of the Council of Scientific and Industrial Research, 12:50-52.

Kenyon PR & Webby RW (2007) Pastures and supplements in sheep production systems. In: Rattray PV, Brookes IM & Nicol AM (Eds.) Pasture and supplements for grazing animals. 14 ed. Hamilton, New Zealand Society of Animal Production. p.255-274.

Medeiros GR, Carvalho FFR, Batista AMV, Dutra Júnior WM, Santos GRA & Andrade DKB (2009) Efeito dos níveis de concentrado sobre as características de carcaça de ovinos Morada Nova em confinamento. Revista Brasileira de Zootecnia, 38:718-727.

Miller JE & Horohov DW (2006) Immunological aspects of nematode parasite control in sheep. Journal of Animal Science, 84:E124-E132.

Molento MB, Tasca C, Gallo A, Ferreira M, Bononi R & Stecca E (2004) Método Famacha como parâmetro clínico individual de infecção por *Haemonchus contortus* em pequenos ruminantes. Ciência Rural, 34:1139-1145.

Monteiro ALG, Silva CJA, Fernandes SR, Prado OR & Paula EFE (2009) Criação e terminação de cordeiros a pasto: implicações econômicas e qualidade do produto final. In: 5º Simpósio Mineiro de Ovinocultura: Sustentabilidade e Perspectivas, Lavras. Anais, Grupo de Apoio a Ovinocultura (GAO). p.89-146.

Mott GO & Lucas HL (1952) The design, conduct and interpretation of grazing trials on cultivated and improved pastures. In: 6º International Grassland Congress, State College. Anais, Pensylvania State College Press. p.1380-1385.

NRC – National Research Council (1985) Nutrient requirements of sheep. Washington DC, National Academy Press. 99p.

Poli CHEC, Monteiro ALG, Barros CS, Moraes A, Fernandes MAM & Piazzetta HL (2008) Produção de ovinos de corte em quarto sistemas de produção. Revista Brasileira de Zootecnia, 37:666-673.

Rattray PV, Thompson KF, Hawer H & Sumner RMW (1987) Pasture for sheep production. In: Nicol AM (Ed.) Livestock feeding on pasture. Hamilton, New Zealand Society of Animal Production. p.89-104.

Ribeiro TMD, Monteiro ALG, Prado OR, Natel AS, Salgado JA, Piazzetta HL & Fernandes SR (2009) Desempenho e características das carcaças de cordeiros em quatro sistemas de produção. Revista Brasileira de Saúde e Produção Animal, 10:366-378.

Ribeiro TMD (2010) Produção intensiva de cordeiros Suffolk em pastagem com ou sem desmama e comportamento seletivo de ovelhas Coopworth em pastejo. Tese de Doutorado. Faculdade de Medicina Veterinária e Zootecnia da Universidade Estadual Paulista “Júlio de Mesquista Filho”, Botucatu. 103p.

Roy NC, Bermingham EN, Sutherland IA & McNabb WC (2003) Nematodes and nutrient partitioning. Australian Journal of Experimental Agriculture, 43:1419-1426.

SEAB-PR (2013) Secretaria da Agricultura e do Abastecimento do Paraná. Preços pagos pelo produtor, trimestre: Maio-2013. Disponível em: <http://www.pr.gov.br/seab/>. Acessado em: 11 de junho de 2013.

Silva JJ, Costa C, Ducatti C, Monteiro ALG & Garcia CA (2010) Determinação da fase lactente-ruminante de cordeiros pela técnica do ^{13}C. Ciência Animal Brasileira, 11:264-270.

SAS Institute Inc. (2001) Statistical Analysis System user’s guide. Version 8.2. Cary, Statistical Analysis System Institute. 1686p.

Van Soest PJ (1994) Nutritional Ecology of the Ruminats. 2ªed. Ithaca, Cornell University. 476p.