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Growth and Feed Efficiency of Pure and F1 Pelibuey Lambs Crossbred with Specialized Breeds for Production of Meat

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Abstract: Growth and feed efficiency were evaluated for pure and F1 crossbred Pelibuey (Pb) male lambs. Four different genotypes were used: pure Pelibuey×Pelibuey (PbPb), Black Head Dorper×Pb (BHDPb), White Dorper×Pb (WDPb) and Katahdin×Pb (KdPb). Thirty six lambs with an average live weight (average±SD) of 20.81±2.7 kg, were distributed in a randomized block design with a 4×3 factorial arrangement: 4 genotypes and 3 dietary ME concentrations (2.2, 2.5 and 2.8 Mcal kg^{-1} DM). There were 2 experimental periods, representing the initial (33 days) and final phases (42 days) of lamb fattening. During these 2 phases, 19 and 14.8% dietary crude protein concentration, respectively were used. A higher ($p<0.05$) DMI, CPI and MEI was observed in the KdPb lambs in comparison with PbPb in the final phase of growth, however not an effect was found ($p<0.05$) due to the genotype upon the variables in the total growing phase. The ADG, DMI, CPI and MEI observed (average±SEM) was 182±6 (g $animal^{-1}$), 79±1.4 and 12.8±0.2 (g kg^{-1} $LW^{0.75}$) and 197±3.6 (kcal kg^{-1} $LW^{0.75}$), respectively. Lambs fed with 2.8 (Mcal ME kg^{-1} DM), had ($p<0.01$) the highest DMI, CPI, ADG and better FG in the initial phase and a highest ($p<0.05$) ADG in the final stage of growth. The animals fed with a highest levels energy had ($p<0.01$) a better FG in the whole fattening period (6.5^a, 5.1^b and 4.7^b±0.3). No interaction effect ($p>0.05$) were detected between the genotype and energy level. The genotypes specialized for meat production, expressed a similar ADG and feed efficiency to the pure pelibuey lambs. The best performance for all genotypes was obtained using a 2.8 Mcal ME kg^{-1} DM diet.

Key words: Lambs, genotypes, energy, growth, feed efficiency

INTRODUCTION

The industrialized meat production systems in the world have based their strategy in crossbreeding, as they combine characteristics of 2 or more breeds thus, taking advantage of the phenomenon known as hybrid vigor. In this sense and in order to improve meat production, schemes of crossbreeding have been designed between tropical hair sheep and meat specialized breeds (Velázquez, 1989; Bores *et al*., 2002). However, discrepancies about the weight gain in F1 crosses sheep have been reported (Partida and Martinez, 1991; Canton and Velázquez, 1993; Bores *et al*., 2002).

Additional, in recent years the development of breeds for meat production has taken apogee, thus, we found genotypes like the Dorper and Katahdin, which have characteristics that make them interesting for this purpose, due to their high post-weaning growth rate (Milne, 2000) and good carcass yield when compared with breeds of Down type (Snowder and Duckett, 2003). However, there are few reports on the performance achieved for such crosses and cost: profit relationship, when they are reared under tropical conditions.

On the other hand, diverse studies indicate that dietary energy level is the first limiting factor for sheep growth (Partida and Martinez, 1992; MacLeod and Baldwin, 2000). Consequently, increasing dietary energy level results in a positive response in weight gain. However, this response can vary according to the genotype utilized, mainly due to differences in body composition (Freking and Leymaster, 2004) and digestive and metabolic efficiencies of the animals (Caton and Dhuyvetter, 1997).

Thus, an experiment was carried out, with the purpose of evaluating growth rate and feed efficiency of pure and F1 Pb lambs crossbred with Black Head Dorper (BHD), White Dorper (WD) and Katahdin (Kd) breeds when fed with three different Metabolizable Energy (ME) levels.

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MATERIALS AND METHODS

The research was carried out, at the facilities of the faculty of veterinary medicine, at the Autonomous University of Yucatan, located at a height of 8 m above sea level. The climate prevailing in the area is hot and humid type AWO, according to the Koopen classification, as amended by Garcia (2003) and the average annual temperature is 24°C, with a rainfall of 750-1000 mm $year^{-1}$ (Duch, 2002), mainly during the winter and spring.

Thirty six weaned male lambs were used, with an average±Standard Deviation (SD) of 20.81±2.7 kg Live Weight (LW), from 4 different genotypes: PbPb, BHDPb, WDPb and KdPb, which were distributed in a randomized block design with a factorial arrangement 4 (genotype)× 3 (ME level) (Montgomery, 2004). Metabolizable energy levels were set at 2.2, 2.5 and 2.8 Mcal kg^{-1} DM. Each treatment had 3 replicates and each of these consisted of an animal installed in a pen of cement floor with roof, drinker and feeder. The growth of the animals was evaluated in 2 stages (initial and final). The first stage in average lasted 33 days, from (average±SD) 20.81±2.7-25.57±1.54 kg LW and the second in average lasted 42 days, from 25.57±1.54-32.92±4.1 kg LW, respectively. The diets had 19 and 14.8% Crude Protein (CP) for initial and final stage, respectively (Table 1 and 2).

Feed intake was recorded daily. Dietary CP level was changed when the animals in the initial phase achieved a similar or greater live weight of 25.0 kg, approximately.

Before starting, the experiment all the animals were dewormed and were vaccinated against pneumonic pasteurellosis. Likewise, they had a period of adaptation to the diets and pens of 21 days. The animals were fasted 16 h before, they were weighed at the beginning and then every 14 days until the end of the experiment, which had a total duration of 75 days.

Measured variables were, Dry Matter (DMI) and Crude Protein (CPI) intakes, Metabolizable Energy Intakes (MEI) only for genotype effect, Average Daily Gain (ADG), Final Weight (FW) and Feed:Gain ratio (FG). The results were analyzed separately per each stage and total growing phase (initial + final stage). The ADG was analyzed using a repeated measures model (Maxwell and Delaney, 2004), whereas the other variables were analyzed using a linear model (GLM) for fixed effects that considered the effects of genotype and the level of energy in the diet. The comparison between averages was made through the Minimum Significant Difference Procedure (MSD). The statistical analyses were carried out with the statistical package (SAS Institute Inc., (2003).

Table 1: Experimental diets used in the initial stage of growth (DM%)

	ME (Mcal kg^{-1} DM)		
Ingredients	2.2	2.5	2.8
Star grass chopped hay	54.100	45.300	21.600
Sorghum ground	20.400	22.400	46.300
Soya bean meal	16.800	18.000	17.600
Sugarcane molasses	5.300	5.300	5.300
Vegetable oil	-	5.500	5.500
Salt	1.000	1.000	1.000
Urea	1.000	1.000	1.000
Sodium bicarbonate ($NaHCO_3$)	0.670	0.670	0.670
Phosphoric acid (H_3PO_4)	0.430	0.430	0.350
Calcium carbonate ($CaCO_3$)	0.100	0.250	0.690
Minerals and vitamins	0.100	0.100	0.100
Chemical composition			
Dry matter (%)	85.410	84.320	84.970
ME (Mcal kg^{-1} DM)[a]	2.200	2.500	2.800
Crude protein (%)	19.540	18.000	19.530
NDF (%)	62.830	57.610	48.360
ADF (%)	29.410	23.050	10.140
Calcium (%)[a]	0.800	0.800	0.800
Phosphorus (%)[a]	0.400	0.400	0.400

[a]Estimation based on NRC (1985)

Table 2: Experimental diets used in the final stage of growth (DM%)

	ME (Mcal kg^{-1} DM)		
Ingredients	2.2	2.5	2.8
Star grass chopped hay	54.000	45.200	21.400
Sorghum ground	27.600	29.600	53.400
Soya bean meal	10.000	11.000	10.700
Sugarcane molasses	5.300	5.300	5.300
Vegetable oil	-	5.500	5.500
Salt	1.000	1.000	1.000
Urea	0.560	0.560	0.560
Sodium bicarbonate ($NaHCO_3$)	0.670	0.670	0.670
Phosphoric acid (H_3PO_4)	0.570	0.560	0.480
Calcium carbonate ($CaCO_3$)	0.220	0.360	0.800
Minerals and vitamins	0.100	0.100	0.100
Chemical composition			
Dry matter (%)	86.250	87.740	87.090
ME (Mcal kg^{-1} DM)[a]	2.200	2.500	2.800
Crude protein (%)	14.960	14.460	14.500
NDF (%)	62.140	63.230	54.930
ADF (%)	28.820	25.830	14.920
Calcium (%)[a]	0.800	0.800	0.800
Phosphorus (%)[a]	0.400	0.400	0.400

[a]Estimation based on NRC (1985)

RESULTS

The average±Standard Error of Mean (SEM) LW registered at the beginning and end of the first stage of growth was 20.81±0.5 and 25.57±0.3 kg, respectively (Table 3). No effect ($p>0.05$) due to genotype on any of the variables was detected. The ADG obtained for all genotypes was 181±13 (g $animal^{-1}$), the average DMI and CPI recorded was 72±1.3 and 13.79±0.2 (g kg^{-1} $LW^{0.75}$), respectively, while MEI fluctuated from 181-195 (kcal kg^{-1} $LW^{0.75}$). The animals had an average FG of 5.1±1.3.

Table 4 shows the results of ME level on the different variables evaluated during the initial stage of growth. The animals that consumed the diet with 2.8 Mcal ME kg^{-1}

Table 3: Productive performance of lambs from different genotypes during the initial stage of growth (average±SEM)

	Genotype			
Variables	PbPb	BHDPb	WDPb	KdPb
No. animals	9	9	9	9
DM intake (g kg^{-1} LW$^{0.75}$)	71±2	73±2	72±2	73±2
CP intake (g kg^{-1} LW$^{0.75}$)	13.6±0.5	13.9±0.5	13.8±0.5	13.8±0.5
ME intake (kcal day^{-1})	1976±97	1915±97	1935±97	1991±105
ME intake (kcal kg^{-1} LW$^{0.75}$)	195±10	184±10	181±10	183±10
Initial weight (kg)	19.6±0.9	20.4±0.9	21.3±0.9	21.9±0.9
Final weight (kg)	24.6±0.5	25.4±0.5	25.8±0.6	26.5±0.5
ADG (g day^{-1})	178±20	185±21	215 ± 23	205 ± 23
Feed:gain ratio	5.2±0.6	5.2±0.6	4.5±0.6	5.6±0.6

Table 4: Effect of energy level in the diet on the productive performance of lambs during the initial stage of growth (average±SEM)

	ME (Mcal kg^{-1} DM)		
Variables	2.2	2.5	2.8
No. animals	12	12	12
DM intake (g kg^{-1} LW$^{0.75}$)	68±2a	68±2a	80±2b
CP intake (g kg^{-1} LW$^{0.75}$)	13.3±0.4a	12.3±0.4a	15.6±0.4b
ME intake (kcal day^{-1})	1695	1791	2377
ME intake (kcal kg^{-1} LW$^{0.75}$)	160	170	226
Initial weight (kg)	21.6±0.8	20.6±0.8	20.2±0.8
Final weight (kg)	25.3±0.5	25.5±0.4	25.9±0.4
DWG (g day^{-1})	143±19a	171±18b	275±12c
Feed:gain ratio	6.7±0.5a	4.8±0.5b	3.9±0.5b
Protein:energy (g kcal^{-1} ME)	0.08:1	0.07:1	0.07:1

Different letter in same row are statistical different (p<0.01)

DM, registered the higher DMI and CPI (p<0.01). There were no statistical differences in DMI and CPI between animals that consumed the diets with 2.2 and 2.5 Mcal ME kg^{-1} DM. A significant increase (p<0.01) in ADG as ME increases in the diet was observed. The animals fed with 2.5 and 2.8 Mcal ME kg^{-1} DM had a better FG (p<0.01).

In the final stage of growth, the animals had an initial and final LW of 25.57±0.3 and 32.90±0.7, respectively. A greater (p<0.05) DMI, CPI and MEI was observed in the KdPb compared with the PbPb, however, no differences were detected (p>0.05) among the latter with BHDPb and WDPb, nor between KdPb and the WDPb. No effect (p>0.05) due to the genotype was found on any of the variables measured (Table 5).

Higher ADG and FW was observed (p<0.05) in animals fed 2.5 and 2.8 Mcal ME kg^{-1} DM, but no differences were observed (p>0.05) for DMI, CPI and FG (Table 6).

No significant interaction effect (p>0.05) were detected between the genotype and energy level for all variables in the two periods of growth.

The results for the whole experiment (initial + final stage), are shown in Table 7. No effect (p<0.05) due to genotype was detected on any of the variables. The ADG was of 181±6 (g animal^{-1}), the average DMI, CPI and MEI recorded was 79±1.4, 12.8±0.2 (g kg^{-1} LW$^{0.75}$) and 197±3.6 (kcal/LW$^{0.75}$ kg), respectively.

Table 5: Productive performance of lambs from different genotypes during the final stage of growth (average±SEM)

	Genotype			
Variables	PbPb	BHDPb	WDPb	KdPb
No. animals	9	9	9	9
DM intake (g kg^{-1} LW$^{0.75}$)	81±3ab	77±3a	86±3bc	89±3c
CP intake (g kg^{-1} LW$^{0.75}$)	11.8±0.4a	11.4±0.4a	12.6±0.4ab	13.1±0.4b
ME intake (kcal day^{-1})	2428±120a	2434±120a	2742±120ab	2920±130b
ME intake (kcal kg^{-1} LW$^{0.75}$)	201±7a	194 ±7a	214 ±7ab	224 ±7b
Initial weight (kg)	24.6±0.5	25.4±0.5	25.8±0.5	26.5±0.5
Final weight (kg)	30.3±1.4	32.7±1.4	33.8±1.4	34.8±1.4
ADG (g day^{-1})	193±18	216±16	211±16	222±18
Feed:gain ratio	6.5±0.6	5.3±0.6	5.9±0.6	5.7±0.6

Different letter in same row are statistical different (p<0.05)

Table 6: Effect of energy level in the diet on the productive performance of lambs during the final stage of growth (average±SEM)

	ME (Mcal kg^{-1} DM)		
Variables	2.2	2.5	2.8
No. animals	12	12	12
DM intake (g kg^{-1} LW$^{0.75}$)	84±2	82±2	84±2
CP intake (g kg^{-1} LW$^{0.75}$)	12.7±0.4	11.9±0.4	12.1±0.4
ME intake (kcal day^{-1})	2277	2577	3039
ME intake (kcal kg^{-1} LW$^{0.75}$)	186	206	233
Initial weight (kg)	25.3±0.4	25.4±0.4	25.9±0.4
Final weight (kg)	31.1±1.2a	32.6±1.2ab	35.1±1.2b
ADG (g day^{-1})	175 ±16a	207±15a	251±14b
Feed:gain ratio	6.6±0.5	5.6±0.5	5.4±0.5
Protein:energy (g kcal^{-1} ME)	0.07:1	0.06:1	0.06:1

Different letter in same row are statistical different (p<0.05)

Table 7: Productive performance of lambs from different genotypes during both stages of growth (average±SEM)

	Genotype			
Variables	PbPb	BHDPb	WDPb	KdPb
No. animals	9	9	9	9
DM intake (g kg^{-1} LW$^{0.75}$)	76±3	78±3	81±3	82±3
CP intake (g kg^{-1} LW$^{0.75}$)	12.5±0.4	12.4±0.4	12.9±0.4	13.2±0.4
ME intake (kcal day^{-1})	2143±125	2227±125	2420±125	2542±130
ME intake (kcal kg^{-1} LW$^{0.75}$)	190±7	190 ±7	201 ±7	206 ±7
Initial weight (kg)	19.6±0.9	20.4±0.9	21.3±0.9	21.9±0.4
Final weight (kg)	30.3±1.4	32.7±1.4	33.8±1.4	34.8±1.4
ADG (g day^{-1})	182±14	199±14	211±14	206±18
Feed:gain ratio	5.8±0.4	5.0±0.4	5.4±0.4	5.6±0.4

Table 8 shows the results of the effect of energy level. A higher CPI (p<0.01) was observed in the animals fed with 2.8 Mcal ME kg^{-1} of DM. No effect was observed (p>0.05) between 2.2 and 2.5 Mcal ME kg^{-1} DM treatments.

Lambs fed with 2.5 and 2.8 Mcal ME kg^{-1} DM had a better FG. No effect (p>0.05) due to the energy level on the DMI was detected. Similarly, the effect of the genotype was independent (p>0.05) of the level of ME in the diet for all the variables evaluated in whole fattening period.

Table 8: Effect of energy level in the diet on the productive performance of lambs during both stages of growth (average±SEM)

	ME (Mcal kg^{-1} DM)		
Variables	2.2	2.5	2.8
No. animals	12	12	12
DM intake (g kg^{-1} W$^{0.75}$)	76±2	76±2	83±2
CP intake (g kg^{-1} W$^{0.75}$)*	12.8±0.4ab	12.0±0.4a	13.5±0.4b
ME intake (kcal day^{-1})	1958	2236	2806
ME intake (kcal kg^{-1} LW$^{0.75}$)	167	190	233
Initial weight (kg)	21.6±0.8	20.6±0.8	20.2±0.8
Final weight (kg)*	31.1±1.3a	32.6±1.2ab	35.1b±1.2b
ADG (g day^{-1})**	157±12a	190±12b	252±12c
Feed:gain ratio**	6.5±0.3a	5.1±0.3b	4.7±0.3b
Protein:energy (g kcal^{-1} ME)	0.07:1	0.06:1	0.06:1

Different letter in same row are statistical different *($p<0.05$) **($p<0.01$)

DISCUSSION

The animals increased 38% their DMI during the final stage of growth. In this regard, Macedo and Aguilar (2005) observed an increase of 30% in food consumption in the final stage of growing Pelibuey lambs, fed with an integral diet. It is expected a higher consumption of DM in the final stage of growth, because the animals had a higher body weight. This has been reported by other authors (NRC, 1985; Solis *et al*., 1991), which found a positive relationship between DMI and the live weight of animals.

The DMI achieved by the Pelibuey lambs were slightly lower than previous reports (Solis *et al*., 1991; Macedo and Aguilar, 2005). However, DMI was similar to the findings by Huerta and Colin (1997), which did not find significant differences between the initial and final growing periods, using animals of similar LW and age and fed with a 21% CP and 2.8 Mcal ME kg^{-1} DM diet.

As for the BHDPb, WDPb and KdPb genotypes, their results are lower than previous reports with growing lambs (Nogueira *et al*., 2005; Bradley, 2005; Canton *et al*., 2005).

The DMI for the evaluated genotypes coincide with reports by Turner *et al*. (2003) using Blackbelly, Katahdin and St. Croix lambs. Also, Wildeus *et al*. (2007) did not find significant differences between Katahdin and St. Croix lambs in confinement.

The highest DMI, CPI and MEI obtained in KdPb in the final stage of growth, is probably due to the fact that these were 15% heavier than PbPb. Was not observed the same with the other genotypes. In this regard, it has been reported that during the growth phase, the animal changing its consumption to fill heir nutritional requirements, according to their live weight (Forbes, 1986), there is a positive relationship between consumption of food and the live weight of animals (NRC, 1985).

Bradley (2005) observed a higher DMI in Dorper (7/8) and Blackbelly (1/8) lambs, which were slightly heavier in comparison with Blackbelly (50%) crossed with St. Croix (25%) and Dorper (25%).

One factor that might have influenced the consumption of DM in genotypes BHDPb and WDPb, because of their genetic composition, is heat stress, which was not measured in this study. It has been observed that one of the main symptoms of caloric stress in ruminants is a reduction on DMI (Mader *et al*., 2002). In agreement, Ross *et al*. (1985) observed that the ewes Dorper× Blackbelly were more affected by temperature than in comparison with the purebred Blackbelly.

In the initial stage of growth and whole experiment, the highest level of energy of the diet had a significant effect ($p<0.01$) on the DMI and CPI. It has been reported that the consumption of DM is influenced by the relationship protein-energy (P:E) of the diet, since, this decreases if low protein and high energy levels are employed, due to metabolic constraints that exist to process energy. In contrast, increases if high protein and low energy levels are used, because the excess protein is metabolized to energy. Although, the diet with 2.5 Mcal ME kg^{-1} DM, was slightly lower in protein, the P:E (g kcal^{-1} ME) was similar in all treatments (0.07:1), so it is unlikely to have affected the DMI.

The high DMI registered, was probably due to improvement on diet quality. In order to obtain higher density, it was necessary to increase sorghum ground up by 50% and reduce chopped hay, which probably increased diet digestibility. Many studies have shown that the digestibility of the diet has a marked influence on DM consumption, due to an increase in digestibility and rate of passage of food (Jung and Allen, 1995; Faverdin, 1999; Ferrell *et al*., 1999; Dwight, 2002). Ferrell *et al*. (1999) observed a higher consumption of DM and nitrogen (N) in male sheep, which were supplemented with a higher level of energy (2.75 Mcal ME days^{-1}) and protein (8 g N days^{-1}) compared with those receiving a lower amount of these nutrients (2.26 Mcal ME days and 7.5 g N days^{-1}) in a diet with chopped hay. These levels of protein and energy were similar to those used in this study.

Likewise, it is important to indicate that the animals were in accelerated growth. In this stage, energy is an important constraint for the animal to express its maximum growth (Solis *et al*.,, 1991; Ferrell, 1993). This effect is less accentuated when the animal approaches mature weight (McLeod and Baldwin, 2000), just as happened in the final part of the test, in which the energy level had no effect on DMI.

The greatest consumption of PC registered with the highest energy levels in the initial stage of growth, as well as the whole test, is the result of increased DMI with these energy inputs. In this regard, Ferrell *et al*. (1999) reported an increase in the consumption of N in males lambs, which were supplemented with a greater amount of ME and N.

The energy level did not have a significant effect ($p>0.05$) on DMI and CPI during the second experimental period. Similar results were obtained by Huerta and Colin (1997), when using 2.8 and 3.2 Mcal ME kg^{-1} DM in Pelibuey lambs and Bores *et al.* (2001) with terminal Suffolk×Pelibuey lambs.

As for the little difference in ADG of genotypes found in both experiment period, Avendaño *et al.* (2004) reported similar trends in Dorper×Pelibuey, KdPb and PbPb lambs, which were fed with a commercial concentrate and alfalfa hay. Similarly, Canton *et al.* (2005) nor observed differences in the ADG of purebred Pelibuey and their crosses with Dorper and Katahdin, however, the values reported by these authors were slightly higher than those obtained in this research. In contrast, Turner *et al.* (2003) observed a higher ADG in Katahdin in comparison with Blackbelly, during the growth phase. Also, Burke and Apple (2005) reported a higher post weaning weight gain in Dorper (3/4 or 7/8) than in Katahdin and St. Croix lambs. Bonilla *et al.* (2003) observed higher ADG in F1 Katahdin×Pelibuey lambs in comparison with purebred Pelibuey, concluding that Katahdin have a better rate growth.

Moreover, when the level of energy was increased, a significative response in ADG was observed during the whole experiment. The highest ADG (252 g $animal^{-1}$) was achieved with 2.8 Mcal ME kg^{-1} DM, which represented an increase of 60% in relation to the ADG obtained (157 g $animal^{-1}$) with the lower energy level (2.2 Mcal ME kg^{-1} DM). Huerta and Colin (1997) observed an increase of 15% in the ADG as energy level in the diet increased from 2.8-3.2 Mcal ME kg^{-1} DM. Likewise, Bores *et al.* (2002) reported a 10-12% increase as energy levels increased (2.27, 2.54 and 2.7 Mcal ME kg^{-1} DM).

All genotypes showed a similar feed conversion during the experiment. The values for Pelibuey were better than those reported by Partida and Martinez (1992), however, are similar to those found by Macedo and Aguilar (2005). Canton and Velazquez (1993) obtained similar results in Suffolk × Pb lambs (F1). Similarly, Bradley (2005), found lower feed efficiency in crossed Blackbelly (50%) × St. Croix (25%)-Dorper (25%) lambs in comparison with Dorper (7/8)×Blackbelly (1/8), whereas Wildeus *et al.* (2007) did not found differences between Katahdin, Blackbelly and St. Croix lambs. The similar results in feed conversions found in this study can be explained by little change in the DMI and ADG of genotypes.

The best FG was obtained when 2.5 and 2.8 Mcal ME kg^{-1} DM were used. Huerta and Colin (1997), found differences in feed conversion when different ME levels were used in the diet, getting values lower than those reported in this study.

CONCLUSION

The genotypes specialized for meat production, express a daily weight gain and feed efficiency similar to those of pure Pelibuey, however, they have a higher consumption of food in the final stage of growth. The best performance was obtained using a 2.8 Mcal ME kg^{-1} DM in the diet.

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