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Influence of protein level on growth performance, dietary energetics and carcass characteristics of Pelibuey × Katahdin lambs finished with isocaloric diets

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ABSTRACT

Forty Pelibuey × Katahdin intact male lambs (23.0 ± 1.8 kg initial shrunk weight) were used in an 84-day feeding trial (5 pens per treatment, randomized complete block design) to evaluate crude protein level (110, 140, 170, and 200 g/kg diet DM) in isocaloric diets (2.03 Mcal NE_m/kg) on finishing-phase growth performance, dietary energetics and carcass traits. Increases in protein levels were accomplished by increasing levels of canola and meat meal. Tallow was used to equilibrate energy levels among diets. Increasing dietary protein level increased (linear effect, $P = 0.01$) 84-d average daily gain, dry matter intake (linear effect, $P = 0.03$), and gain efficiency (linear effect, $P < 0.01$). The ratio of observed:expected dietary net energy increased (linear effect, $P \leq 0.02$) with increasing protein level during initial 56 days. However, overall the 84-d effect was not appreciable ($P = 0.17$). Hot carcass weight, kidney-pelvic-heart fat, and fat thickness increased (linear effect, $P \leq 0.03$) with dietary protein level. However, treatments effects on *longissimus thoracis* area, wall thickness, estimated yield grade, and carcass composition were not appreciable. It is concluded that during the initial growing phase (first 56 days) increasing dietary CP level up to 170 g CP/diet DM will enhance growth performance and efficiency of energy utilization. Thereafter (final 28 days), the effect of dietary CP levels greater than 110 g CP/kg diet DM on growth-performance and dietary energy utilization are not appreciable.

1. Introduction

Dorper, Katahdin and Saint Croix sheep breeds were introduced into México in recent years. However, due to their prolific nature and adaptability to a wide variety of climatic conditions, the Pelibuey breed (Cubano Rojo) and their crosses continue to be the most representative genotype (Partida and Martínez, 2010). In Mexico, usually, Pelibuey lambs and their crosses are placed on growing-finishing diets at initial body weights (BW) of 20–25 kg, and harvested at final BW of 30–35 kg. The growing-finishing diets fed typically contained between 1.78 and 1.95 Mcal/kg of net energy for maintenance (NE_m), and 16% to 18% of crude protein (Pineda et al., 1998; Ríos et al., 2011). During the relatively brief growing-finishing period (35–45 days) these high dietary CP levels were needed to support of optimal growth performance (Manso et al., 1998; Haddad et al., 2001; Zundt et al., 2002). However, present market demands have pushed for a heavier target harvest weights (45–50 kg), resulting in a greater degree of finish and extending the growing-finishing period to > 70 days (Muñoz-Osorio et al., 2016). In feedlot cattle, the extra-caloric effect of increased metabolizable protein (MP) intake is more likely to be manifest during the initial part of the growing-finishing period (Zinn et al., 2007; Carrasco et al., 2013). Very little information is available in the literature regarding to the influence of the protein level on overall growth performance of lambs over the more extended growing finishing phase. The objective of this experiment was to evaluate the growth performance, dietary energetics, carcass characteristics, and visceral mass in lambs fed isocaloric diets with different protein level during an 84-d growing-finishing period.

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2. Materials and methods

2.1. Diets, animals and experimental design

This experiment was conducted at the Universidad Autónoma de Sinaloa Feedlot Lamb Research Unit, located in the Culiacán, México (24° 46′ 13″ N and 107° 21′ 14″ W). Culiacán is about 55 m above sea level, and has a tropical climate. All animal management procedures were conducted within the guidelines of locally-approved techniques for animal use and care: NOM-051-ZOO-1995: Humanitarian care of animals during mobilization of animals; NOM-062-ZOO-1995: Technical specifications for the care and use of laboratory animals. Livestock farms, farms, centers of production, reproduction and breeding, zoos and exhibition halls, must meet the basic principles of animal welfare; NOM-024-ZOO-1995: Animal health stipulations and characteristics during transportation of animals, and NOM-033-ZOO-1995: Humanitarian care and animal protection during slaughter process.

Forty Pelibuey × Katahdin [23.04 ± 1.80 kg (average shrunk body weight)] crossbred intact male lambs were used in a growth-performance experiment from February to May to evaluate the effects of protein level on growth performance, dietary energetics, carcass traits, and visceral organ mass. The average ambient temperature and relative humidity during the course of the experiment were 24.9 °C, and 41%, respectively. Four weeks before the experiment started, lambs were treated for endoparasites (Albendaphorte 10%, Animal Health and Welfare, México City, México), and injected with 1×10^6 IU vitamin A (Synt-ADE®, Fort Dodge, Animal Health, México). Upon initiation of the experiment, lambs were weighed individually before the morning meal (electronic scale; TORREY TIL/S: 107 2691, TOR REY electronics Inc, Houston TX, USA) and randomly assigned within five weight blocks of four pens each (2 lambs/pen). In this way, the experiment consisted of 4 treatments (10 lambs in each treatment) with 5 pen replication per treatment. The 20 pens used in the experiment were 6 m^2 with overhead shade, automatic waterers and 1 m fence-line feed bunks. Lambs were adapted to the assigned treatment 14-d before the start of experiment (Table 1). Dietary treatments consisted of a cracked corn-based diets which were formulated to be isocaloric (2.07 Mcal NE_m/kg). The energy concentration of diet was manipulated by addition of tallow while protein level was mainly adjusted replacing cracked corn grain with combinations of urea, canola meal and rendered pork meat meal to reach CP concentrations of 110 (CP11), 140 (CP14), 170 (CP17), and 200 g CP/kg of diet DM (CP20), respectively. In the case of the CP11 treatment, urea was the sole source of supplemental N. Urea was added in all diets to ensure that degradable intake protein (DIP) in diet not limit microbial efficiency, and hence optimal ruminal fermentation (Zinn and Shen, 1998). The average of estimated ruminal undegradable intake protein (UIP) in experimental diets averaged 38 ± 0.46%. Corn was prepared by passing whole regional white corn through rollers (46 × 61 cm rolls, 5.5 corrugations/cm; Memco, Mills Rolls, Mill Engineering & Machinery Co., Oklahoma, CA). Roll pressure was adjusted so that the kernels were broken to produce a bulk density of approximately 0.50 kg/L. The canola meal used was a standard quality US canola meal obtained by solvent extraction (Industrial de Oleaginosas, Guadalajara, Jalisco, México). The rendered strictly pork meat meal was obtained from El Kowi Enterprise (Hermosillo, Sonora, México). The forage source (wheat straw) was ground in a hammer mill (Bear Cat #1A-S, Westerns Land and Roller Co., Hastings, NE) with a 3.81 cm screen, before incorporation into complete mixed diets. Dietary treatments were randomly assigned to pens within blocks, resulting in 5 pens replicates per treatment. The experiment lasted 84 days. Lambs were allowed *ad libitum* access to dietary treatments. Daily feed allotments to each pen were adjusted to allow minimal (< 5% of total offered) residual feed remaining in feed bunk just prior to the morning feeding. The amount of feed offered and residuals were weighed daily. Lambs were provided fresh feed twice daily at 0800 and 1400 h in a 40:60 proportion (as feed basis). Feed bunks were visually assessed between 0740 and 0750 h each morning, refusals were collected and weighed and feed intake was determined. Adjustments, to either increase or decrease daily feed delivery, were provided at the afternoon feeding. Lambs were individually weighed at the beginning of the trial and 28-d intervals thereafter. The initial and interim shrunk body weight (SBW) was determined as full BW × 0.96 (adjustment for gastrointestinal fill; Cannas et al., 2004). Upon completion of the study, all lambs were weighed following an 18 h fast (food but not drinking water was withdrawn) to obtain final SBW.

Table 1
Composition of experimental diets (DM basis).

Item	Protein level, % of DM			
	11	14	17	20
White corn, dry rolled	75.00	68.50	63.15	57.40
Canola meal	–	6.25	9.50	16.00
Meat meal[a]	–	2.50	5.50	7.25
Wheat Straw	10.00	9.50	9.00	7.00
Molasses	8.65	7.00	6.50	5.50
Tallow	3.00	3.50	4.00	4.50
Urea	1.10	1.00	1.10	1.10
Limestone	0.50	0.50	–	–
Phosphate deflourinated	0.50	–	–	–
Zeolite	0.75	0.75	0.75	0.75
Trace mineral salt [b]	0.50	0.50	0.50	0.50
Chemical composition, g/kg DM basis [c]				
CP	111	141	169	198
NDF	154	165	169	171
EE	63.8	71.1	78	84.2
Ash	37	42.7	49.1	53.7
Rumen degradable intake protein, %	61.0	60.4	60.5	61.1
Rumen undegradable intake protein, %	39.0	39.6	39.5	38.9
Estimated NE, Mcal/kg[d]				
NE_m	2.06	2.06	2.06	2.06
NE_g	1.41	1.41	1. 41	1.41
E:P ratio[e]	0.183	0.144	0.120	0.102

[a] Pure pork meat meal (El Kowi Enterprice, Hermosillo, Sonora, México).
[b] Trace mineral salt contained: $CoSO_4$, 6.8 g/kg; $CuSO_4$, 10.4 g/kg; $FeSO_4$, 35.7 g/kg; ZnO, 12.4 g/kg; $MnSO_4$, 10.7 g/kg; KI, 0.52 g/kg; and NaCl, 923.5 g/kg.
[c] Degradable intake protein (DIP) was calculated based on tabular DIP values for individual ingredients (NRC, 2007). Dietary chemical composition for CP, NDF, EE, ash, and neutral detergent fiber (assayed with amylase and expressed exclusive of residual ash) were determined by analyzing subsamples collected and composited throughout the experiment.
[d] Net energy was calculated based on tabular net energy (NE) values for individual feed ingredients (NRC, 2007).
[e] Estimated kcal net energy of maintenance/g protein.

2.2. Sample analysis

Corn, canola meal, pork meat meal, and urea were subjected to the following analyses: DM (oven drying at 105 °C until no further weight loss; method 930.15; AOAC, 2000), and CP (N × 6.25, method 984.13; AOAC, 2000). While the complete diets were subjected to the following analyses: DM (oven drying at 105 °C until no further weight loss; method 930.15; AOAC, 2000); CP (N × 6.25, method 984.13; AOAC, 2000); ash (method 942.05; AOAC, 2000); NDF (Van Soest et al., 1991, corrected for NDF-ash, incorporating heat stable α-amylase (Ankom Technology, Macedon, NY) at 1 mL per 100 mL of NDF solution (Midland Scientific, Omaha, NE)), and ether extract (method 920.39; AOAC, 2000). Feed and refusal samples were collected daily for DM analysis (oven-drying at 105 °C until constant weight, method 930.15; AOAC, 2000).

2.3. Calculations

Average daily gain (ADG) was determined as the difference in SBW