ECOSISTEMAS Y RECURSOS AGROPECUARIOS

CARCASS AND NON-CARCASS COMPONENTS OF PELIBUEY EWES SUBJECTED TO THREE LEVELS OF METABOLIZABLE ENERGY INTAKE

Componentes de la canal y no canal de ovejas Pelibuey sometidas a tres niveles de consumo de energía metabolizable

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ABSTRACT. The aim of this study was to evaluate carcass and non-carcass components of adult Pelibuey ewes subjected to three levels of metabolizable energy intake (MEI). Eighteen 3-year-old Pelibuey ewes with body weight (BW) of 37.6 $\pm$ 4.0 kg and body condition of 2.5 $\pm$ 0.20 were randomly assigned to three groups of six ewes each in a completely randomized design. Ewes were housed in metabolic crates and fed three levels of MEI: low (L), medium (M), and high (H) for 65 d. Feed offered was adjusted every 15 d based on ewe BW. The MEI was 0.247, 0.472 and 0.532 MJ/ kgBW$^{0.75}$d^{-1} for L, M and H levels, respectively. Data recorded at slaughter were weights of viscera, offal and carcass. Carcass was split at the dorsal midline into two equal halves, weighed, and chilled at 6°C for 24 h. The left half carcass was then divided into five cuts, each of which was dissected into fat, muscle and bone, and weighed separately. Hot and cold carcass weight and hot carcass dressing were greater for the H group than for the L group ($p < 0.05$). The weights of rib/flank and shoulder were different among groups ($p < 0.05$). Weights of empty rumen, liver, lungs and trachea, skin and internal fat were greater for the H group than for the L group ($p < 0.05$). A high level of MEI improves commercial dressing percentage due to increased lean meat and fat deposition with a lower proportion of bone in the carcass of adult Pelibuey ewes.
Key words: Hair ewes, carcass characteristics, energy balance, undernutrition

RESUMEN. El objetivo del presente estudio fue evaluar los componentes de la canal y no canal de ovejas Pelibuey sometidas a tres niveles de consumo de energía metabolizable (CEM). Dieciocho ovejas Pelibuey de 3 años de edad, peso vivo (PV) de 37.6 $\pm$ 4.0 kg y condición corporal de 2.5 $\pm$ 0.20 fueron asignadas aleatoriamente a uno de tres grupos de seis animales, bajo un diseño completamente a la azar. Las ovejas fueron mantenidas en jaulas metabólicas y alimentadas con tres niveles de CEM: Bajo (B), Medio (M) y Alto (A) durante 65 d. El alimento ofrecido fue ajustado cada 15 d con base al PV. El CEM fue: 0.247, 0.472 y 0.532 MJ/ kgPV$^{0.75}$d^{-1} para B, M y A, respectivamente. Al sacrificio se registró el peso de las vísceras, desperdicios y canal; esta última fue dividida en dos partes, pesadas y refrigeradas a 6°C por 24 horas. La media canal izquierda fue seccionada en cinco cortes; los cuales fueron separados en grasa, músculo y hueso, para pesarlos por separado. El peso de la canal caliente y fría, y el rendimiento de la canal caliente fueron mayores para A respecto a B ($p < 0.05$). El peso del costillar y paleta fueron diferentes entre grupos ($p < 0.05$). El peso del rumen vacío, hígado, pulmones y tráquea, piel y la grasa interna fueron superiores en A con respecto a B ($p < 0.05$). Altos CEM mejoran el rendimiento comercial debido al incremento en la deposición de musculo y grasa, con una baja proporción de hueso en la canal de ovejas Pelibuey.
Palabras clave: Borregas de pelo, características de la canal, balance energético, subnutrición

INTRODUCTION

In ruminants climatic and physiological conditions frequently cause fluctuations in forage intake, inducing periods of underfeeding and refeeding throughout the year (Kamalzadeh *et al*. 2009). In grazing animals, these seasonal variations cause periodic live weight loss during scarcity and weight gain when forage is abundant (Kamalzadeh *et al*. 2009, Souza-Rodrigues *et al*. 2014). Also, in these periods of subnutrition, the weight of organs such as the gastrointestinal tract, liver and the carcass of those animals decrease (Atti *et al*. 2000, Mahouachi and Atti, 2005, Martins *et al* 2014).

The sheep population in Mexico is around 8.6 million head and produces 153,507 tons of young sheep meat (SIAP, 2014). The tropical region in Mexico constitutes around 28 % of the national territory, and the sheep production systems in this area contribute 25 % of the national sheep meat production. Tropical sheep production systems are managed under harsh environmental conditions. They are characterized by low inputs and low technology adoption, and also by the use of hair sheep population, mainly Pelibuey breed (Magaña-Monforte *et al*. 2013). Adult females are kept on pasture with little or no supplementation, which generally results in seasonal fluctuations in energy intake and use of body reserves and, subsequently, low meat production (Mahgoub and Lu, 2004).

In Mexico, many sheep sold for slaughter are discarded adult animals (González-Garduño *et al*. 2011) with poor body condition. Therefore, if producers want to avoid penalty rates when marketing these animals, ewes need to be housed to achieve better weight and body condition, because the demand is for animals with a minimal amount of body fat for preparation of traditional dishes such as barbacoa (Rubio *et al*. 2004). Also, Bhatt *et al*. (2012b) and Mendiratta *et al*. (2008) reported that in many developing countries, approximately 40 % of slaughtered sheep are culls whose meat is not preferred by the consumers. Bhatt *et al*. (2012ab) reported that culled ewes have low body condition scores (BCS) and poor dressing yield (38 to 40 %), and most herd owners dispose of culled ewes at lower prices, not regarding them as valuable meat animals.

The growing market for lamb meat requires young animal carcasses (150 d old) weighing between 12 and 14 kg. Adult ewes could have an important economic role in complete cycle systems if sound management is used before marketing. For this reason, knowledge of the carcass characteristics of adult ewes of different body weight and condition score is necessary (Pelegrini *et al*. 2008).

One element of sound management could be short-term supplementation of culled ewes, which can have a favorable effect on their carcass characteristics (Bhatt *et al*. 2012ab, Bhatt *et al*. 2013). Although sex and nutritional status are important aspects in the trading price of sheep (Martínez *et al*. 1987, Partida and Rojas, 2010, Bhatt *et al*. 2012a), for adult Pelibuey ewes there is little information relative to the characteristics of carcass and non-carcass components at different nutritional levels to prove whether supplementation improves carcass traits and tissue deposition in this type of animals. The aim of the present work was to evaluate the effect of metabolizable energy intake (MEI) on characteristics of carcass and non-carcass components of adult Pelibuey ewes under tropical conditions.

MATERIALS AND METHODS

Study site

The experiment was conducted at the Faculty of Veterinary Medicine and Animal Science, University of Yucatan, Mexico, located at 20^o 45' N, 89^o 30' W; 8 masl. Climate in the area is AW$_0$ (tropical warm sub-humid with summer rains). The average annual temperature ranges from 26 to 27.8 ^{o}C, and annual precipitation ranges from 940 to 1 100 mm (García, 1973).

Animals, diets, management, and experimental design

Eighteen 3-year-old, non-pregnant and non-lactating Pelibuey ewes with similar body weight (BW) of 37.6 $\pm$ 4.0 kg and body condition score

(BCS) of 2.5 ± 0.20 were randomly assigned to three groups of six ewes each in a completely randomized design. The ewes were individually housed in metabolic crates, and were fed at three levels of metabolizable energy intake (MEI): Low (L), Medium (M) and High (H) for 65 d, to assess changes in BW and BCS. MEI was: 0.247, 0.472 and 0.532 MJ/ kgBW$^{0.75}$/d for L, M and H levels, respectively. Feed offered was adjusted every 15 d based on ewe BW. The feeding levels were established as proportions of metabolizable energy requirement (MER) for maintenance (ME$_m$, 0.426 MJ/kg BW$^{0.75}$/d, AFRC, 1993). The diet consisted of fresh, chopped Taiwan grass (*Pennisetum purpureum*) using only the grass stems in order to reduce variation in nutrient composition throughout the experimental phase. Grass (dry matter (DM): 283 g/kg fresh matter; crude protein (CP): 31 g/kg DM; neutral detergent fiber (NDF): 693 g/kg DM and acid detergent fiber (ADF): 470 g/kg DM) was offered in equal portions at 0800 and 1500 h, supplying 44 g DM/kg BW$^{0.75}$/d for all treatments, and a concentrate based on velvet bean (grain and pods: *Mucuna pruriens*), ground corn and cane molasses (DM: 900 g/kg FM; CP: 141 g/kg DM; NDF: 425 g/kg DM and ADF: 180 g/kg DM) at a rate of 0, 16 and 32 g DM/kg BW$^{0.75}$/d for treatments L, M and H, respectively. The amount of feed offered was adjusted every 15 d based on ewe BW. Ten grams of a commercial mineral mixture were given daily to each animal. The composition of the diet and intakes of DM, organic matter and MEI is described in greater detail in Chay-Canul *et al*. (2011).

Slaughter procedures and carcass measurements

At the end of the experimental phase, the animals were slaughtered. Before slaughter, shrunk body weight (SBW) was recorded after feed and water were withdrawn for 24 h. Ewes were slaughtered humanely following the Mexican Official Norms (NOM-08-ZOO, NOM-09-ZOO and NOM-033-ZOO) established for slaughter and processing of meat animals. Gastrointestinal tract (GIT) content was recorded as the difference in weight of the GIT before and after emptying and flushing with running water. Empty body weight (EBW) was computed as the difference between SBW at slaughter and GIT contents. The data recorded at slaughter included the weight of internal organs and hot carcass weight (HCW). Internal fat (IF, internal adipose tissue) was dissected, weighed and grouped as pelvic (around kidneys and pelvic region) and omental and mesenteric fat (surrounding the digestive tract). Subsequently, carcasses were then split at the dorsal midline into two equal halves and weighed. The carcass was then chilled at 6°C for 24 h, after which the cold carcass weight (CCW) was recorded, and the left half-carcasses were divided into five cuts: leg (included posterior arm), shoulder (included anterior arm), rib/flank, loin and neck (Furusho-Garcia *et al*. 2004), which were weighed separately. Each cut was then completely dissected into subcutaneous and intermuscular fat (carcass fat, CF), muscle, and bone. Dissected tissues of the left carcass were adjusted as whole carcass. Other variables obtained were as follows: hot carcass dressing (HCD%=(HCW/SBW)×100), cold carcass dressing (CCD%=(CCW/SBW)×100), and true dressing (TD%= (HCW/EBW)×100) as described by Santos-Cabral *et al* (2013).

Statistical analyses

At the end of the experiment, one ewe from treatment L and another from treatment H were removed from the experiment because of illness and their data were not included in the analysis. Data on body and carcass composition were analysed as a completely randomized design using analysis of variance and the Tukey test when significant differences among treatments were detected. Statistical tests were carried out with PROC GLM of SAS (SAS, 2002).

RESULTS

The characteristics of carcass and non-carcass components of adult Pelibuey ewes subjected to three levels of MEI are presented in Tables 1 and 3,

Table 1. Carcass characteristics of adult Pelibuey ewes fed three levels of metabolizable energy intake.

	Low (n=5)	Medium (n=6)	Hihg (n=5)	CV	P value
SBW (kg)	30.9	34.8	40.4	3.81	0.0937
EBW (kg)	23.3a	27.2a	32.3b	10.65	0.0013
Hot carcass weight (HCW), (kg)	12.4a	14.8ab	17.5b	11.91	0.0022
Cold carcass weight (CCW), (kg)	11.2a	14.3ab	17.0b	13.34	0.0030
Hot carcass dressing (HCD)	41.7a	42.6ab	43.2b	3.99	0.0261
Cold carcass dressing (CCD)	37.8	41.1	41.9	6.54	0.0811
True dressing (TD)	53.13	55.4	54.04	4.09	0.5710
Cuts of half-carcass (kg)					
Neck	0.42a	0.49ab	0.65b	19.75	0.0128
Shoulder	1.14a	1.32ab	1.54b	13.95	0.0335
Rib/flank	1.50a	2.09b	2.56c	12.65	0.0002
Loin	0.40a	0.61b	0.82c	17.39	0.0002
Leg	2.24a	2.76ab	3.14b	12.85	0.0127
Proportions (% half carcass)					
Neck	7.1	6.8	7.5	15.98	0.5160
Shoulder	20.1b	18.2a	17.8a	4.53	0.0013
Rib/flank	26.5a	28.9b	29.6b	4.88	0.0125
Loin	7.1a	8.4ab	9.5b	12.87	0.0069
Leg	39.5b	38.2ab	36.2a	4.57	0.0230

$^{a-c}$ Means with a different superscript letter in a row differ (P<0.05). CV: coefficient of variation (%).

and the carcass commercial cuts and their tissues in Table 2.

Carcass characteristics

In this study, it was found that the EBW was different ($p < 0.05$) among feeding groups and the HCW, CCW and HCD were greater for the H group, relative to the L group ($p < 0.05$), but they were not different from those of the M group. The CCD and TD were similar in feeding groups (Table 1). The rib/flank and loin weights were different among treatments ($p < 0.05$), although the neck, shoulder and leg weights of group H were higher than those of group L ($p < 0.05$), and M was similar to both groups (Table 1). For the proportion of each cut of the dissected left half-carcass, it can be observed that the proportion of neck was similar among groups, and that of shoulder and leg were greater for L ($p < 0.05$) than for M and H. The rib/flank and loin were smaller for L ($p < 0.05$), and the M and H groups were similar (Table 1).

Carcass tissues

The carcass tissues of the ewes are shown in Table 2. Muscle weight was greater for groups H and M than for group L ($p < 0.05$). Carcass fat weight was different among groups ($p < 0.05$), but bone weight was not ($p > 0.05$). The proportion of muscle in the carcass was lower in group L than in group M; however, the H group did not differ ($p > 0.05$). For bone in the carcass, L was different from H and M groups ($p < 0.05$). Proportion of carcass fat was different ($p < 0.05$) among groups.

No differences among feeding groups were found for the percentages of muscle in any of the cuts ($p > 0.05$). Percentages of fat in neck, rib-flank and leg were lower in group L ($p < 0.05$). For the shoulder and loin, percentages of muscle and fat were similar among groups ($p > 0.05$). Percentages of bone in shoulder, rib/flank, loin and leg in the L group were greater than that in H, and M was not different from L or H (Table 2).

Non-carcass components

Regarding non-carcass components (Table 3), weights of empty rumen, liver, lungs and trachea and kidneys were greater in the H group than in L ($p < 0.05$); however, those of the M group were not different from either. Weights of empty intestines, heart and spleen were not different (p

Table 2. Carcass tissues of the carcass of Pelibuey ewes fed three levels of metabolizable energy intake.

Tissues in carcass	Low (n=5)	Medium (n=6)	Hihg (n=5)	CV (%)	P value
Carcass muscle (kg)	7.17a	9.13b	10.68b	0.139	0.0006
Carcass fat (kg)	0.81a	1.47b	2.17c	0.046	0.0002
Carcass bone (kg)	3.82	3.79	4.22	0.044	0.0756
Proportions in the carcass					
Muscle	61.2a	63.4b	62.5ab	0.391	0.0440
Fat	6.6a	10.3b	12.4c	0.367	0.0001
Bone	32.3b	26.3a	25.1a	0.501	0.0010
Proportions in each component					
Neck					
Muscle	54.3	53.5	52.2	11.21	0.8572
Fat	7.2a	14.2b	11.6ab	33.62	0.0275
Bone	38.8	32.2	36.3	19.25	0.3063
Shoulder					
Muscle	64.4	66.9	69.2	4.55	0.0752
Fat	7.3	7.9	8.8	26.35	0.5637
Bone	28.4b	25.1ab	22.0a	9.73	0.0039
Rib/flank					
Muscle	52.1	55.2	53.5	5.14	0.2329
Fat	6.6a	10.0ab	14.3b	27.88	0.0018
Bone	41.4b	34.9a	32.1a	8.91	0.0015
Loin					
Muscle	48.5	58.5	53.3	16.61	0.2744
Fat	17.7	20.0	29.2	33.24	0.1111
Bone	33.8b	21.5a	17.4a	21.40	0.0021
Leg					
Muscle	67.7	70.6	71.2	3.63	0.1137
Fat	4.8a	8.4b	9.4b	19.59	0.0012
Bone	27.6b	21.0a	19.3a	7.79	<.0001

$^{a-c}$ Means with a different superscript letter in a row differ (P<0.05). CV: coefficient of variation (%).

> 0.05) among feeding groups. Weights of blood, head and paws were similar among feeding groups (p > 0.05). Nonetheless, weights of skin and internal fat were greater in H than in L (p < 0.05).

DISCUSSION

Characteristics and carcass yield

The EBW was different among feeding groups of Pelibuey ewes. The EBW obtained in the present study was similar to that obtained by Martínez *et al.* (1987) in adult Pelibuey ewes. This increased with level of feeding, similar to that found for Lacaune ewes receiving 30 to 60 % of MER (Bocquier and Chilliard, 1994) and to that reported for dry Barbarine ewes, receiving 20 to 40 % of MER (Atti *et al.* 2000) as well as to what has been described for growing sheep maintained at three levels of feeding (Mahouachi and Atti, 2005). However, EBW expressed as % SBW was similar among feeding groups. Chay-Canul *et al* (2014) in Pelibuey ewes at different physiological states reported that the EBW represented 81 % of SBW. Nonetheless, a rising trend can be observed as level of feeding increases, as has been reported for growing sheep (Mahouachi and Atti, 2005). Nonetheless, Martins *et al* 2014) reported that the EBW was affected by feeding level in indigenous goats.

Weights of the cuts and their percentages of the dissected carcass for sheep of the L group in our

Table 3. Non-carcass components of adult Pelibuey ewes fed three levels of metabolizable energy intake.

	Low (n=5)	Medium (n=6)	Hihg (n=5)	CV	P value
Organs (kg)					
Empty Rumen	1.09	1.33	1.45	14.15	0.0428
Empty Intestines	0.77	0.84	0.92	17.85	0.4725
Liver	0.32	0.39	0.46	12.89	0.0027
Heart	0.17	0.18	0.19	16.15	0.5119
Lungs and trachea	0.49	0.54	0.66	17.01	0.0437
Kidneys	0.07	0.08	0.09	11.58	0.0059
Spleen	0.05	0.06	0.07	25.95	0.1157
Offals (kg)					
Blood	1.19	1.23	1.47	21.19	0.2354
Head	2.93	2.23	2.23	8.40	0.6348
Skin	1.95	2.24a	2.79	12.31	0.0015
Paws	0.79	0.75	0.79	11.86	0.6230
Internal fat	0.80a	1.95b	3.35c	24.42	<.0001

$^{a-c}$ Means with a different superscript letter in a row differ ($p < 0.05$).
CV: coefficient of variation (%).

study were similar to those reported by Martínez *et al*. (1987) but lower than the weights of groups M and H. Similarly, percentages of leg, shoulder and neck relative to weight of the carcass were similar to those reported by Pelegrini *et al*. (2008) in adult ewes.

Carcass weight of the ewes increased with level of feeding because the animals were adults in their reproductive stage with a body condition of 2.5, allowing expression of energy level in weight and carcass composition. This agrees with reports by other authors (Atti *et al*. 2000, Mahouachi and Atti, 2005). Also, Martins *et al* (2014) reported that HCW and CCW carcass weight increased for ad libitum fed indigenous goats compared with restricted animals (25 or 50 % of ad libitum).

The HCD of Pelibuey ewes in this study was similar to that reported for culled adult Santa Ines ewes, a hair sheep (40-45 %, Pinheiro *et al*. 2009). Nonetheless, in culled Ideal and Texel ewes, average HCD was 45 % (Pelegrini *et al*. 2008), slightly higher than those recorded in this work; however, these breeds are specialized in meat production and for many years have been selected for high weight gain, whereas tropical breeds are generally rustic breeds adapted to difficult climate conditions and nutritional stress (Rubio *et al*. 2004). Moreover, in Peligrini's (2008a) study ewes were not subjected to nutritional stress. In this respect, it has been reported that carcass yield is lower in underfed animals (Atti *et al*. 2000). The data obtained in the present study regarding HCD and CCD were comparable with data reported for adult Santa Inês hair ewes (Constantino *et al*. 2014). Also, the results of the current study were similar to those obtained by Martins *et al* (2014) in indigenous goats fed different feeding levels; they reported that HCD was superior in the animals fed at ad libitum level. The difference between feeding levels of the current study may be attributed to higher feed intake and consequently greater nutrient availability to promote weight gain at the H level (Chay-Canul *et al* 2011, Martins *et al* 2014, Souza-Rodrigues *et al*. 2014)).

Average HCD values recorded in this work were greater than those recorded previously in adult Pelibuey ewes (Martínez *et al*. 1987). Atti *et al*. (2000) and Aziz *et al*. (1993) reported that carcass yield was low when animals were underfed; this was due to the increase in the proportions of offals and also to mobilization of fat in underfed animals

(Azziz *et al*. 1993b, Atti *et al*. 2000). Furthermore, Yañez *et al*. (2007) state that true, or biological, yield more accurately describes development of parts that comprise live weight; this parameter, however, is untraceable under production conditions, and it is thus limited only to research. In our study the TD was similar among feeding groups.

In Malpura ewes, Bhatt *et al*. (2013) reported that the HCD increased as the level of rumen bypass fat supplementation increased. The values reported by these authors ranged from 47.7 to 52.4 %, which are superior to those recorded in the current study. With respect to TD, they also stated that the values ranged from 55.2 to 59.4 %; these values are similar to those of our study. Partida *et al*. (2009), when evaluating pure Pelibuey ewes, found an HCD of 51.6 % and a TD of 56.4 %. Bhatt *et al*. (2012a) reported that the level and period of supplementation in Malpura adult ewes did not improve HCD, reporting mean value of 40 %. Nonetheless, TD improved in the groups supplemented for 90 d. The values obtained by these authors are comparable to those obtained in the current study. On the other hand, Bhatt *et al*. (2012b) reported that the HCD was higher in concentrate fed groups, with a mean value of 48.6 % in animals consuming 223 to 810 g/d of concentrate; these values are higher than those obtained in this study. Also, Bhatt *et al*. (2012b) observed significant improvement in carcass attributes of cull ewes after supplementation with high concentrate (2.5 % of BW) feeding. On the other hand, Wang *et al* (2014) reported that crude protein and digestible energy levels in the diet had no effect on carcass characteristics of Hainan black goats.

Carcass tissues

Values for the percentage of muscle in the carcass of adult Pelibuey ewes reported by Martínez *et al*. (1987) were higher than those found in this work. Likewise, the percentages of bones reported by these authors were comparable to those of group L and higher than those of groups H and M. Weight of fat in the carcass was different among feeding groups and showed a linear response to MEI, coinciding with that reported for growing animals given different levels of feeding (Atti *et al*. 2003, Atti *et al*. 2005). Bone weight was similar among feeding groups. In this regard, it has been reported that in growing animals bone weight is not affected by level of feeding, because bone is an early maturing tissue, and it is thus more a function of animal age rather than of the nutritional level to which it is being subjected (Aziz *et al*. 1993). Percentage of muscle of the carcass cuts obtained in the present work was lower than that reported by Martínez *et al*. (1987). However, data from the present study for the proportion of bones were similar to those reported by these authors. On the other hand, percentage of fat in the leg obtained in the present study were lower than that reported by Pelegrini *et al*. (2008), although percentage of bone in the present work was higher than that reported by these authors. Yañez *et al*. (2007) found that the proportion of bone increased while proportion of muscle and fat decreased with feed restriction in kids, which agrees with the findings of our study. Bhatt *et al*. (2013) reported that the percentage of carcass muscle was 56.1 to 59.1 % and varied with the level of rumen bypass fat supplementation in Malpura ewes. The bone percentage ranged between 19.9 to 24.4 % and decreased as the level of rumen bypass fat supplementation was increased. These values are comparable to the findings of this study. However, Bhatt *et al*. (2012b) observed smaller values for muscle percentage in the carcass of cull ewes, reporting mean value of 51 %; this value is smaller than that obtained in the present study.

It was notable that the muscle: fat ratio was 8.5, 6.2 and 5 for the L, M and H feeding groups, respectively. This aspect is very important since it has implications for growth energy efficiency, or in the case of adult animals, the composition of weight gain. In the muscle: bone ratio the values obtained were 1.9, 2.4 and 2.5 for the L, M and H feeding groups, respectively.

Non-carcass components

In recent years, the use of organs and offals from slaughter houses for human consumption has been re-assessed. There is a relationship between these residues and carcass yield: the heavier they are, the lower the carcass yields (Kuss *et al*. 2007, Pinheiro *et al*. 2009). The increase in the weight of rumen and liver as MEI increased agrees with what has been reported by other authors in growing sheep and adult ewes (Yurtman and Coskuntuna 2006). For organs related to the respiratory system such as lungs and trachea, Atti *et al*. (2000) reported there was no effect of MEI in Barbary ewes. Similarly, weight of intestines was not affected by MEI; this agrees with Atti *et al*. (2000). The same authors reported that the weights of the heart and spleen increased with level of intake, a result that differs from ours since these organs were not affected by MEI in Pelibuey ewes. Weights of spleen, lungs and trachea, kidneys and pancreas were similar to those reported for Pelibuey ewes (Martínez *et al*. 1987) and Babarine ewes (Atti *et al*. 2000). Weight of the heart was similar to that reported by Martínez *et al*. (1987) but slightly lower than that reported for Barbary ewes (Atti *et al*. 2000), while weight of the liver reported by these authors was higher than that obtained in the present study. Weights of blood, head and paws were similar among treatments. However, weights of skin and internal fat were greater for treatment H with respect to L.

Weight of the head was greater than that reported by Martínez *et al*. (1987) for adult Pelibuey ewes with weights similar to those of the ewes used in our work. Moreover, this same parameter was similar to that reported for underfed Barbary ewes (Atti *et al*. 2000). Weight of paws and head was unaffected by level of intake, which agrees with data presented by other researchers (Mahouachi and Atti, 2005), who reported that components with a high proportion of bone and low metabolic activity (head and paws) showed little variation when animals were subjected to different levels of feeding. However, Atti *et al*. (2000) found in adult sheep that offals high in bone content (paws and head) had reduced ash content, which suggests that prolonged underfeeding (160 d) of adult animals can mobilize bone tissue, contrasting with what happens in growing animals (Aziz *et al*. 1993, Atti *et al*. 2005). Similarly, weight of skin in the present work increased with MEI, which is similar to what has been reported in adult ewes and growing sheep (Mahouachi and Atti 2005). This is due to the fact that the skin is considered an organ with high metabolic activity, which is closely related to blood flow, which in turn is related to the level of feed intake (Mahouachi and Atti 2005). However, Atti *et al*. (2000) reported that the weight of most non-carcass components (offals) depends more on weight at slaughter than on the level of feed intake or chemical composition of the ration.

Working with goats, Martins *et al* (2014) reported that the weights of non-carcass components, organs, and viscera were higher for animals fed ad libitum, compared with the animals fed at 25 and 50 % of restriction. These authors concluded that the high dry matter intake could have led to further development of the stomach and liver to digest and metabolize greater amounts of feed and nutrients in animals with high feed availability. Further studies should focus on determining the optimum level of supplementation so that producers can obtain the greatest economic benefits and identifying which carcass quality characteristics of cull animals should be improved in order to provide a quality product for human consumption.

CONCLUSIONS

A high level of metabolizable energy intake improves commercial dressing percentage due to increased lean meat and fat deposition with a lower proportion of bone in the carcass of adult Pelibuey ewes. Therefore, short periods of feeding can increase body weight and raise the condition score of adult ewes in order to fetch a better market price.

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