METABOLIZABLE ENERGY INTAKE AND CHANGES IN BODY WEIGHT AND BODY CONDITION OF PELIBUEY EWES FED THREE LEVELS OF ROUGHAGE DIETS UNDER TROPICAL CONDITIONS

[CONSUMO DE ENERGÍA METABOLIZABLE Y CAMBIOS DE PESO Y CONDICIÓN CORPORAL DE BORREGAS PELIBUEY ALIMENTADAS CON TRES NIVELES DE DIETAS FIBROSAS BAJO CONDICIONES TROPICALES]

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SUMMARY

The aim of the study was to evaluate the effect of metabolizable energy intake (MEI) on changes in body weight (BW) and body condition score (BCS) of non pregnant, non lactating Pelibuey ewes. The experiment had two phases: first, 24 three-yr-old ewes were kept in pens (six ewes per pen) and fed for 60 days to homogenize BW and BCS. Thereafter ewes with BW 37.2 ± 4.1 kg, BCS of 2.5±0.12 (mean±SD), were randomly divided in groups of six animals, and one group was slaughtered for baseline measurements; the remaining groups were assigned to a completely randomized experimental design and individually penned in metabolic crates, and fed at low (L), medium (M) and high (H) MEI for 65 days. Feeding was based on Taiwan grass (*Pennisetum purpureum*) given at a rate of 44 g DM/kgBW$^{0.75}$/day, and a supplement (140 g CP/kgDM and 11.5 MJ ME/kgDM) given at 0, 16 and 32 g DM/kgBW$^{0.75}$/day for L, M and H respectively. After 65 days, daily BW changes were: -107, -21 and 30 g/day for L, M and H respectively. Changes in BCS were: -0.8, 0.0 and 0.5 points for L, M and H respectively. MEI was different (P<0.05) among L, M and H, but M and H levels did not differ (P>0.05), MEI were 0.247, 0.472 and 0.532 MJ/kgBW$^{0.75}$/day for L, M and H respectively. A unit of change in BCS corresponded to 5.8 kg BW in adult Pelibuey ewes. It was required 60 MJ of ME above maintenance to gain a kg of BW, indicating that a unit change in BCS may require 345 MJ of ME. Our data suggest that ME_m may range from 0.481 to 0.529 MJ/kgBW$^{0.75}$/day, values higher than previously reported.

Key words: Pelibuey ewes; metabolizable energy; body weight change; body condition score.

RESUMEN

El objetivo del estudio fue evaluar el efecto del consumo de energía metabolizable (CEM) sobre los cambios de peso (PV) y condición corporal (CC) en borregas Pelibuey no lactantes y no gestantes. El experimento tuvo dos fases: en la primera, 24 borregas de 3 años de edad, fueron mantenidas en corrales (6 por corral) y fueron alimentadas por 60 días para homogenizar el PV y CC. Después, las borregas con PV de 37.2 ± 4.1 kg, CC de 2.5±0.12 (media±DE), fueron divididas aleatoriamente en grupos de seis animales; un grupo fue sacrificado, para obtener mediciones de base; los restantes fueron asignados a un diseño completamente al azar y fueron individualmente mantenidas en jaulas metabólicas y alimentadas a bajo (B), medio (M) y alto (A) CEM por 65 días. La alimentación se basó en pasto Taiwán (*Pennisetum purpureum*) ofrecido a razón de 44 g MS/kgPV$^{0.75}$/d, y un suplemento (140 g PC/kgMS y 11.5 MJ EM/kgMS) ofrecido a razón de 0, 16 and 32 g MS/kgPV$^{0.75}$/d para B, M y A respectivamente. Después de 65 días, los cambios diarios de PV fueron: -107, -21 y 30 g/d para B, M y A respectivamente. Los cambios en la CC fueron: -0.8, 0.0 y 0.5 puntos en B, M y A respectivamente. El CEM fue diferente (P<0.05) entre B, M y A, pero los niveles M y A no difirieron (P>0.05), el CEM fue 0.247, 0.472 y 0.532 MJ/kgPV$^{0.75}$/d en B, M y A respectivamente. Una unidad de cambio en la CC correspondió a 5.8 kg PV en borregas Pelibuey adultas. Se requieren 60 MJ de EM sobre el mantenimiento para ganar un kg de PV, indicando que para un cambio en la CC se requerirían 345 MJ de EM. Nuestros datos sugieren que EM_m puede estar entre 0.481 a 0.529 MJ/kgPV$^{0.75}$/d, estos valores son superiores a los reportados previamente.

Palabras clave: Borregas Pelibuey; Energía metabolizable; Cambios de peso vivo; Condición corporal.

INTRODUCTION

Estimation of maintenance energy requirements (ME_m) has been a key nutritional research objective in the past and that still remains at present time (Cannas et al., 2010), because the energy costs for maintenance in a herd represents from 60 to 80% of all the energy consumed in a ruminant production system (Ferrell and Jenkins, 1985; Cannas et al., 2010).

In tropical regions of Mexico, sheep production is based in systems where the breeding flock is kept grazing on tropical pastures from medium to low quality, with or without supplementary feeding (Duarte, 2007). The breeds employed are mostly hair sheep, mainly Pelibuey and Blackbelly (SAGARPA, 2002), although recently Katahdin, Dorper and Santa Cruz breeds have been introduced (Zavala-Elizarraraz et al., 2008).

Attempts have been made to determine, energy and protein requirements for hair sheep (Duarte, 2007; Silva et al., 2007), but results have been contradictory and sometimes confusing (Solís et al., 1991; Duarte, 2007), particularly those of the adult ewe. This aspect is critical, considering that adult females define productive efficiency of the system (Ferrell and Jenkins, 1984). Additionally, when metabolizable energy intake (MEI) is below the requirements for maintenance, the animal mobilizes body reserves, particularly fat, leading to the appearance of metabolic and reproductive disturbances which result in a low productive efficiency (Whitney et al., 2009). Moreover current models to determine energy requirements for sheep have been developed mostly with concentrate rations using wool breeds under temperate conditions and little is known regarding energy requirements of hair sheep fed high-fibre rations in tropical environments.

A useful tool which relate feeding, production and reproduction, is the body condition score (BCS) at particular times of the reproductive cycle (Roche et al., 2009). BCS is used as an index of the body energy reserves and the nutritional status of the ewes (Sanson et al., 1993, Oregui et al., 1997; Caldeira et al., 2007). It has been demonstrated that BCS has an effect on reproductive performance (Caldeira et al., 2007), affecting the onset of oestrus, ovarian activity (Viñoles et al., 2002) and ovulation rate (De la Isla et al., 2010). Little is known in Pelibuey ewes about the relation between BCS and BW change. The objective of the present study was to evaluate the effect of MEI on changes in BW and BCS of adult, non pregnant, non lactating Pelibuey ewes, fed diets with three levels of ME under tropical conditions.

MATERIALS AND METHODS

Animals, diets, management and experimental design

The experiment was carried out in the School of Veterinary Medicine and Animal Science, University of Yucatan, Mexico located at 20° 45' N, 89° 30' W; 8 masl. Climate of the area is AW_0 (tropical warm sub-humid with summer rainfall). The average annual temperature ranges from 26 to 27.8 °C, and annual rainfall ranges from 940 to 1100 mm (Garcia, 1988). The experiment had two phases: in the first, 24 three-yr-old, non pregnant, non lactating Pelibuey ewes were kept in pens (6 ewes per pen) for 60 d. The aim was to homogenize BW and BCS. All ewes were treated against internal parasites. Feeding was fresh, chopped Taiwan grass (*Pennisetum purpureum*) offered *ad libitum* and supplemented with a concentrate based on velvet bean (grain and pods: *Mucuna pruriens*), ground corn, cane molasses and minerals. In the second phase, the 24 ewes with BW of 37.2 ± 4.0 kg and BCS of 2.5±0.12 were randomly assigned to four groups of six animals each. One of these groups (6 ewes) was slaughtered, for baseline measurements of carcass traits. The remaining ewes were randomly assigned to three groups of six animals each. At this phase, only two ewes had a parasite load above 750 eggs per gram feces and were therefore dewormed. Ewes were individually housed in metabolic crates, and were fed at levels of MEI: Low (L), Medium (M) and High (H) for 65 d, to achieve desirable changes in BW and BCS. Levels of feeding were established as proportions of ME energy requirement for maintenance (ME_m, 0.426 MJ/kg $BW^{0.75}$/d, AFRC, 1993). The diet consisted of fresh, chopped Taiwan grass (*P. purpureum*) using only the stems of grass in order to reduce the nutritional variation throughout the experimental phase, and a supplement. Grass was offered in equal portions at 08:00 and 15:00 h, supplying 44 g DM/kg $BW^{0.75}$/d for all treatments, and the concentrate at a rate of 0, 16 and 32 g DM/kg $BW^{0.75}$/d for treatments L, M and H, respectively. Feed offered was adjusted every 15 days based on BW of the ewes. To equalize the intake of crude protein, urea (mixed with cane molasses) was given at a rate of 1.8, 0.6 and 0 g urea/kg $BW^{0.75}$/d for L, M and H treatments respectively. Ten grams of a commercial mineral mixture were given daily to each animal. Details of the diets are given in Tables 1 and 2.

Table 1. Amount offered and composition of the diets (% DM) offered to adult non pregnant, non lactating Pelibuey ewes, during the experimental measurements.

Ingredients	% DM	Feeding level		
		Low	Medium	High
Concentrate				
Pods of velvet bean	72			
Corn grain	25			
Cane molasses	3.0			
*Characteristics				
ME (MJ / kg DM)	11.49			
CP (g/kg DM)	152.0			
Grass offered (g DM/kg $BW^{0.75}$)		44	44	44
Concentrate offered (g DM/kg $BW^{0.75}$)		0	16	32
**Urea (g/kg $BW^{0.75}$)		1.6	0.8	0
Minerals (g/d)		10	10	10
**Cane molasses (g/d)		40	40	0
Total offered (g DM/d)		776	1014	1210
ME offered (MJ/d)		5.3	8.2	10.5
CP offered (g CP/kg $BW^{0.75}$)		7.8	7.9	7.9

*Estimated for diet formulation (AFRC, 1993).
**Mixed with twice its volume in water and applied on the grass.

Intake and digestibility measurements

DM intake (DMI) and apparent DM digestibility (DMD) were measured in four periods of 15 days with five consecutive days of measurements in each period. Samples of feed offered and refused and feces (10%) were taken for each animal. At the end of each period, a subsample was taken per animal for ash determinations to estimate organic matter digestibility (OMD) in the first period of measurements. MEI was estimated according to DMI and energy of the diet estimated from the digestible organic matter content in the DM (DOMD) by Equation 1 (AFRC, 1993).

$$\text{ME of diet (MJ/kg DM)} = \%\ \text{DOMD} \times 0.16 \qquad [1]$$

Table·2. Chemical composition of the concentrate and forage offered to adult, non pregnant, non lactating Pelibuey ewes

	Concentrate	Forage
DM (g/kg Fresh matter)	900	283
CP (g/kg DM)	141	31
NDF (g/kg DM)	425	693
ADF (g/kg DM)	180	470
OM (g/kg DM)	963	953
EE (g/kg DM)	37	19.2
ME (MJ/kg DM)*	11.5	7.6

*Estimated from AFRC (1993)

Changes of BW and BCS

BW and BCS of the ewes were recorded during the experiment five times every 15 days after feed and water were withdrawn for 18 h. Scale for BCS was 1 (thin) to 5 (obese) according to Russell (1984) and Russell et al. (1969). Daily BW change (DBWC) and BCS changes (BCSC) were estimated by regression, using the five records of BW and BCS, the slope of the regression representing the rate of DBWC and BCSC of the ewes.

The change of weight (kg) associated with a unit change in BCS was estimated by regression analysis using the initial, intermediate and final (before the slaughter of the animals) weights of the animals.

Slaughter and empty BW determination

At the end of phase 1, six ewes were humanitarianly slaughtered according to Mexican Official Norms (NOM-08-ZOO, NOM-09-ZOO and NOM-033-ZOO) established for slaughter and processing of meat animals. Before slaughter, BW was taken after feed and water were withdrawn for 24 h. The gastrointestinal tract (GIT) was weighed before and after emptying with flushing water and weight of GIT content was calculated. Empty BW (EBW) was computed as the difference between BW at slaughter and contents of the GIT.

To reduce the effect of GIT fill of the ewes on estimating changes in BW, the initial EBW of the animals allotted to feeding levels were estimated based on Equation 2 (MSE= 0.602; RSD = 0.776; R^2= 0.95; P= 0.0009; n= 6) which was derived from the initial slaughtered group. At the end of experiment ewes were slaughtered and EBW determined (final EBW). EBW changes (kg) were determined by means of Equation 3, and daily EBW gain (g/d) was calculated.

Initial EBW = 3.044 ± (2.955) + 0.709 ± (0.080) * initial BW [2]

EBW change (kg) = final EBW-initial EBW [3]

Chemical analysis

Feed and fecal samples were dried at 60 °C in a forced-air oven for 48 h for DM determination. Dry samples were ground through a 1 mm sieve in a Wiley mill prior to chemical analysis. Nitrogen determinations of feed samples were carried out with a LECCO CN-2000 series 3740 (LECCO Corporation) instrument. OM was assessed by incineration of the sample in a muffle furnace at 600 °C for 6 h. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined using the methods described by Van Soest et al. (1991).

Statistical analyses

At the end of the experiment, a ewe from treatment L and another from treatment H were taken off the experiment because of illness and data were not included in the analysis. Data on feed intake, digestibility, DBWC and BCSC, were analyzed as a completely randomized design by analysis of variance and the Tukey test was performed when a significant treatment effect (P<0.005) was detected. Linear (*L*) and quadratic (*Q*) effects of treatments were tested for the response variables. Statistical analyses were performed with PROC GLM of SAS (SAS, 2002). Relationships between DBWC, BCSC, MEI, BCS, BW and EBW were estimated by regression models using PROC REG of SAS (SAS, 2002), and correlation coefficients among variables by the procedure PROC CORR of SAS (SAS, 2002).

RESULTS AND DISCUSSION

Intakes and digestibility

Total DMI and MEI were different (P<0.05) among treatments (Table 3). Forage:concentrate ratio for feed consumed were 100:0, 70:30 and 55:45 for L, M and H respectively, and estimated MEI was approximately 58, 110 and 125% of ME requirements for maintenance (ME_m: 0.426 MJ ME/kg $BW^{0.75}$) for L, M and H respectively (AFRC, 1993). No differences were found (P>0.05) among treatments for DMD; however, DOMD was linearly increased with level of intake (P<0.05). This increment was likely a consequence of the higher proportions of the concentrate in the consumed feed. ME content of the diet estimated by DOMD was 10% greater than that estimated from diet composition (Table 1).

Table 3. Intake of DM, OM, ME and digestibility in adult non pregnant, non lactating Pelibuey ewes fed roughage diets at three levels of feeding.

	Low (n=5)	**Medium (n=6)**	**High (n=5)**	**SEM**	***P***	
					L	***Q***
Intake						
Total DM , g/d	504.6[a]	815.9[b]	1045.2[c]	31.83	<0.0001	0.544
Total DM, g/kg$^{0.75}$/d	36.1[a]	56.2[b]	65.7[c]	1.336	<0.0001	0.077
DMD , g/kg DM	512.2	544.1	555.0	9.45	0.096	0.615
*DOMD, g/kg DM	462.9[a]	544.6[a]	558.6[b]	13.375	0.014	0.2417
**ME content, MJ/kg DM	6.8	8.1	8.7	-	-	-
***ME content, MJ/kg DM	7.6	8.7	8.9	0.211	0.026	0.326
MEI, MJ/d	3.40[a]	7.09[b]	9.29[c]	0.287	<0.0001	0.405
MEI, MJ/kg$^{0.75}$/d	0.247[a]	0.472[b]	0.532[b]	0.019	<0.0001	0.061
MEI, MJ/kg EBW$^{0.75}$/d	0.323[a]	0.582[b]	0.699[c]	0.016	<0.0001	0.057

*DOMD: Digestible organic matter in DM, determined once in the first period of measurements
**ME content: estimated from diet composition (AFRC, 1993)
***ME content (MJ/kg DM): estimated by DOMD: % DOMD x 0.16 (AFRC, 1993).
SEM: standard error of the mean

Body weight changes

The resulting DBWC were: -107, -21 and 30 g/d for L, M and H respectively (Table 4). Similarly, when Lacaune ewes received 60% of ME_m, they lost 9 kg BW in 85 days (Bocquier and Chilliard, 1994). In that experiment DBWC was -106 g/d, similar to the DBWC registered for treatment L with non pregnant, non lactating Pelibuey ewes in this study. On the other hand, when non pregnant, non lactating Barbarine ewes received 20-40% of ME_m during 161 days, they lost 17.2 and 12.6 kg BW and DBWC were -107 and -79 g/d, respectively (Atti et al., 2009).

Table 5 shows regression equations to estimate MEI at zero change in BW. DBWC data are expressed as changes in BW (g BW/d) and changes of EBW (g EBW/d). ME_m thus obtained with the equations involving MEI expressed as MJ/kg $EBW^{0.75}$ was adjusted to MJ/kg $BW^{0.75}$ (ARC, 1980; NRC, 1985). From the slaughter measurements of all animals, it was estimated that $EBW^{0.75}$ was 84% of the $BW^{0.75}$. Equations yielded estimations of ME_m ranging from 0.481 to 0.529 MJ/kg $BW^{0.75}$. These results suggest that ME_m in adult Pelibuey ewes is 13-24% higher than values reported by AFRC (1993) for adult ewes. Similarly, our estimation is 23 to 35% higher than the value reported by NRC (2007).

These results are in agreement with those obtained by other workers. Kawas and Huston (1990) and Solis et al. (1991) concluded that ME requirements of growing Pelibuey sheep in a tropical climate are greater than those reported for wool sheep in a temperate climate. On the other hand, Silva et al. (2003) found the ME_m in hair and wool sheep kept in tropical climate were similar, reporting a ME_m of 0.470 MJ/kg $BW^{0.75}$/d, this requirement being 6% higher to that reported for wool sheep in temperate climates. Similarly, G. Cantón et al. (1995) with growing Pelibuey sheep, reported a ME_m of 0.490 MJ/kg $BW^{0.75}$/d, concluding that this value was 13% greater than that reported for wool sheep; these authors concluded that this requirement could be explained by the high temperature and relative humidity prevailing in the tropics. Early et al. (2001) estimated in Omani growing lambs a ME_m of 0.526 MJ/kg $BW^{0.75}$/d and suggested that ME_m in hot climates were 12 and 10% higher than those predicted by NRC (1985) and AFRC (1993) respectively for sheep in temperate climates. Rattray et al. (1974) working with Targhee ewes found a ME_m value of 0.531 MJ/kg $BW^{0.75}$/d, a value similar to that estimated in the current study for Pelibuey ewes. Olthoff et al. (1989) evaluated adult ewes from seven breeds reporting an average ME_m of 0.615 MJ/kg $BW^{0.75}$/d, concluding that ME_m was increased according to productive potential of the breeds, which agrees with data from Ferrell and Jenkins (1985). In this sense, Ferrell and Jenkins (1984) and Solis et al. (1988) suggested that site of fat storage has an effect on ME_m in livestock. Those authors have reported a low ME_m for meat breeds compared to milk breeds, a fact probably related to deposition of internal fat. Similarly, Thompson et al. (1983) suggested that metabolic activity in internal adipose tissue is greater than that of peripheral fat depots. The above results supports the hypothesis of a greater ME_m in sheep with a pattern of higher internal fat deposition and agrees with data reported by Chay-Canul et al. (2011) who found in Pelibuey ewes that internal fat deposition was increased in a higher proportion as energy intake increased compared to the fat depots in the carcass. This agrees with data from Partida and Martínez (2010) who reported a significant deposition of internal fat in growing sheep of the Pelibuey breed. It has been suggested that climate conditions affect the preferential site for fat deposition (Sprinkle et al., 1998; Ermias et al., 2002). Pelibuey ewe is adapted to high temperatures of the tropical regions and could affect preferentially, an internal fat deposition as an adaptation strategy to cope with fluctuations of feed supply in tropical areas (Chay-Canul et al., 2011).

In terms of ME_m for adult Pelibuey ewes, in the current study MEI (MJ/d) needed for zero change in BW (BW mean 36.5 kg) was estimated to be 7.85 MJ/d, derived from Equation 4 (R^2: 0.67; RSD: 1.49; P: 0.0001 and n: 16).

$$\text{MEI (MJ/ day)} = 7.85\ (\pm 0.43) + 34.73\ (\pm 6.48)^{*}\ \text{DBWC} \quad [4]$$

Changes in body condition score

Different values of changes in BW per unit of BCS (BW/BCS) are reported for different breeds of adult ewes (Table 6) due to differences among breeds for body size and/or fill of the GIT (Caldeira and Portugal, 2007). Data from the present work indicate that, each unit change of BCS, corresponded to a change of approximately 5.8 kg BW (Table 6). BW and BCS had a correlation coefficient of 0.56. The BW/BCS was smaller than the 11.3 kg BW found for Rasa Aragonesa ewes (Teixeira et al., 1989), and to the 10.6 kg BW value reported by Russell et al. (1969) for Scottish Blackface ewes. Sanson et al. (1993) in western-range ewes, found that BW and BCS were highly correlated (r = 0.89) and reported that BW/BCS was 5.1 kg BW, using a 1-9 scale. On the other hand, Zygoyiannis et al. (1997) found that the BW/BCS in three breeds of ewes, was equivalent to 13% of mature BW of those breeds, being this percentage similar to that reported for other sheep breeds or even for cattle breeds (CSIRO, 2007). Duarte (2007) suggested that mature BW corresponds to a value of 45 kg BW for three year old Pelibuey ewes, therefore, the proportion of change in BW/BCS in the Pelibuey ewe in the current study (5.8 kg) was 13% of mature BW, which agrees with Zygoyiannis et al. (1997), Cannas et al. (2004) and CSIRO (2007). However, considering average BW of ewes at the medium level of feeding in this work, such BW would represent almost 16% of mature BW. It is noteworthy that the BW/BCS for the Pelibuey ewe is similar to that of other breeds such as the Churra (Frutos et al., 1997) and Laxta (Oregui et al., 1997); not being the case for other tropical breeds such as the Awassi (Treacher and Filo, 1995) and Cuban Pelibuey (Cruz et al., 1999).

The amount of additional energy (MJ of ME) required to increase one unit of BCS above maintenance in non pregnant, non lactating Pelibuey ewes can be estimated from the relation BW/BCS, applying a value for the energy content of gain (MJ/kg) and assuming an efficiency of utilization of ME for energy retention (k_g) of 0.43 (CSIRO, 2007). CSIRO (2007) suggested that the amount of energy required to gain one kg BW in sheep is 23 MJ net energy (NE), requiring then 53.5 MJ of ME, which represents 310 MJ of ME to increase one unit BCS from 2 to 3 or in other words 5.8 kg BW in Pelibuey ewe. Considering the total MEI and changes in BW of ewes in group H of the present experiment, it was estimated that the amount of ME (MJ) required to change one kg BW was 59 MJ of ME. Assuming a k_g of 0.43, this gives a value of 25.4 MJ of NE/kg of weight gain in these ewes, which is close to the 26 MJ NE/kg reported by ARC (1980) and AFRC (1993) for non pregnant non lactating adult ewes. Therefore, non pregnant non lactating Pelibuey ewes may require 345 MJ ME to increase one point in BCS, which agrees well with values reported ARC (1980), AFRC (1993) and CSIRO (2007).

Table 4 Body weight, empty body weight and body condition score changes in adult non pregnant, non lactating Pelibuey ewes fed at three levels of ME intake

Item	Low (n=5)	Medium (n=6)	High (n=5)	SEM	*P*	
					L	*Q*
BW (kg)						
Initial	38.2	36.2	38.7	1.036	-	-
Final	30.2^a	34.8^{ab}	40.8^b	0.988	0.0022	0.6665
DBWC, g/d	-106^a	-22^b	30^c	4.811	<0.0001	0.1200
EBW (kg)						
*Initial	30.1a	28.7	30.4	0.739	-	-
Final	23.3^a	27.2^a	32.3^b	0.731	0.0003	0.6859
**EBW changes, g/d	-106a	-23.5b	31.8c	5.11	<0.0001	0.2209
BC						
Initial	2.6a	2.5a	2.7a	0.032	-	-
Final	1.7^a	2.5^b	3.2^c	0.053	<0.0001	0.6596
BCSC	-0.8	0.0	0.5	0.058	<0.0001	0.1190

DBWC: Daily BW, BCS and EBW changes, were estimated by regression
*Estimated with Equation 2 for animals in Low, Medium and High groups
**Estimated with Equation 3
$^{a-c}$ Means with different superscript letter in a row differ (P<0.05)
SEM: standard error of the mean

Table 5. Regression equations for estimation of maintenance energy requirements of adult non pregnant, non lactating Pelibuey ewes (n=16)

Regression	SE a	SE b	R^2	MSE	RSD	*P*	*MEm
DBWC (g/d)= -0.168 + 0.323*MEI (MJ/kg$^{0.75}$/d)	0.031	0.069	0.61	0.001	0.038	0.0003	0.520
MEI (MJ/kg$^{0.75}$/d)= 0.481 + 1.892*DBWC(g/d)	0.026	0.403	0.61	0.008	0.092	0.0003	0.481
DBWC (g EBW/d)= -216.72 + 343.96 MEI (MJ/kg EBW$^{0.75}$)	31.37	56.44	0.73	1046.55	32.35	<0.0001	0.529
MEI (MJ/kg EBW$^{0.75}$)= 0.605 + 0.002 DBWC(g EBW/d)	0.0229	0.0003	0.73	0.0064	0.0801	<0.0001	0.508

* ME_m: ME requirement for zero change in live weight (MJ/kg$^{0.75}$/d)
SE: Standard Error
MSE: Mean Square Error
RSD: Residual Standard Deviation

Table 6 Regression of live weight (kg) on body condition score of non pregnant non lactating adult ewes of different breeds

Breed, sex and physiological state	n	Scale range	Intercept	Slope[A]	R^2	RSD	MBW (kg)	%MBW
Dry ewes								
*Pelibuey ewes	54	1-5	21.67 (± 3.09)	5.84 (±1.21)	0.31	3.82	45	13
[B] Serra de Estrela	1396	1-5	20.89	11.0	0.66	6.55	----	---
[C] Western-range	14	1-9	35.79	5.1	0.78	-----	----	---
[D] Pelibuey Cubans	107	1-5	28.34	2.4	0.95	-----	----	---
[E] Churra	35	1-5	30.12	5.6	0.83	-----	----	10
[F] Latxa (pre mating)	1173	1-5	34.7	6.2	0.42	6.61	----	10-14
[F]Latxa (post lambing)	945	1-5	38.7	6.0	0.38	6.68	----	10-14
[G] Scottish Blackface	30	1-5	33.0	10.6	0.76	-----	----	---
[H] Awassi	84	1.5	27.9	11.8	0.60	----	----	----
[I] Rasa Aragonesa	52	1-5	12.6	11.3	0.95	5.0	----	--
[J] Boutsko	225	1-5	19.5	7.36	0.31	3.73	56.3	13
[J] Serres	292	1-5	26.7	8.62	0.48	5.08	69.8	12
[J]Kiragouniko	301	1-5	33.6	9.27	0.46	5.08	80.0	12

Adapted from Nutrient Requirements of Domesticated Animals (CSIRO, 2007).
*Adult Pelibuey ewes, non lactating and non pregnant of current study.
MBW: Mature Body Weight
%MBW: % change in live weight per unit change in BCS
[A] Change in live weight (kg) per unit change in BCS.
[B] Caldeira and Portugal, 2007.
[C] Sanson, et al., 1993
[D] Cruz et al., 1999
[E] Frutos et al., 1997
[F] Oregui et al., 1997
[G] Russell et al., 1969.
[H] Treacher and Filo, 1995
[I]Teixeira et al., 1989
[J] Zygoyiannis et al., 1997

CONCLUSION

A unit change in body condition score of adult Pelibuey ewes corresponded to 5.8 kg BW, representing 13-16% of BW of the ewes in this work. Non pregnant, non lactating Pelibuey ewes may need to consume 60 MJ ME above maintenance to gain a kg BW, which suggest that a unit change in BCS requires approximately 345 MJ of ME. Based on these results, it is concluded that adult, non pregnant, non lactating Pelibuey ewes, may have a ME_m ranging from 0.481 to 0.529 $MJ/kgBW^{0.75}/d$, which suggest that the ME_m could be 13-24% higher than values previously reported for other breeds of sheep.

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