

Prediction of carcass energy content of Pelibuey ewes by ultrasound measurements

Predicción del contenido de energético de la canal de ovejas Pelibuey por mediciones de ultrasonido

Enmanuel Rodríguez-Valenzuela¹, Alfonso J. Chay-Canul¹, Ricardo A. García-Herrera^{1*}, Rosario Salazar-Cuytun², Ángel T. Piñeiro-Vázquez³, Fernando Casanova-Lugo⁴, José R. Velázquez-Martínez¹, José Herrera-Camacho⁵

¹Division Académica de Ciencias Agropecuarias, Universidad Juárez Autónoma de Tabasco. Carr. Villahermosa-Teapa, km 25, CP. 86280. Villahermosa, Tabasco, México.

²Universidad Autónoma de Yucatán, Facultad de Medicina Veterinaria y Zootecnia, Carr. Mérida-Xmatkuil km 15.5, CP. 97100 Mérida, Yucatán, México.

³Instituto Tecnológico de Conkal, Avenida Tecnológico s/n. CP. 97345, Conkal, Yucatán, México.

⁴Instituto Tecnológico de la Zona Maya, Carretera Chetumal-Escárcega km. 21.5, Ejido Juan Sarabia, CP. 77960, Othón P. Blanco, Quintana Roo, México.

⁵Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo. Carretera Morelia-Zinapécuaro Km 9.5. El Trébol, CP. 58893. Tarímbaro, Michoacán, México.

*Corresponding author: ricardogarciaherrera@hotmail.com

Scientific note received: October 07, 2016 accepted: December 22, 2016

ABSTRACT. The aim of this study was to evaluate the relationship between body ultrasound measurements (USM) and carcass energy content (CEC) of Pelibuey ewes. USM were taken 24 h before slaughter in twenty-two ewes. Fat thickness (FT) and *Longissimus dorsi* area (LDA) were determined in the thoracic (TFT and TLDA) and lumbar region (LFT and LLDA). CEC was considered as the sum of the energy of muscle and adipose tissues in the carcass. The correlation coefficient (r) between body weight (BW) and CEC was 0.89 ($p < 0.001$). Nonetheless, correlations for LDA and CEC were not significant ($p > 0.05$). The r^2 for equation including BW and LFT was 0.87 (RSD= 15.34). The inclusion of LFT improved the prediction by about 8 %. The use of some USM in combination with BW provides good CEC estimates in Pelibuey ewes.

Key words: Body condition, ultrasound, carcass energy

RESUMEN. El objetivo fue evaluar la relación entre mediciones corporales por ultrasonido (MUS) y el contenido de energía de la canal (CEC) de ovejas Pelibuey. Las MUS se registraron 24 h antes del sacrificio en 22 ovejas. El espesor de grasa (EG) y el área del *Longissimus dorsi* (ALD) fueron determinados en la región torácica (EGT y ALDT) y lumbar (EGL y ALDL). El CEC se consideró como la suma de la energía del tejido muscular y adiposo en la canal. El coeficiente de correlación (r) entre el peso vivo (PV) y CEC fue de 0.89 ($p < 0.001$). No obstante, las correlaciones entre ALD y CEC no fueron significativas ($p > 0.05$). La ecuación que incluyó al PV y EGL, tuvo una r^2 de 0.87. La inclusión de EGL mejoró la predicción en un 8 %. El uso de algunas MUS en combinación con el PV en ovejas Pelibuey proporciona buenas estimaciones del CEC.

Palabras clave: Condición corporal, ultrasonido, energía en la canal

INTRODUCTION

Due to the high cost represented by dissection, grinding and chemical analysis, alternative

methods for determining the composition of the carcass and body of farm animals have been studied (Silva et al. 2015, Silva et al. 2016, Silva 2016). Among these, indirect methods are preferred be-

cause they are considered non-invasive (Scholz *et al.* 2015), are easier and cheaper to implement and can be applied to live animals (Silva *et al.* 2015, Silva 2016). Among current techniques, the most notable are ultrasound (Aguilar-Hernández *et al.* 2016), biometric measures (Fonseca *et al.* 2017, Bautista-Díaz *et al.* 2017) and digital image analysis (Gomes *et al.* 2016).

Some authors have reported that the use of ultrasonography is a non-invasive technique that can predict the amount of muscle, bone and fat in meat and wool sheep breeds (Silva *et al.* 2006, Ripoll *et al.* 2009) and recently in hair ewes (Aguilar-Hernández *et al.* 2016). Moreover, ultrasound measurements (USM) may contribute to predicting subcutaneous body fat, and the characteristics of carcass tissues such as the *Longissimus dorsi* area and depth in live farm animals such as sheep (Chay-Canul *et al.* 2016). Additionally, Silva *et al.* (2016) indicate that the use of USM provided good estimates of the fat and energy content of the empty body of two ewe breeds. Also, Silva *et al.* (2005) reported that the use of body weight and USM allows accurate predictions of empty body carcass chemical composition in lambs.

Nonetheless, few studies exist in the literature dealing with the use of USM to predict chemical composition and energy content of carcasses (Silva *et al.* 2005, Silva *et al.* 2016, Silva 2016). Moreover, as far as the authors are concerned, in hair sheep such as the Pelibuey breed, studies related to the prediction of carcass energy content using USM are not available. The aim of this study was to evaluate the relationship between live USM and carcass energy content in Pelibuey ewes.

MATERIALS AND METHODS

Study area location

The study area was located at 20° 45' N, 89° 30' W, and has a warm tropical sub-humid climate. The annual temperature ranges from 26 to 27.8 °C, with annual rainfall ranging from 940 to 1100 mm (García 1973).

Animals, management and ultrasound measurements (USM)

The study was carried out using data from twenty-two 3-year-old, non-pregnant, non-lactating Pelibuey ewes with body weight (BW) of 35.63 ± 5.03 kg (mean ± SD) and body condition score (BCS) of 2.47 ± 0.55 (Table 1). BCS for each ewe was evaluated by two experienced technicians, using a 1-5 scale, with 0.5 increments, where BCS 1 represents a thin animal and 5 an obese animal as described by Russel *et al.* (1969).

Table 1. Mean (± SD) and minimum and maximum values for variables measured in adult Pelibuey ewes (n=22).

Variable	Mean ± SD	Maximum	Minimum
TFT (mm)	1.91 ± 0.69	3.40	1.00
LFT (mm)	1.82 ± 0.64	3.40	1.00
BW (kg)	35.63 ± 5.03	48.75	29.00
BCS	2.47 ± 0.55	3.50	1.50
TLDA (cm ²)	7.19 ± 1.63	9.95	4.14
LLDA (cm ²)	6.98 ± 1.44	8.91	3.59
CEC (MJ)	107.90 ± 41.15	218.73	48.30

SD: standard deviation, BCS: body condition score, BW: body weight, TFT: thoracic fat thickness, LFT: lumbar fat thickness, TLDA: Thoracic L. dorsi area, LLDA: lumbar L. dorsi area, CEC: carcass energy content.

The ewes were selected from a commercial farm and were kept in roofed pens with a concrete floor and no walls. The diet consisted of 66 % forage and 34 % concentrate, with an estimated metabolizable energy of 12 MJ KG⁻¹ DM and 10 % CP (AFRC 1993). The dietary ingredients were cereal grains (corn or sorghum), soybean meal, hay tropical grasses, vitamins, and minerals.

USM were taken 24 h before slaughter. Fat thickness (FT) and *Longissimus dorsi* area (LDA) were determined using Pie Medical[®] 100 B-mode real-time ultrasound equipment, with a 6/8 MHz linear probe (Aguilar-Hernández *et al.* 2016, Chay-Canul *et al.* 2016). Previously, the ewes were shaved between the 12th and 13th thoracic vertebrae (TFT and TLDA) and the 3rd and 4th lumbar vertebrae (LFT and LLDA) as described by Aguilar-Hernández *et al.* (2016) and Chay-Canul *et al.* (2016). All measurements were taken on the left side of ewes and the area of the muscle (TLDA and LLDA) and fat thickness (TFT and LFT) in both

regions were measured using the equipment's digital callipers (Chay-Canul *et al.* 2016). USM were recorded on all animals using the same method described by Aguilar-Hernandez *et al.* (2016).

Slaughter of animals

The animals were humanely slaughtered following the Official Mexican standards (NOM-08-ZOO, NOM-09-ZOO and NOM-033-ZOO) established for the slaughtering and processing of meat animals. Before slaughter, shrunk BW (SBW) was measured after feed and water were withdrawn for 24 h. The limbs, pelt, head and all internal organs were separated. The data recorded at slaughter were internal organs and hot carcass weights. Internal fat (TIF, internal adipose tissue) was dissected, weighed and grouped as either pelvic (around kidneys and pelvic region) or omental and mesenteric fat. Then the carcasses were split at the level of the dorsal midline in two equal halves, weighed, and chilled at 6 °C for 24 h. Subsequently, the left half-carcass was completely dissected into subcutaneous and intermuscular fat (carcass fat, CF), muscle, bone plus cartilage and each component was weighed separately. Dissected tissues of the left carcass were adjusted as whole carcass.

Chemical determinations

A sample of 500 g was taken from each animal from the muscle and adipose tissue of the carcass. This sample was ground separately with a screw grinder (Torrey, Co) through a 4 mm mesh; then the tissue samples were freeze-dried to determine water and dry matter content using freeze-dry equipment (Labconco, Co., USA). The dry samples were then ground in a hammer mill for chemical analyses for gross energy (adiabatic bomb calorimeter, Parr, USA). The CEC was determined as the sum of energy of muscle and adipose tissues in the carcass.

Data analysis

Correlation coefficients among variables were analysed by the PROC CORR procedure of SAS. Relationships between BW, BCS, USM and CEC were estimated by linear regression models using

PROC REG. The STEPWISE option was used in the SELECTION statement for significant ($p < 0.05$) variables to be included in the statistical models. The accuracy of the models was evaluated by the determination coefficient (r^2) and the mean square error (MSE).

RESULTS AND DISCUSSION

In an attempt to develop practical and inexpensive methods for predicting the chemical composition (water, fat, protein and energy) of the body of farm animals, several methods have been evaluated, but some are very sophisticated, expensive and laborious. The USM method has shown great potential for this estimation. In hair sheep breeds, the use of USM is very limited. Although there are some studies that evaluated the use of USM to predict carcass traits, to our knowledge this is the first study that uses USM to assess the carcass energy content in Pelibuey ewes.

The means (\pm SD) and minimum and maximum values for BW, BCS, USM and CEC for ewes used in this study are shown in Table 1. The correlation coefficient for BW and CEC was 0.89 ($p < 0.001$) and for BCS the r -value was 0.69. Nonetheless, the correlation between LDA (TLDA and LLDA) and CEC was low and not significant (Table 2). Conversely, for FT (TFT and LFT) the r -values ranged from 0.57 to 0.68 ($p < 0.05$).

In the models selection, only the LFT was significant ($p < 0.001$). Simple regression equations using only the (LFT, Equation 1) had an r^2 value of 0.41 for CEC (RSD= 18.56). On the other hand, the inclusion of BW as an independent variable (Equation 2) increased the r^2 value to 0.79 (RSD= 18.88). The multiple linear regression equation that included BW and LFT had the highest r^2 value (0.87; RSD= 15.34). The inclusion of LFT improved the prediction of carcass energy content by about 8 % (Table 3).

In this sense, Silva *et al.* (2005), in working with lambs, reported that for predicting the carcass energy content, the subcutaneous fat depth over the 13th thoracic vertebra (TFT) explained 90 %

Table 2. Correlation coefficients for body traits and carcass variables to predict the carcass energy content using ultrasound measurements in adult Pelibuey ewes in a tropical zone.

Variable	TFT	LFT	BW	BCS	TLDA	LLDA
LFT	0.83***					
BW	0.37	0.50*				
BCS	0.67**	0.67**	0.58**			
TLDA	0.37	0.30	0.07	0.32		
LLDA	0.35	0.19	0.19	0.31	0.86***	
CEC	0.57**	0.68**	0.89***	0.69**	0.05	0.18

***P < 0.0001, **P < 0.001, *P < 0.05, BCS: body condition score, BW: body weight, TFT: thoracic fat thickness, LFT: lumbar fat thickness, TLDA: Thoracic *L. dorsi* area, LLDA: lumbar *L. dorsi* area, CEC: carcass energy content.

Table 3. Regression equations to predict the carcass energy content using ultrasound measurements in 22 adult Pelibuey ewes reared in a tropical zone.

Eq. No	Equation	R ²	MSE	RSD	P
1	CEC (MJ)= 27.39 (±20.17) + 44.06 (±10.44) × LFT	0.41	344.76	18.56	0.0004
2	CEC (MJ)= -152.85 (±29.48) + 7.31 (±0.82) × BW	0.79	356.64	18.88	<0.0001
3	CEC (MJ)= -143.55 (±24.11) + 20.32 (±6.04***) × LFT + 6.01 (±0.77) × BW	0.87	235.44	15.34	<0.0001

R²: determination coefficient, MSE: mean square error, RSD: residual standard deviation, P: P-value.

of the variation, while the subcutaneous fat depth between the 3rd and the 4th lumbar vertebrae (LFT) explained 82 % of it. Also, Silva *et al.* (2016) observed similar results, reporting that the TFT explained around of 90 and 82 % of the variation in energy content of EBW in Churra da Terra Quente (CTQ) and Ile de France (IF) ewes, respectively, while the LFT explained around 90 and 85 % of these variations in CTQ and IF ewes, respectively. In the current study the TFT was not significant in the models tested; moreover, the equations for predicting carcass energy content using LFT as the single predictor had an r² that ranged from 0.41 to 0.47 (Equations 1, 2 and 3).

In the present study, the use of multiple regression equations that included BW and LFT improved the accuracy of equations. The use of BW explained 60 to 80 % of the variation in carcass energy; moreover, the inclusion of LFT improves the prediction 5 to 15 %. BW, a trait easy to evaluate, is also a trait that in most studies of body composition tends to account for a large amount of the variation observed in different body components. This has been shown by Silva *et al.* (2005) and (Silva *et al.* 2016) in sheep, as in the current study.

In lambs, Silva *et al.* (2005) found that in-

clusion of BW and two of the three USM (TFT, LFT, and tissue depth over the 11th rib) explained 80 to 97 % (p < 0.01) of the carcass energy content and reported that the use of BW and some USM, particularly TFT, allow accurate prediction of carcass chemical composition. The results of this study strongly suggest that body chemical composition and the retained energy of adult Pelibuey ewes can be predicted by body weight and real-time ultrasonography measurements. Also, Silva *et al.* (2016) found that multiple regression models gave good estimates of chemical body composition for CTQ and IF ewes from BW and USM.

The use of ultrasound measurements (LFT) in combination with BW in live adult Pelibuey ewes provided good estimates of the carcass energy content. It is important to know that ultrasound measurements can be used to estimate body composition of adult Pelibuey ewes because carcass information on these animals being evaluated for fattening purposes is not available.

ACKNOWLEDGEMENTS

The authors are very grateful to Dr. Jose Manuel Piña Gutiérrez who allowed us to use the

facilities at Rancho El Rodeo. Financial support: (PROMEP-UJAT-PTC-110).
Programa para el Mejoramiento del Profesorado

LITERATURE CITED

- Aguilar-Hernández E, Chay-Canul AJ, Gómez-Vázquez A, Magaña-Monforte JG, Ríos FG, Cruz-Hernández A (2016) Relationship of ultrasound measurements and carcass traits in Pelibuey ewes. *The Journal of Animal and Plant Sciences* 26: 325-330.
- Bautista-Díaz E, Salazar-Cuytun ER, Chay-Canul AJ, Garcia Herrera RA, Piñeiro-Vázquez AT, Magaña-Monforte JG, *et al.* (2017) Determination of carcass traits in Pelibuey ewes using biometric measurements. *Small Ruminant Research* 147: 115-119.
- Chay-Canul AJ, Garcia-Herrera RA, Meza-Villalvazo VM, Gomez-Vazquez A, Cruz-Hernandez A, Magaña-Monforte JG, *et al.* (2016) Body fat reserves and their relationship to ultrasound back fat measurements in Pelibuey ewes. *Ecosistemas y Recursos Agropecuarios* 3: 407-413.
- Fonseca MA, Tedeschi LO, Valadares-Filho SC, De Paula NF, Silva LD, Sathler DFT (2017) Evaluation of equations to estimate body composition in beef cattle using live, linear and standing rib cut measurements. *Animal Production Science* 57: 378-390.
- García E (1973) Modificaciones al sistema de clasificación climática de Köppen (Para adaptarlo a las condiciones de la República Mexicana). Segunda edición. Instituto de Geografía de la Universidad Nacional Autónoma de México. México. 246p.
- Gomes RA, Monteiro GR, Assis GJF, Busato KC, Ladeira MM, Chizzotti ML (2016) Estimating body weight and body composition of beef cattle through digital image analysis. *Journal of Animal Science* 94: 5414-5422.
- Ripoll G, Joy M, Alvarez-Rodriguez J, Sanz A, Teixeira A (2009) Estimation of light lamb carcass composition by *in vivo* real-time ultrasonography at four anatomical locations. *Journal of Animal Science* 87: 1455-1463.
- Russel AJF, Doney JM, Gunn RG (1969) Subjective assessment of body fat in live sheep. *Journal Agriculture Science* 72: 451-454.
- Scholz AM, Bünger L, Kongsro J, Baulain U, Mitchell AD (2015) Non-invasive methods for the determination of body and carcass composition in livestock: dual-energy X-ray absorptiometry, computed tomography, magnetic resonance imaging and ultrasound: invited review. *Animal* 9: 1250-1264.
- Silva SR (2016) Use of ultrasonographic examination for *in vivo* evaluation of body composition and for prediction of carcass quality of sheep. *Small Ruminant Research* 152: 144-157.
- Silva SR, Afonso J, Guedes CM, Gomes MJ, Santos VA, Azevedo JMT, *et al.* (2016) Ewe whole body composition predicted *in vivo* by real-time ultrasonography and image analysis. *Small Ruminant Research* 136: 173-178.
- Silva SR, Afonso JJ, Santos VA, Monteiro A, Guedes CM, Azevedo JMT, *et al.* (2006) *In vivo* estimation of sheep carcass composition using real-time ultrasound with two probes of 5 and 7.5 MHz and image analysis. *Journal of Animal Science* 84: 3433-3439.
- Silva SR, Gomes MJ, Dias-da-Silva A, Gil LF, Azevedo JMT (2005) Estimation *in vivo* of the body and carcass chemical composition of growing lambs by real-time ultrasonography. *Journal of Animal Science* 83: 350-357.

Silva TS, Chizzotti ML, Busato KC, de Souza-Rodrigues RT, da Silva IF, Queiroz MAA (2015) Indirect methods for predicting body composition of Boer crossbreds and indigenous goats from the Brazilian semiarid. *Tropical Animal Health and Production* 47: 1217-1220.