



Prediction of carcass characteristics of discarded Pelibuey ewes by ultrasound measurements



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Abstract:

The objective of present study was to predict the carcass characteristics of 28 discarded Pelibuey ewes (41.01 ± 8.43 kg) using ultrasonography. The ultrasonic measurements of fat thickness (FT), area, (LDA), depth (DLD) and width (WLD) of the *Longissimus dorsi*, between the 12th and 13th thoracic vertebra and between the 3rd and 4th lumbar vertebra, were performed 24 h before slaughter. At the slaughter, hot carcass, internal organs and internal fat were weighed. The carcasses were divided in two half, refrigerated (1 °C; 24 h) and the chilled carcass were weighed. Then were dissected and weighed in the main tissues. With the data it was calculated the correlation coefficients between the variables and their relationships were estimated using regression models. It was observed that the ultrasonic measurements of thoracic and lumbar backfat thickness had a positive r^2 that ranged from 0.51 to 0.66 ($P < 0.001$) for prediction of the carcass weights; and an r^2 from 0.44 to 0.57 ($P < 0.001$) to predict the carcass muscle quantity. It is possible to use the measurements of ultrasound as a tool for the evaluation of carcass characteristics in discarded Pelibuey ewes and it is possible to predict the carcass weights and edible tissues.

Key words: Backfat, Hair ewes, Regression, *Longissimus dorsi* area.

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The sheep population in the States of Tabasco and Yucatan during the period of 2002 to 2011, increased by 37 and 95 %⁽¹⁾, respectively; both entities are located in the South-eastern region of Mexico and are characterised by tropical climate. In this region, the main breed used in mixed grazing systems due for their high prolificacy, good rusticity, resistance to parasites and great capacity of adaptation to various environmental conditions is the Pelibuey breed^(1,2).

In Mexico, the wide range of productive systems gives rise to seasonal fluctuations in the availability of sheep for the slaughter and causes a lot of irregularity in the type and condition of the animals that are produced, which is reflected in the quality of the final product; all this causes seasonal fluctuations with a strong irregularity in the offer of animals throughout the year, and leads to marked differences in their characteristics and conditions at the time of sale, since it provides the market with very varied, ranging from young lambs of specialized breeds to discarded animals with advanced in age and in very low-quality meat⁽³⁾.

To predict the carcass characteristics of animals *in vivo*, non-invasive techniques have been established that are preferred on the techniques that involve the destruction of the

carcass^(4,5). In Pelibuey ewes, the ultrasound have been used for predict of the carcass characteristics⁽⁵⁾, the body fat depots⁽⁶⁾ and carcass energy content⁽⁷⁾. Also, body measurements have been evaluated to the prediction of the carcass characteristics⁽⁸⁾.

On the other hand, cull or discarded ewes, with carcass weights ranging from 20 to 40 kg, are more difficult to market due to the low acceptability in the consumer market, which is related to a low price for sale due to the lack of commercial importance of this category. Moreover, studies related to the quality of the carcass and meat are scarce^(9,10,11). As described above, the objective of this study was to predict the carcass characteristics of discarded Pelibuey ewes by ultrasonic measurement.

The Pelibuey ewes were selected from one commercial flock in the “El Rodeo” farm, located at 17° 84 N, 92° 81 W; 10 m asl and 14 km from the road Villahermosa-Jalapa, Tabasco, Mexico; average of annual temperature of 28.2 °C, and annual rainfall of 2,299.5 mm⁽¹²⁾.

Twenty eight (28) 4-yr-old, non-pregnant and non-lactating, clinically healthy Pelibuey ewes with a mean of body weight (BW) of 41.01 ± 8.43 kg and body condition score (BCS) of 2.82 ± 1.29 , were drawn from a commercial flock. The ewes were in confinement, in group pens in a roofed building with concrete floor and no walls. The diet offered consisted of 66 % forage and 34 % concentrate, with an estimated of metabolizable energy of 12 MJ/kg DM and 10% CP⁽¹³⁾. The dietary ingredients were cereal grains (corn or sorghum), soybean meal, hay tropical grasses, vitamins, and minerals. The BCS was evaluated by two procedures using the technique of Russel *et al*⁽¹⁴⁾. The animals were assigned according to their BCS in six groups: 1 (n= 4); 2 (n= 8); 2.5 (n= 3); 3 (n= 5); 4 (n= 5) and 5 (n= 3).

The ultrasound measurements (USM) were taken 24 h before slaughter were determined using a real-time ultrasound equipment Aloka 500 B mode, with a 5 MHz linear probe. Ewes were shaved previously between the 12.th and 13.th thoracic vertebrae and the 3.rd and 4.th lumbar vertebrae regions according to what is described in the literature^(5,6). The USM included the fat thickness (FT), area (LDA), depth (DLD) and width (WLD) of *Longissimus dorsi* in both thoracic and (TFT, TLDA, TLDD and TLDW) and the lumbar region (LFT, LLDA, LLDD and LLDW). The ewes were manually immobilized and acoustic gel was used to create good contact between the probe and the skin of ewes. The pressure over the transducer head was kept to a minimum to avoid compression of the subcutaneous fat^(5,6). All measurements were taken on the left side of ewes. After capturing the scan image, the area of the muscle (TLDA and LLDA) and the fat thickness (TFT and LFT) in both regions were measured using the digital callipers of the equipment and the USM were recorded on all animals by the same operator as elsewhere described^(5,6).

Ewes were humanely slaughtered following the Mexican Official norms^(15,16) 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 the 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. Subsequently, the carcasses were split at the level of the dorsal midline in two equal halves, weighed, and chilled at 6 °C for 24 h. After refrigeration, 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.

Correlation coefficients among variables were analysed by the PROC CORR procedure of SAS⁽¹⁷⁾. Relationships between BW, BCS, USM and CEC were estimated by linear regression models using PROC REG⁽¹⁷⁾. 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).

The means (\pm SD), minimum and maximum values of BW, BCS, carcass characteristics and USM of adult Pelibuey ewes are shown in Table 1. The correlation coefficients (r) of USM in thoracic region (TFT, TLDA and TLDW) between CCW, carcass muscle (CM) and CF were all significant ($P<0.01$) with values that ranged from 0.37 to 0.76; nonetheless, the relations with CB were not significant ($P>0.05$). Also, a similar trend was observed for relation to lumbar USM and carcass, the r values ranged from 0.34 to 0.73.

Table 1: Descriptive analysis of the data on carcass characteristics and ultrasound measures of discarded Pelibuey ewes (n=28)

Variable	Description	Mean \pm SD	Minimum	Maximum
BW	Body weight, kg	41.01 \pm 8.43	29.80	59.80
BCS	Body condition score	2.77 \pm 1.22	1.00	5.00
HCW	Hot carcass weight, kg	19.65 \pm 5.14	13.42	31.48
CCW	Cold carcass weight, kg	18.86 \pm 4.99	12.68	30.52
CM	Carcass muscle, kg	10.80 \pm 2.05	8.33	15.44
CF	Carcass fat, kg	4.25 \pm 2.81	0.68	10.62
CB	Carcass bone, kg	3.82 \pm 0.46	3.18	5.27
TFT	Thoracic fat thickness, mm	0.81 \pm 0.49	0	1.80
TLDA	Thoracic <i>L. dorsi</i> area, cm ²	7.00 \pm 2.04	4.09	12.95
TLDD	Thoracic <i>L. dorsi</i> depth, cm	1.69 \pm 0.36	1.10	2.77
TLDW	Thoracic <i>L. dorsi</i> width, cm	5.14 \pm 0.63	3.64	5.94
LFT	Lumbar fat thickness, mm	0.91 \pm 0.99	0	5.50
LLDA	Lumbar <i>L. dorsi</i> area, cm ²	6.32 \pm 1.71	3.79	9.56
LLDD	Lumbar <i>L. dorsi</i> depth, cm	1.72 \pm 0.33	1.20	2.67
LLDW	Lumbar <i>L. dorsi</i> width, cm	5.09 \pm 0.49	4.02	5.75

SE: standard deviation.

For the prediction of both HCW and CCW (Equations 1 to 4) the equations obtained had an r^2 that ranged from 0.51 to 0.66 (Table 2), in these models the TFT and LFT were included ($P < 0.05$). Regression equations developed to predict the carcass muscle had an r^2 that ranged from 0.44 to 0.57; the USM that were included in the models were the fat thickness (TFT and LFT). Also, for the relationship between CF and USM, as the intercept of this equation was not significant, we fitted linear regressions through the origin (Equations 7 and 8). For the prediction of the CB does not match any equation based on the USM.

Table 2: Regressions equations to predict the carcass traits using ultrasound measurements in discarded Pelibuey ewes (n =28)

Eq. No	Equation	r^2	CME	RSD	P
Hot carcass weight (HCW):					
1	HCW (kg) = 13.54 (± 1.34 ***)+ 7.50 (± 1.42 ***) \times TFT	0.51	13.24	3.63	<.0001
2	HCW (kg) = 13.35 (± 1.16 ***)+ 5.22 (± 1.42 ***) \times TFT + 2.23 (± 0.70 **) \times LFT	0.65	9.83	3.13	<.0001
Cold carcass weight (CCW):					
3	CCW (kg) = 12.94 (± 1.12 **)+ 7.26 (± 1.38 ***) \times TFT	0.52	12.50	3.53	<.0001
4	CCW (kg) = 12.75 (± 1.30 ***)+ 5.01 (± 1.37 **) \times TFT + 2.21 (± 0.68 **) \times LFT	0.66	9.14	3.02	<.0001
Carcass muscle (CM):					
5	CM (kg)= 8.53 (± 0.57 ***)+ 2.77 (± 0.60 ***) \times TFT	0.44	2.41	1.55	0.0001
6	CM (kg)= 8.46 (± 0.51 ***)+ 1.90 (± 0.63 **) \times TFT + 0.85 (± 0.31 *) \times LFT	0.57	1.93	1.38	<.0001
Carcass fat (CF):					
7	CF (kg)= 4.99 (± 0.36 ***) \times TFT	0.87	3.41	1.84	<.0001
8	CF (kg)= 3.66 (± 0.49 ***) \times TFT + 1.22 (± 0.35 **) \times LFT	0.91	2.41	1.55	<.0001

R^2 = determination coefficient; MSE= mean square error; RSD= residual standard deviation; P= P-value; * $P < 0.05$; ** $P < 0.001$; *** $P < 0.0001$; ns= non-significant; HCW= hot carcass weight; CCW= cold carcass weight; CM= carcass muscle; CF= carcass fat; CB= carcass bone; TFT= thoracic fat thickness; LFT= lumbar fat thickness.

The real-time ultrasound is a noninvasive method that allows you to predict the body fat, the area and depth of the *Longissimus dorsi* muscle in sheep^(5,18,19). On the other hand, Silva *et al*⁽²⁰⁾ indicate that the use of the ultrasound measurements provided good estimates of fat content and energy in the body of the sheep of two racial groups. A researcher group⁽²¹⁾ reported that to include the BW and some USM is possible to predict the chemical composition of lambs. However, in the specialized literature the availability

of studies on the prediction of the composition and of the energy content of the carcass of sheep is limited^(7,21). In Mexico, the Pelibuey breed is one of the most important maternal breeds in the tropical zone and it supports the production of sheep meat; in spite of this, the information about the prediction of the carcass characteristics of discarded Pelibuey ewes is very scarce in the scientific literature⁽⁵⁾.

Other authors⁽²²⁾ who evaluated Akkaraman sheep with a mean body weight of 42 kg, the value for TLDA was 8.86 cm², as well as for TFT of 4.03 mm; the TLDA was higher than that recorded in the present study; also⁽⁵⁾, reported for the TLDA and LLDA values of 7.06 and 6.81 cm², respectively, which is consistent with the present study; moreover, they found values of 7.00 and 6.32 cm² for TLDAT and LLDA, respectively. In the case of the TFT this value was higher in the order of the double for the values found in adult Pelibuey ewes. In Churra breed sheep with a mean body weight of 36 kg, reported average values in GT and GL of 0.38 and 0.44 mm, respectively⁽²³⁾; these values are lower than those found in the present study (0.81 and 0.91 mm for the TFT and LFT, respectively); in a recent study⁽⁵⁾ reported average values of 1.91 and 1.99 mm for TFT and LFT respectively, these average values are higher than those recorded in the present study.

On the other hand, it was indicated⁽²²⁾ that ultrasound measurements alone showed lower r^2 values than that obtained when the BW was included as a variable in the equations. A similar situation was observed by Aguilar-Hernández *et al*⁽⁵⁾ and in same way in the present work. It was also reported⁽²³⁾ that use the BW and the TFT in multiple equations to predict the total fat in the carcass had a r^2 of 0.88, which differs from that found by other authors⁽⁵⁾, who using the same variables in the equation had an r^2 of 0.51 and the TFT was not significant in the model; a similar situation was observed in the present study, so that it was able to deduce that the inclusion of ultrasound measurements improve slightly (4 %) the prediction of this tissue (Equation 5).

It was also pointed out⁽²³⁾ that the weight of the bone is highly associated with the BW of the sheep, and registering an r^2 of 0.92; in this regard, other reserchers⁽⁵⁾ reported in Pelibuey ewes that this relationship achieved a r^2 of 0.22, which resembles the value obtained in Aragon lambs⁽²⁴⁾, in assessing this same relationship ($r^2=0.19$). In the present investigation it was observed that the BW alone predicts the weight of the bone with the r^2 value of 0.41. In this sense, it was found that the measures by ultrasound in animals *in vivo*, were highly related to the measurements determined in the carcass, as well as conclude that these measurements can be used for the prediction of the carcass characteristics of the cull ewes⁽²⁵⁾; this is consistent with the results observed in the present work. Several authors conclude that the use of ultrasound is a valuable tool for the prediction of the carcass and body composition of the meat producer animals^(20,26).

It is possible to use the ultrasound measurements as a tool for carcass characteristics evaluation in discarded Pelibuey ewes and it is possible to predict the hot carcass weight and the protein and fat quantity in carcass. In this way, a higher value will be able to assign to the ovine carcass, depending on its yield and attributes, besides improve the

body condition in animals next to slaughter to improve their meat quality and to achieve a greater position in the commercial scale.

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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Literature cited:

1. Muñoz-Osorio GA, Aguilar-Caballero AJ, Sarmiento-Franco LA, Wurzinger M, Cámara-Sarmiento R. Technologies and strategies for improving hair lamb fattening systems in tropical regions: a review. *Ecosist Rec Agrop* 2016;3: 267-278.
2. Chay-Canul AJ, Magaña-Monforte JG, Chizzotti ML, Piñero-Vázquez AT, Canul-Solís JR, Ayala-Burgos AJ, Ku-Vera JC, *et al.* Energy requirements of hair sheep in the tropical regions of Latin America. Review. *Rev Mex Cien Pecu* 2016;7:105-125.
3. Arbiza S, De Lucas J. Producción de carne ovina (Ovine meat production). México: Editores Mexicanos Unidos; 1996.
4. Scholz AM, Bünger L, Kongsro J, Baulain U, Mitchell AD. 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* 2015;9:1250-1264.

5. Aguilar-Hernández E, Chay-Canul AJ, Gómez-Vázquez A, Magaña-Monforte JG, Ríos FG, Cruz-Hernández A. Relationship of ultrasound measurements and carcass traits in Pelibuey ewes. *J Anim Plant Sci* 2016;26:325-330.
6. Chay-Canul AJ, Garcia-Herrera RA, Meza-Villalvazo VM, Gomez-Vazquez A, Cruz-Hernandez A, Magaña-Monforte JG, Ku-Vera JC. Body fat reserves and their relationship to ultrasound back fat measurements in Pelibuey ewes. *Ecosist Recur Agropec* 2016;3:407-413.
7. Rodríguez-Valenzuela E, Salazar-Cuytun R., García-Herrera RA, Piñeiro-Vázquez ÁT, Casanova-Lugo F, Velázquez-Martínez JR, Herrera-Camacho J, *et al.* Prediction of carcass energy content in Pelibuey ewes by ultrasound measurements. *Ecosist Rec Agrop* 2017 [in press].
8. Bautista-Díaz E, Salazar-Cuytun ER, Chay-Canul AJ, García-Herrera RA, Piñeiro-Vázquez AT, Magaña-Monforte JG, Tedeschi LO, *et al.* Determination of carcass traits in Pelibuey ewes using biometric measurements. *Small Ruminant Res* 2017;147:115–119.
9. Civit D, Díaz MD, Rodríguez E, González CA. Características de la canal y efecto de la maduración sobre la calidad de la carne de ovejas de desvieje de raza Corriedale. *ITEA*, 2014;110(2):160-170.
10. Cacere RAS, Morais MG, Alves FV, Feijó GLD, Ítavo CCBF, Ítavo LCV, Ribeiro CB. Quantitative and qualitative carcass characteristics of feedlot ewes subjected to increasing levels of concentrate in the diet. *Arq Bras Med Vet Zootec* 2014;66:1601-1610.
11. Ruiz-Ramos J, Chay-Canul, AJ, Ku-Vera JC, Magaña-Monforte JG, Gómez-Vázquez A, Cruz-Hernández A, Gonzalez-Garduño R, *et al.* Carcass and non-carcass components of Pelibuey ewes subjected to three levels of metabolizable energy intake. *Ecosist Rec Agrop* 2016;3:21-31.
12. COMISIÓN NACIONAL DEL AGUA (CONAGUA). <http://www.conagua.gob.mx/>. Consultado 26 May, 2016.
13. AFRC. Energy and protein requirements of ruminants. Agricultural and Food Research Council. CAB International, Wallingford, UK. 1993.
14. Russel A, Doney J, Gunn R. Subjective assessment of body fat in live sheep. *J Agric Sci (Cambridge)* 1969;72:451-454.
15. Norma Oficial Mexicana. NOM-009-ZOO-1994. Proceso sanitario de la carne. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Diario Oficial de la Federación: 31/07/2007. México, DF.
16. Norma Oficial Mexicana. NOM-033-SAG/ZOO. Métodos para dar muerte a los animales domésticos y silvestres. Secretaría de Agricultura, Ganadería, Desarrollo

- Rural, Pesca y Alimentación. Diario Oficial de la Federación: 26/08/2015. México, DF.
17. SAS. Institute Inc., SAS/STAT. Software, Ver. 9.00, Cary, NC27512-8000. USA. 2002.
 18. Silva SR, Afonso JJ, Santos VA, Monteiro A, Guedes CM, Azevedo JMT, Dias-da-Silva A. *In vivo* estimation of sheep carcass composition using real-time ultrasound with two probes of 5 and 7.5 MHz and image analysis. *J Anim Sci* 2006;84(12):3433-3439.
 19. Ripoll G, Joy M, Alvarez-Rodriguez J, Sanz A, Teixeira A. Estimation of light lamb carcass composition by *in vivo* real-time ultrasonography at four anatomical locations. *J Anim Sci* 2009;87(4):1455–1463.
 20. Silva SR, Afonso J, Guedes CM, Gomes MJ, Santos VA, Azevedo JMT, Dias-da-Silva A. Ewe whole body composition predicted *in vivo* by real-time ultrasonography and image analysis. *Small Ruminant Res* 2016;136:173-178.
 21. Silva SR, Gomes MJ, Dias-da-Silva A, Gil LF, Azevedo JMT. Estimation *in vivo* of the body and carcass chemical composition of growing lambs by real-time ultrasonography. *J Anim Sci* 2005;83:350–357.
 22. Sahin EH, Yardimci M, Cetingu IS, Bayram I, Sengor E. The use of ultrasound to predict the carcass composition of live Akkaraman lambs. *Meat Sci* 2008;79:716-721.
 23. Teixeira A, Matos S, Rodrigues S, Delfa, R., Cadavez V. *In vivo* estimation of lamb carcass composition by real-time ultrasonography. *Meat Sci* 2006;74:289-295.
 24. Delfa R, Teixeira A, Gonzalez C, Blasco I. Ultrasonic estimates of fat thickness and *longissimus dorsi* muscle depth for predicting carcass composition of live Aragon lambs. *Small Ruminant Res* 1995;16(2):159-164.
 25. Pinheiro RSB, Jorge AM, Yokoo MJ. Correlações entre medidas determinadas *in vivo* por ultrassom e na carcaça de ovelhas de descarte. *Rev Bras Zootec* 2010;39(6):1161-1167.
 26. Silva SR. Use of ultrasonographic examination for *in vivo* evaluation of body composition and for prediction of carcass quality of sheep. *Small Ruminant Res* 2017;152(2):144-157.