RELATIONSHIP OF ULTRASOUND MEASUREMENTS AND CARCASS TRAITS IN PELIBUEY EWES

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ABSTRACT

Twenty Pelibuey ewes were used to assess the relationship between ultrasound measurements (USM) and carcass traits. Animals were slaughtered, and the left half of each carcass was divided into five cuts, and then each cut was dissected into muscle, fat and bone. The subcutaneous fat thickness and the Longissimus dorsi muscle area were determined 24 h post-mortem using a ultrasound equipment, the USM were taken between the 12º and 13º thoracic vertebra (TF and TLD) and between 3º and 4º lumbar vertebra (LF and LLD). The relationships among USM and carcass traits were estimated by regression. The regression equations using only the USM have a R² that ranged from 0.22 to 0.45. When including the BW in the equations, the R² was from 0.52 to 0.55 for muscle, 0.51 to 0.53 for fat and 0.47 for bone. The best equations were: CM (kg) = 0.18(±0.03)xBW +0.38(±0.17)xTLDA; CF (kg)=-1.66(±0.79)+ 0.09(±0.03”xBW + 0.38(±0.19)xF; TLD -0.11(±0.09)xTLD and CB (kg)= 2.44(±0.49)”+ 0.06(±0.01”xBW -0.23(±0.11”xTFT. In conclusion, it is possible to predict the amount of muscle, fat and bone in the carcasses of adult Pelibuey ewes using USM and BW, nonetheless, other alternatives, should be considered to improve the accuracy of predictions.

Keywords: Pelibuey ewes, carcass composition; ultrasound measurements.

INTRODUCTION

The sheep population in Mexico is around 8.6 million of heads 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 with 25% of the national sheep’s meat production. Sheep tropical systems are managed under harsh environment, also is characterized as low-input, low technology adoption and the use of hair sheep population, mainly Pelibuey breed (Magaña-Monforte et al., 2013).

In Mexico, as in other tropical countries, a significant proportion (about 40%) of animals intended for slaughter corresponds to cull animals, which have a low body condition and live weight (Mendiratta et al., 2008; González-Garduño et al., 2014). The previous conditions of these animals results in a reduced selling price (Civit et al., 2014). In lamb production systems, the ewes are culled for different reasons (Abdelqader et al., 2013), then adult or cull ewes, may represent an economic option if the selling price could be based on the carcass weight and the amount of edible tissues (Pinheiro et al., 2010; Civit et al., 2014; González-Garduño et al., 2014). It is therefore important to know the carcass characteristics of adult ewes and thereby provide the producer a viable option for the sale and consumption of this type of meat animals (Civit et al., 2014).

On the other hand, the main objective of the livestock and meat industry is to have an accurate, low cost, objective and easy method for predicting the carcass traits in order to determine the value on live animals (Sahin et al., 2008; Souza et al., 2013; Vardanjani et al., 2014).

Some authors have reported that the use of ultrasound is a non-invasive method that can help to predict the amount of muscle, bone and fat in meat and wool breeds (Teixeira et al., 2006; Silva et al., 2006; Ripoll et al., 2009). The real time ultrasound is a non-invasive method that allows to predict the subcutaneous body fat, as well as the characteristics of carcass tissues such as the Longissimus dorsi area and depth in live animals such as sheep (Ripoll et al 2009; Sahin et al., 2008; Pinheiro et al., 2010; Esquivelzeta et al., 2012; Monau et al., 2013).

However, in hair sheep breed such as Pelibuey, the use of ultrasound for this purpose has not been
The US transducer head was kept to a pressure of 0.18(±0.03)×BW, where BCS 1 and 5 represented a thin animal and an obese animal as described by Russell et al. (1969).

**MATERIALS AND METHODS**

**Animals and management:** Twenty, non-pregnant, non-lactating Pelibuey ewes with BW of 37.2 ± 4.0 kg were used in this study. The area of study was located at 20° 45' N, 89° 30' W; 8 masl, with a climate AWo (tropical warm sub-humid with summer rainfall). The average annual temperature ranges from 26 to 27.8 °C, with an annual rainfall ranging from 940 to 1100 mm (Garcia 1988). The body weight and body condition score (BCS) of these animals are listed in the Table 1. The BCS were registered, with a scale ranging from 1 to 5, with subdivisions of 0.5 (e.g. 1.5, etc.), where BCS 1 represents a thin animal and 5 an obese animal as described by Russell et al. (1969).

**Ultrasound measurements:** The USM were taken 24 hours before slaughter. The fat thickness (FT) and *Longissimus dorsi* area (LDA) was determined using a real-time ultrasound equipment Pie Medical® 100 B mode, with a 6/8 MHz linear probe. To do so, the animals were shaved previously between the 12º and 13º thoracic vertebrae (TFT and TLDA) and the 3º and 4º lumbar vertebrae (LFT and LLDA) according to Teixeira et al. (2006) and Silva et al. (2006). 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 fat as described by Sahin et al. (2008). All measurements were taken on the left side. After capturing the scan image, the area of muscle (TLDA and LLDA) and the fat thickness (TFT and LFT) in both regions were measured using the electronic callipers of the equipment as described Sahin et al. (2008). The USM were recorded on the left side of all animals by the same operator as described by Ripoll et al (2010).

**Carcass measurements:** Ewes were humanely slaughtered by following the Mexican Official norms (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 a period of 24 h. The limbs, pelt, head and all internal organs were separated. The data recorded at the slaughter were weights of internal organs and carcass. 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 during 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 weighed separately. Dissected tissues of the left carcass were adjusted as whole carcass.

**Data analysis:** Correlation coefficients among variables were analyzed by the procedure PROC CORR of SAS (SAS Ver. 9.00, 2002). Regressions were developed with PROC REG of SAS (SAS Ver. 9.00, 2002). The option STEPWISE was used in the SELECTION statement to select the variables included in the model. The accuracy of the models was evaluated by the determination coefficient ($R^2$) and the residual standard deviation (RSD).

**RESULTS**

The mean, standard deviation, maximum and minimum values of BW, ultrasound measurements (USM) and carcass tissues are shown in Table 1. The data regarding LDA for Pelibuey ewes were found to be 7.06 and 6.89 cm² for thoracic (TLDA) and lumbar (LLDA) regions respectively and the average values of fat thickness were 1.99 and 1.91 mm for thoracic (TFT) and lumbar (LFT) regions, respectively.

Simple regression equations using only the USM have $R^2$ values that ranged from 0.22 to 0.45. Nonetheless, to include the BW as independent variable in a multiple regression equations improved the accuracy of equations (Table 2). The multiple linear regression equations that included the BW and USM, had an $R^2$ value that ranged from 0.52 to 0.55 for muscle, from 0.51 to 0.53 for fat and 0.47 for bone (Table 2).

In order to calculate the relationship between USM and carcass muscle (CM), and because the intercept of the Equation 1 was not significant, we fitted a new linear regression through the origin (Equation 10): CM (kg) = 0.18(±0.03)×BW +0.38(±0.17)×TLDA ($R^2$: 0.98; MSE: 1.04; RSD: 1.02; $P < 0.0001$ y $n = 20$). The best equations for predicting carcass fat and carcass bone were the Equations 5 and 9 respectively.
Table 1. Mean (±SD), maximum and minimum values of body weight, ultrasound measurements and carcass traits in Pelibuey ewes (n=20)

<table>
<thead>
<tr>
<th></th>
<th>Mean ±SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>36.13±4.99</td>
<td>29.00</td>
<td>48.75</td>
<td>13.80</td>
</tr>
<tr>
<td>BCS grades</td>
<td>2.56±0.51</td>
<td>1.50</td>
<td>3.50</td>
<td>19.99</td>
</tr>
<tr>
<td>CM (kg)</td>
<td>9.16±1.56</td>
<td>6.89</td>
<td>13.44</td>
<td>17.06</td>
</tr>
<tr>
<td>CF(kg)</td>
<td>1.82±0.69</td>
<td>0.67</td>
<td>3.25</td>
<td>37.91</td>
</tr>
<tr>
<td>CB (kg)</td>
<td>3.97±0.39</td>
<td>3.36</td>
<td>4.74</td>
<td>9.76</td>
</tr>
<tr>
<td>TFT (mm)</td>
<td>1.99±0.69</td>
<td>1.00</td>
<td>3.40</td>
<td>34.53</td>
</tr>
<tr>
<td>LFT (mm)</td>
<td>1.91±0.61</td>
<td>1.00</td>
<td>3.40</td>
<td>32.05</td>
</tr>
<tr>
<td>TLDA(cm²)</td>
<td>7.06±1.59</td>
<td>4.14</td>
<td>9.95</td>
<td>22.52</td>
</tr>
<tr>
<td>LLDA(cm²)</td>
<td>6.89±1.45</td>
<td>3.59</td>
<td>8.91</td>
<td>21.08</td>
</tr>
</tbody>
</table>


Table 2. Regressions equations to predict the carcass traits using ultrasound measurements in Pelibuey ewes

<table>
<thead>
<tr>
<th>Eq. No</th>
<th>Equation</th>
<th>n</th>
<th>R²</th>
<th>MSE</th>
<th>RSD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carcass muscle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CM (kg) = 0.73±(±1.77)×BW + 0.16(±0.06)×TFT + 0.37(±0.17)×TLDATA</td>
<td>20</td>
<td>0.55</td>
<td>1.093</td>
<td>1.046</td>
<td>0.0004</td>
</tr>
<tr>
<td>2</td>
<td>CM (kg) = 0.75(±1.81)×BW - 0.21(±0.42)×TFT + 0.41(±0.19)×TLDATA</td>
<td>20</td>
<td>0.53</td>
<td>1.145</td>
<td>1.069</td>
<td>0.0016</td>
</tr>
<tr>
<td>3</td>
<td>CM (kg) = 0.76(±1.82)×BW - 0.08(±0.34)×TLDATA + 0.43(±0.30)×TLDATA</td>
<td>20</td>
<td>0.53</td>
<td>1.157</td>
<td>1.076</td>
<td>0.0017</td>
</tr>
<tr>
<td>4</td>
<td>CM (kg) = 0.74(±1.84)×BW - 0.07(±0.34)×TFT + 0.37(±0.19)×TLDATA + 0.02(±0.49)×TLDATA</td>
<td>20</td>
<td>0.52</td>
<td>1.162</td>
<td>1.079</td>
<td>0.0018</td>
</tr>
<tr>
<td></td>
<td>Carcass fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CF (kg) = -1.66(±0.79)×BW + 0.09(±0.03)×TFT - 0.11(±0.09)×TLDATA</td>
<td>20</td>
<td>0.53</td>
<td>0.223</td>
<td>0.472</td>
<td>0.0016</td>
</tr>
<tr>
<td>6</td>
<td>CF (kg) = -1.85(±0.84)×BW - 0.30(±0.37)×TFT + 0.60(±0.32)×TFT + 0.02(±0.49)×TFT + 0.37(±0.19)×TLDATA</td>
<td>20</td>
<td>0.52</td>
<td>0.227</td>
<td>0.477</td>
<td>0.0039</td>
</tr>
<tr>
<td>7</td>
<td>CF (kg) = -1.70(±0.81)×BW + 0.36(±0.19)×TFT + 0.12(±0.15)×TLDATA</td>
<td>20</td>
<td>0.52</td>
<td>0.228</td>
<td>0.478</td>
<td>0.0040</td>
</tr>
<tr>
<td>8</td>
<td>CF (kg) = -1.77(±0.81)×BW - 0.08(±0.02)×TFT + 0.29(±0.17)×TFT</td>
<td>20</td>
<td>0.51</td>
<td>0.230</td>
<td>0.480</td>
<td>0.0008</td>
</tr>
<tr>
<td></td>
<td>Carcass bone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>CB (kg) = 2.44(±0.49)×BW + 0.06(±0.01)×TFT + 0.23(±0.11)×TLDATA</td>
<td>20</td>
<td>0.41</td>
<td>0.088</td>
<td>0.296</td>
<td>0.0042</td>
</tr>
<tr>
<td>10</td>
<td>CM (kg) = 0.18(±0.03)×BW + 0.38(±0.17)×TLDATA</td>
<td>20</td>
<td>0.98</td>
<td>1.04</td>
<td>1.02</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

R²: 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

DISCUSSION

The body and carcass composition may be estimated by direct and indirect methods. The main direct method is the comparative slaughter and it is considered the most suitable because of its greater precision; nonetheless, it is very expensive and destructive method (Silva et al., 2015). On the other hand the indirect methods are preferred over direct methods because indirect methods are easier to implement and it is possible to apply on in live animals (Scholz et al. 2015, Silva et al. 2015).

The body weight (BW) is a very important characteristic in animal husbandry as a selection criterion and measure of economic profit. Within a breed, BW might be affected by management, environment and feeding conditions. The correlation is one of the most common and most useful statistics that describes the relationship between two variables (Cam et al., 2010). The attempts to predict accurately BW from body...
measurements utilizes this characteristic of correlation. The accurate estimation of live weight from simple live body measurements is very important for livestock enterprises. For assessing the profitability a producer can measure all the body measurements easily from a live animal to determine body weight to predict some carcass traits (Vardanjani et al., 2014).

In Akkaraman sheep weighing 42 kg, Sahin et al. (2008) found values for TLDA of 8.86 cm². In addition, they reported TFT mean values of 4.03 mm. The values for TLDA were slightly superior to those found in the current study. For TFT, the value was superior to that register in Pelibuey ewes of the present study. Teixeira et al. (2006) reported that the TFT and LFT had mean values of 0.38 and 0.44 mm respectively in Churra sheep with body weight of 36 kg; values inferior to the found in the present study.

Pinheiro et al. (2010) in discarded ewes reported a LDA values determined by ultrasound that ranged from 8.86 to 11.62 cm², also the SFT varied from 1.37 to 2.72 mm; the values for LDA were slightly higher to those of the current study in Pelibuey ewes, nevertheless, the values for SFT were similar. These authors concluded that the USM could be used as alternative to predict the carcass characteristics, due to the facility and precision of the measurement. However, no research was found on ultrasound measurements of Pelibuey ewes.

Orman et al. (2010) in Awassi female lambs with BW between 30.35 to 38.95 kg found a LMA with USM values of 7.93 to 10.81 cm² and for same animals reported a SFT of 2.59 to 4.22 mm. Also these authors reported that at same BW female lambs had greater SFT than the male lambs.

On the other hand, Sahin et al. (2008) observed that the use of USM alone present R² smaller values, than the obtained using the BW as other variable in the equations, this situations was similar to observed in the present study.

Teixeira et al. (2006), using the BW and the TFT in multiple equations to predict the total carcass fat, obtained a R² of 0.88, the R² obtained for these authors differ to found in the current study, since using both variables the R² of equation was lightly 0.51 and the variable TFT was no significant in the equation, for what the inclusion of USM only improves lightly (2%) the prediction of this tissue (Equation 5).

It can be observed that the inclusion of one or more USM in addition to BW slightly improve the predictive ability of equations, similar reports were made by Silva et al. (2006).

Silva et al. (2006) reported that BW was a powerful estimator of the muscle content in a carcass and 87-95% of the variation was explained by BW, and when ULDA (over the 13th thoracic vertebra) was included in the multiple regression analysis, variation of total carcass muscle led to an increase of 6% in Churra de Terra Quente sheep. Similar results were reported by Ripoll et al (2010). Contrasting this observation, Teixeira et al. (2006) reported increased variation (96%) for total muscle weight based on only BW of Churra Galega Bragancana male lambs. Similar results have been reported by Orman et al. (2008) and Sahin et al. (2008), who reported that the variation changed between 79 and 80% for total muscle weight based on BW and when ULDA was included in the regression equations in fat-tailed male lambs. Also, Agamy et al. (2015) reported that the BW contributed 66% of the variation in total trimmed meat weight of Egyptian ram-lambs, whereas ultrasound Longissimus dorsi muscle area came next and scored a partial determination of 16% increasing the model’s R² to 82%. Vardanjani et al. (2014) also concluded that the combination of BW with some ultrasound measurements generally accounted for the majority of the variation of the carcass traits in Torki-Ghashghaii sheep.

Teixeira et al. (2006) reported that the bone weight was greater related to BW of the animals, and they obtained a R² of 0.92, a greater value than ours, because in our study this relationship scarcely reach a R² of 0.22, this value was similar to reported by Delfa et al. (1995) who evaluated this same relationship and obtained a R² value of 0.29; also Ripoll et al (2009) found a small R² (0.17) for both variables. On the other hand, Pinheiro et al. (2010) found that the USM in live animals are higher related with the obtained in the carcass, moreover, they concluded that the USM may use for predict the carcass characteristics of discarded ewes.

The highest correlation between the USM and the carcass measurements of the back fat thickness and the Longissimus dorsi muscle area has been discussed by some authors (Sahin et al., 2008; Pinheiro et al., 2010; Orman et al., 2010). Therefore, in the current study, these data are no presented and discussed.

Teixeixa et al. (2006) suggested that distinct results between authors and breeds of sheep may be due to differences also in the experimental conditions and therefore prediction equations must be developed for each breed according to the system of production in which it is handled. Several authors conclude that the use of the ultrasound is a valuable tool for the prediction of the body composition of animals (Stouffer, 2004; Emenheiser et al., 2010). Sahin et al. (2008) concluded that it is important to evaluate this tool in native sheep breeds to developing prediction models according to these breeds.

More research is needed in assessing the USM and its potential for predicting body and carcass composition of hair sheep, in order to create predictive models of body and carcass composition of such sheep breeds.
Conclusion: It is possible to predict the amount of muscle, fat and bones in the carcass of Pelibuey ewes, using measurements by ultrasound and the live weight of the animal, nevertheless other alternatives must be evaluated to increase the accuracy of these estimates.

REFERENCES


