Colegio de Postgraduados

Can equations for Black Belly lambs be used to predict the carcass tissue composition of Dorper lambs?

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ABSTRACT

Objective: This study aimed to evaluate the applicability of equations developed in Black Belly lambs for predicting carcass tissue composition in Dorper lambs.

Design/methodology/approach: This study was conducted using twenty 6-month-old ewe lambs (30.53±3.62 kg). Animals were slaughtered, and the carcass was chilled at 1 °C for 24 hours. The carcass was then split along the dorsal midline, and sections 9-11 were removed from the left half of the carcass. The remainder of the left half of the carcass was dissected into muscle (TMC), fat (TCF), and bone (TCB), and the weight of each was adjusted to the total carcass weight. The equations were assessed for their adequacy. The accuracy and precision of the models were assessed by simple linear regression analysis, graphical analysis, mean square error of prediction (MSEP) and its components, and sources of error.

Results: The regression analysis indicated that in equations for TCM and TCF, the slope was not different from unity ($P>0.05$), but the intercept was different from zero ($P<0.05$). Nonetheless, all equations showed low to moderate precision ($0.20 \leq r^2 \leq 0.65$), moderate accuracy (bias correction factor <0.65), and low to moderate reproducibility index and agreement with observed data (concordance correlation coefficient of $0.30 \leq CCC \leq 0.48$) for predicting carcass tissues in Dorper lambs. In equations for TCM and TCF, the main component of the MSEP was the means bias (>73.29%). In the TCB equation, the main component of the MSEP was random error (>69.82%). This result indicates that further evaluation is required to ensure that there is no lack of fit, *i.e.*, simply random variation that cannot be accounted for by the model in its current form.

Study limitations/implications: The study highlights significant limitations in the equations used to estimate the carcass composition of Dorper lambs, showing poor agreement between observed and predicted weights. This highlights the need for more accurate models that consider breed, sex, and local rearing conditions.

Findings/Conclusions: Based on these findings, we suggest that the equations tested in this study are not effective in predicting carcass tissue composition in Dorper lambs.

Keywords: carcass, hair sheep, mathematical models; prediction, rib section cut.

INTRODUCTION

The complete dissection of the sheep carcass allows us to know the tissue composition, but this technique is laborious and expensive. One way of reducing the work involved in dissecting a carcass is to use equations to estimate the carcass tissue composition (Silva *et al.*, 2013). Therefore, several authors present it as an alternative, such as the recording of specific carcass measurements or the use of the tissue composition of primary cuts and the 9-11 rib section to reduce carcass damage (Escalante-Clemente *et al.*, 2022; Rivera-Alegría *et al.*, 2022). Silva *et al.* (2013) state that the evaluation of equations for accurate and precise estimation of carcass composition is a significant advance, as it could help to reduce the cost of experiments. As the evaluation of carcass composition requires the complete dissection of a half carcass, cost is one of the limiting factors for the conduct of some studies in this area. Marcondes *et al.* (2012) also stated that methods that can estimate carcass or body composition without sacrificing the whole carcass are important because they save time, labor and cost. In addition, these methods would have to be of acceptable accuracy to be widely used. Also, due to the wide variety of breeds, management conditions and performance differences between them, it is necessary to look for factors that allow a better integration of the models in different breeds and environmental conditions (Torres *et al.*, 2021).

Due to its low cost, the technique of rib sections 9 to 11 has helped estimate the carcass composition of different animal species (Marcondes *et al.*, 2012; Escalante-Clemente *et al.*, 2021). This technique has recently been used to determine the carcass tissue composition of Black Belly lambs (Escalante-Clemente *et al.*, 2021). Pelibuey and Blackbelly breeds are used in tropical production systems as maternal breeds. Therefore, Katahdin and Dorper breeds have been introduced to increase productivity in these systems. However, there are few reports on carcass traits predicted using these breeds. For example, there have yet to be any reports on using the 9 to 11 rib section to predict carcass traits. According to Tedeschi (2006), the first step in the development of more accurate and reliable models is the identification and acceptance of model inaccuracies. Therefore, assessing the suitability of a mathematical model is an essential step in the modelling process, as it indicates the level of precision and accuracy of the model's predictions for the purpose for which it has been developed. This step is essential to increase confidence in the current model. It also allows the selection of alternative models or suggests model adjustments. The aim of the present study was to evaluate the applicability of an equation developed for Black Belly lambs for predicting carcass muscle weight in Dorper lambs.

MATERIALS AND METHODS

The study was carried out in the experimental area of the The study was carried out at the Centro de Integración Ovina del Sureste (CIOS), located in R/a Alvarado Santa Irene 2nd section, in the municipality of Centro, with a humid tropical climate and temperatures ranging from 15 to 44 °C, with an average of 26 °C, Tabasco, Mexico. Twenty 6-month-old Dorper ewe lambs were used. The animals used in this study were treated following the guidelines and regulations for ethical animal experimentation of the Academic Department of Agricultural Sciences of the Universidad Juárez Autónoma de Tabasco (CIEI: Folio

1173-2022). The average live weight (BW) was 30.53±3.62 kg. Lambs were weaned at 60 days of age and fattened in a cage system with raised slatted floors and group feeding (ten animals per cage) in a feedlot system. When the target BW was reached, animals were selected from the fattening groups for slaughter. The diet consisted of 80% concentrate and 20% forage with an estimated 15% crude protein (CP) and 12 MJ metabolizable energy (AFRC, 1993) and was provided *ad libitum*. The ingredients of the diet included cereal grains (53% ground maize, 14% soya bean meal, 20% star grass hay, 3% molasses, 4% rice flour and a 1% pre-mix of vitamins and minerals.

The animals were slaughtered after a 24-hour fast following the applicable standards (NOM-033-SAG/ZOO-2014 and NOM-088-SAG/ZOO-2014). After slaughter, the carcasses were chilled at 1 °C for 24 h. Ribs 9-11 were taken from the left side of the carcass. The carcass was split medially, and a section through all intercostal spaces between ribs 9-11 (out of a total of 13 pairs of ribs) was taken from the left forequarter, and the segment was removed as described by Escalante-Clemente *et al.* (2022). The left half of the carcass was then weighed and dissected to record the weight of muscle, fat and bone and the weight. The same procedure was followed for rib sections 9-11. The tissues dissected in the left half of the carcass plus those dissected in rib sections 9-11 were adjusted to give the total carcass weight of muscle (TCF), fat (TCF) and bone (TCB).

The equations proposed by Escalante-Clemente *et al.* (2022) were evaluated for predicting total (TCM), fat (TCF), and bone (TCF) of Dorper lambs using the characteristics of the 9-11 rib section (Table 1). The data used to test the equations are shown in Table 2. The equations were assessed for their adequacy. The accuracy and precision of the models were assessed by simple linear regression analysis of the observed values (Y) with the predicted values (X). The carcass tissue compositions estimated by the equations were compared with the values observed using the following regression model:

$$Y = \beta_0 + \beta_1 \times X$$

Where X=predicted value; Y=observed value; β_0 and β_1=intercept and slope of the linear equation, under the following statistical hypothesis: H_0: β_0=0 and H_0: β_1=1 and H_a: not H_0. If the null hypotheses were not rejected, the prediction model accurately estimated the carcass tissue composition.

Also, the following procedures were used: graphical analysis, mean square error of prediction (MSEP) and its components, and sources of error (error due to bias, error due to the slope of the regression between observed and predicted values being different from 1, and random error). The coefficient of model determination (CD) was used to assess the variance of the predicted data. The bias correction factor (Cb), a concordance correlation coefficient (CCC) component, was used to indicate deviation from the line of identity. The CCCs were also used as a reproducibility index to consider precision and accuracy. Coefficients >0.80 were considered high precision and accuracy. Moderate precision and accuracy were assumed when the coefficients were >0.51 and <0.79.

Low precision and accuracy were assumed when the coefficients were <0.50. Finally, all calculations were performed using the Model Evaluation System (Tedeschi, 2006).

RESULTS AND DISCUSSION

The mean, minimum, and maximum carcass traits and 9-11 rib sections for Dorper lambs are presented in (Table 1). The total carcass muscle weight (TCM) ranged from 4.32 to 10.25 kg. As for the characteristics of the 9-11 rib section, the weight of ribs 9-11 (WRib) ranged from 0.11 to 0.28 kg. The muscle of sections 9-11 (MRib) ranged from 0.04 to 0.14 kg, while the fat (FRib) ranged from 0.01 to 0.09 kg.

The regression analysis indicated that in equations for TCF the slope was different from 1 (P>005). However, for TCM and TCB, the slope was not different from unity (P>0.05), but the intercept was different from zero (P<0.05). This analysis indicated that adjustments were required to estimate the true value, although the model could be used to predict carcass tissues in Dorper lambs. Nonetheless, all equations showed low to moderate precision ($0.20 \leq r^2 \leq 0.65$), moderate accuracy (bias correction factor <0.65), and low to moderate reproducibility index and agreement with observed data (concordance correlation coefficient of 0.30≤CCC≤0.48) for predicting carcass tissues in Dorper lambs. In equations for TCM and TCF, the main component of the MSEP was the means bias (>73.29%). In the TCB equation, the main component of the MSEP was random error (69.82%). It is good to have a high proportion of MSEP in random, because this helps us to avoid high proportions of MSEP in systematic and mean bias. This is because most of the variation in results is not due to problems in the equation, but rather due to random effects. For TCM and TCF, the result indicates that further evaluation is required to ensure that there is no lack of fit, *i.e.* simply random variation that cannot be accounted for by the model in its current form. The CD value for equations for TCM and TCF also indicated the model overprediction (CD>1 indicates underprediction and CD<1 indicates overprediction); however, in the equations for TCB, an underprediction was observed by the variation by 63%.

Escalante-Clemente *et al.* (2022) reported that they were able to predict carcass tissue composition in Black Belly lambs using rib dissection 9-11 and found that the use of this technique provided moderate to high accuracy (r^2>0.59≤ and ≤0.92) and precision (>0.96) predictions. The authors conclude that rib dissection 9-11 is a low

Table 1. Regression equations used to predict carcass tissue composition in Dorper ewe lambs using the 9^{th}-11^{th} rib section.

No.	Equation	r^2	MSE	RMSE	P-Value
1	$TCM(\text{kg}) = 0.89(\pm 0.66*) + 1.11(\pm 0.10***) \times LHCW + 24.49(\pm 10.16*) \times FRib$	0.90	0.12	0.34	<0.0001
2	$TCF(\text{kg}) = -0.19(\pm 0.41*) + 0.16(\pm 0.06*) \times LHCW + 20.37(\pm 6.04**) \times FRib$	0.61	0.05	0.22	0.0007
3	$TBC(\text{kg}) = 0.58(\pm 0.34*) + 0.28(\pm 0.05*) \times LHCW + 9.32(\pm 2.49**) \times BRib$	0.80	0.02	0.14	<.0001

TCM: Carcass muscle (kg); TCF: Carcass fat (kg); TCB: carcass bone (kg); MRib: Muscle in the 9^{th}-11^{th} rib section (kg); FRib: fat in 9-11 rib section (kg); BRib: Bone in the 9^{th}-11^{th} rib section (kg); LHCW: left half-carcasses weight (kg). Values within parentheses are the SE of the parameter estimates. *: P<0.05; **: P<0.01; ***: P<0.001.

Table 2. Variables used to estimate carcass tissue composition for Dorper lambs.

Variable	Description	Mean	SD	Minimum	Maximum
LHCW	left half-carcasses weight (kg).	6.83	0.95	4.50	8.70
WRib	Weight of 9^{th}-11^{th} rib section (kg)	0.18	0.04	0.11	0.28
MRib	Muscle in 9^{th}-11^{th} rib section (kg)	0.09	0.02	0.04	0.14
BRib	Bone in 9^{th}-11^{th} rib section (kg)	0.04	0.01	0.03	0.06
FRib	Fat in 9^{th}-11^{th} rib section (kg)	0.04	0.02	0.01	0.09
TCM	Carcass muscle (kg)	7.85	1.41	4.32	10.25
TCF	Carcass fat (kg)	3.24	0.61	2.23	4.59
TCB	Carcass bone (kg)	2.51	0.50	1.64	3.68

SE: standard deviation.

Table 3. Descriptive statistics of the relationships between observed and predicted carcass tissue composition for Dorper lambs.

Variable[1]	Obs	TCM	Obs	TCF	Obs	TCB
Mean	7.84	9.53	2.51	1.78	3.24	2.89
SD	1.41	1.46	0.49	0.59	0.61	0.31
Minimum	4.32	6.25	1.64	0.84	2.23	2.18
Maximum	10.25	12.46	3.68	2.87	4.59	3.54
r^2		0.65		0.45		0.20
r		0.80		0.67		0.44
CCC		0.48		0.35		0.30
Cb		0.59		0.52		0.65
MEF		−0.90		−2.04		−0.14
CD		0.38		0.27		1.63
Regression analysis						
Intercept (β_0)						
Estimate		0.38		1.50		0.76
SE		1.28		0.27		1.17
P-value ($\beta_0=0$)		0.001		0.001		0.04
Slope (β_1)						
Estimate		0.78		0.56		0.85
SE		0.13		0.14		0.40
P-value ($\beta_1=1$)		0.12		0.008		0.72
MSEP source, % MSEP						
Mean bias		79.25		73.29		29.68
Systematic bias		2.67		8.77		0.48
Random error		18.07		17.93		69.82
Root MSEP						
Estimate		1.89		0.84		0.63
% of the mean		19.91		47.38		21.99

[1] Obs: observed evaluation data set; CCC: concordance correlation coefficient; ρ=Correlation coefficient estimate (precision). Cb: bias correction factor; MEF: modelling efficiency; CD: coefficient of model determination; MSEP: mean square error of the prediction.

destructive technique that identifies traits in different ruminant species. In Brazilian Somali lamb carcasses, Souza *et al.* (2020) showed that rib dissection 9-11 accurately predicted water, ethereal extract (fat), and energy content. They also concluded that breed and sex determine the chemical composition of the carcass and that the ethereal extract (fat) content of rib sections 9-11 is the variable that best describes the carcass ethereal extract (fat) in hair sheep. In the present study, we evaluated the applicability of an equation developed by Escalante-Clemente *et al.* (2022) for Black Belly lambs to predict carcass muscle weight in Dorper lambs. The equation was developed using rib section characteristics 9-11.

According to Tedeschi (2006), a model's usefulness should be assessed for its sustainability for a particular purpose. Several tests are available to assess model adequacy to ensure impartiality during the decision process of accepting or rejecting the suitability of a mathematical model. For that, the identification and acceptance of a model's wrongness is an essential step towards the development of more reliable and accurate models. Based on the results of the statistical evaluations, the evaluated equations cannot predict the carcass tissue composition of Dorper lambs.

The differences found in the current study may be because we used equations developed for male lambs of non-meat breeds, whose fat deposition occurs later than in female lambs and adult ewes. Because of this difference in tissue deposition between the sexes, some studies have reported that the equations cannot accurately estimate the amount of each tissue in the carcass (Neves *et al.*, 2018). The differences observed in this study regarding Dorper lambs may lead to inaccurate estimates. The model evaluations supported the results of this investigation due to the equations' inability to predict carcass tissue composition in Dorper lambs. Therefore, more data on carcass tissues of hair sheep breeds are needed to develop accurate models for predicting carcass composition. The study highlights significant limitations in the equations used to estimate the carcass composition of Dorper lambs, showing poor agreement between observed and predicted weights. This highlights the need for more accurate models that consider breed, sex, and local rearing conditions.

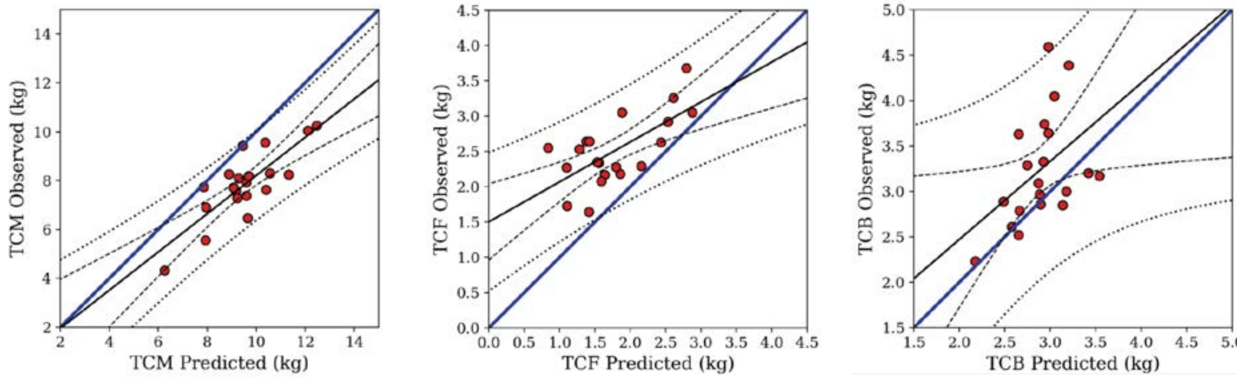

Figure 1. Relationship between the observed and predicted values of carcass tissues in Dorper lambs. The solid line is Y=X, and the dotted line is the linear regression.

CONCLUSIONS

The equations used to estimate the carcass tissue composition of Dorper lambs exhibited a poor fit in predicting the relationship between observed and predicted weights, as well as a low level of agreement. Based on these findings, we suggest that the equations tested in this study are not effective in predicting carcass tissue composition in Dorper lambs. This indicates the need to develop models based on breed- and sex-specific data, considering the rearing and management conditions of each area.

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