CAN THREE-DIMENSIONAL MODELS OF PIG CARCASSES PREDICT CARCASS WEIGHT AND TOTAL SALEABLE MEAT?

Isabelle Pinheiro Siqueira[1], Cris Luana de Castro Nunes[1*], Layla Cristien de Cássia Miranda Dias[1], Pamela Gracioli Vilas Boas[1], Erica Beatriz Schultz[1], Mario Luiz Chizzotti[1]

[1]Department of Animal Science, Universidade Federal de Viçosa, Viçosa, Brazil.

*Corresponding author email: cris.nunes@ufv.br

I. INTRODUCTION

In 2023, pork emerged as the most consumed animal protein worldwide, and its production and consumption have been increasing since then [1]. Therefore, it is important to determine the carcass weight and total saleable or total lean meat yield with high precision for producers' remuneration. In commercial abattoirs, the weight of the carcass is determined by a scale positioned on the rails, but most do not collect information on the yield of the cuts [2]. Given these challenges, some technologies have been studied and used to facilitate the processes throughout the meat supply chain. The three-dimensional (3D) images stand out to provide a larger set of information, such as volume, area, perimeter, coordinates, and vectors. There are already studies evaluating 3D models for different species in the meat industry, such as lambs [3], beef cattle [4, 5], and swine [2, 6] but they are still scarce. Therefore, the objective of this study was to analyze the capability of a handheld 3D scanner to estimate the total volume of carcasses and predict the total saleable meat.

II. MATERIALS AND METHODS

In this study, 39 right half-carcasses of 5-month-old male swine from the Camborough x AGPIC337 (PIC Agroceres) cross were used. Hot carcass weight and 3D images were obtained before the chilling process, whereas the saleable meat yield was obtained after 24h of chilling. To obtain the 3D images, the right half-carcasses were fixed by a hook at a consistent position and height and manually scanned using a portable scanner (Artec Leo). The Artec Leo features automatic light adjustment, eliminating the need for additional lighting adjustments in the room. The digitized images were then imported into Artec Studio 17 software to generate the 3D models. With the final carcass 3D models, the carcass volume was recorded. The collected data were analyzed in RStudio software to investigate the relationship between carcass weight and carcass volume through simple linear regression. To determine the most relevant variable, prediction models were initially developed using carcass volume, hot carcass weight, and saleable meat weight. The regularized regression models chosen were Ridge, Elastic Net, and Lasso, from lowest penalty to highest, respectively. The most accurate and precise model was then subjected to linear regression analysis.

III. RESULTS AND DISCUSSION

The results suggest that the carcass volume of the 3D model is statistically significant ($P \leq 0.05$) to predict the total carcass weight. Therefore, it is possible to predict total carcass weight online with 3D volume using simple regression analyses. The adjustment of equation and error metrics showed that the equation generated is precise and accurate (Table 1).

Table 1 – Simple linear regression analyses to predict the total carcass weight and total saleable meat, using the total volume of the carcass obtained from the 3D model.

Volume	Intercept	β1	R^2	*P*-value	RMSE	MAE
Total carcass weight	4.8628	0.9192	0.9329	<0.001	0.7625	0.6803
Total saleable meat	10.0592	0.6478	0.4805	<0.001	0.9134	1.178

To predict total saleable meat, there was no gain by adding the hot carcass weight variable to the equation (Table 2). The models presented in Table 2 are used in larger databases to get a better fit in the model with a smaller number of variables without overfitting [7], but in this case, it was used to highlight the weight of the variables in the model. The penalization in the Lasso reduces variables judged irrelevant for

the model, making it simpler. Thus, Lasso exhibited the best fit among the models, with no significant differences observed among them, highlighting the importance of 3D model data. Once the variable has been selected, the prediction equation for total saleable meat (Table 1) performed well with low mean absolute error (MAE = 1.178). The moderate R^2 indicates that variable total carcass volume explains 48% of the total saleable meat, however, there is space for improvements.

Table 2 – Regularized regression models for variable selection, using carcass volume and carcass weight in the prediction of total saleable meat.

Total saleable meat (Y)	R^2	RMSE	MAE
RIDGE[1]	0.4782	1.1825	0.9178
ELASTIC NET[2]	0.4805	1.1802	0.9161
LASSO[3]	0.4805	1.1797	0.9158

[1]Y= 12.05543+0.02662×hot carcass weight+0.58297×carcass volume; [2]Y= 12.22485+0.60668×carcass volume; [3]Y= 11.96443+0.61163×carcass volume.

IV. CONCLUSION

The use of 3D models to predict total carcass weight and total saleable meat is possible, as the results presented are promising. More studies and more data are needed to improve the use of this technology, which will be of great benefit to the industry and to the farmers.

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