THE USE OF DUAL-ENERGY X-RAY ABSORPTIOMETRY (DXA) FOR PREDICTING TOTAL AND INTRAMUSCULAR FAT IN PORK LOIN STEAKS

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I. INTRODUCTION

Many swine breeding companies are focused on developing animals with less subcutaneous fat and more intramuscular fat (IMF), aiming not only to make the meat tastier and more appealing but also to add value to the final product [4]. However, laboratory analysis to understand the composition of cuts, including fat analysis, is often laborious, expensive, and prone to errors [5]. To overcome these challenges and increase the speed and reliability of results, the use of modern technologies, such as dual-energy X-ray absorptiometry (DXA), has become an excellent tool to facilitate these analyses [3]. DXA is a non-invasive, easy-to-use and accurate technology that uses differential attenuation of X-rays to analyze key components of animal tissues such as bone, muscle and fat [4]. Therefore, in the present study, the hypothesis was raised that DXA can predict the amount of total fat and intramuscular fat in pork loin steaks, replacing conventional chemical analyses. Therefore, the objective of this study was to validate the fat results obtained by DXA, comparing them with standard chemical analyzes on pork loin steaks.

II. MATERIALS AND METHODS

Pork loin steaks (Longissimus lumborum) from approximately 140 animals sourced from commercial farms, with a thickness of approximately 2.5 cm, of undetermined sex, age, and genetics, were used. The steaks were identified, weighed, and dimensioned (width x length x height). These data was used as input into the GE Healthcare enCORE software, version 18, in "Small Animal" configuration mode [1]. Subsequently, the frozen steaks were scannedusing the DXA medical equipment (GE Healthcare, Lunar Prodigy Advance, USA), calibrated according to the manufacturer's protocol, in the Body Composition and Densitometry Laboratory at the Federal University of Viçosa. Twenty steaks were scanned per scan; and the software provided results for adipose tissue mass (g), lean tissue mass (g), total tissue mass (g), and fat content (%) per sample. Subcutaneous fat was then removed, and the steaks were weighed and scanned again on the DXA to evaluate only the intramuscular fat. Each steak sample was fully ground into meat grader, weighed, and subjected to lyophilization (Liobras, model LP510, São Carlos, SP, Brazil). After water removal by the lyophilization process, the samples were weighed again, frozen in liquid nitrogen, and subsequently ground in a stainless-steel ball mill (TECNAL, model R-TE-350, Piracicaba, SP, Brazil). Dry matter and fat content were determined using a sub-sample of the lyophilized samples. Chemical fat analysis was performed in duplicate using the Ankom XT4 filter bag and Ankom XT15 fat extractor (ANKOM Technology, Macedon, NY, USA), which uses petroleum ether as a solvent. The % chemical fat content was then calculated based on wet tissue. SAS 9.4 software (SAS – Statistical Analysis Systems Institute Inc., Cary, NC, USA) was used to perform general linear regression using the PROC REG procedure, following the model: $Y = \beta 0 \pm \beta 1X + e$ (where: Y is the observed fat represented by chemical analysis; $\beta 0$ and $\beta 1$ are regression components; x is the fat content predicted by DXA scan, and e represents random error). Equation performance was evaluated using the coefficient of determination (R^2) and root mean square error (RMSE) metrics.

III. RESULTS AND DISCUSSION

The regression equation for predicting total fat (steak with subcutaneous fat), had a better prediction accuracy (R^2= 0.48; RMSE = 4.24; P= <.0001) than the equation for pork loin steaks without subcutaneous fat (R^2 = 0.05; RMSE = 0.89; P= 0.0054) (Figure 1). Similar results were found by Nunes et al. (2023) [2], who showed that marbling affects the accuracy of DXA in fat prediction. Prediction was more accurate in Angus steaks than in Nelore steaks, indicating better performance in samples with high fat content. In a literature review, Scholz et al. (2015) [3] compared the prediction accuracy of DXA in different studies. They noted that the relatively low absolute amount of fat leads to relatively larger prediction errors in percentage values for lean and fatty tissues. However, Soladoye et al. (2016) [4] evaluated the prediction by DXA of total dissected fat from carcasses of pigs of different breeds with varying fat contents, presenting equations with $R^2 > 0.80$. This demonstrates that DXA has high accuracy in assessing dissected fat composition. However, the accuracy and precision of fat prediction vary when DXA performance is assessed in low and high-fat content groups, showing better performance in high-fat steaks [2]. However, DXA is a useful tool in animal research, but further studies are needed to assess its ability to predict IMF across a wide range of percentages, aiming to develop a robust regression model regardless of fat content.

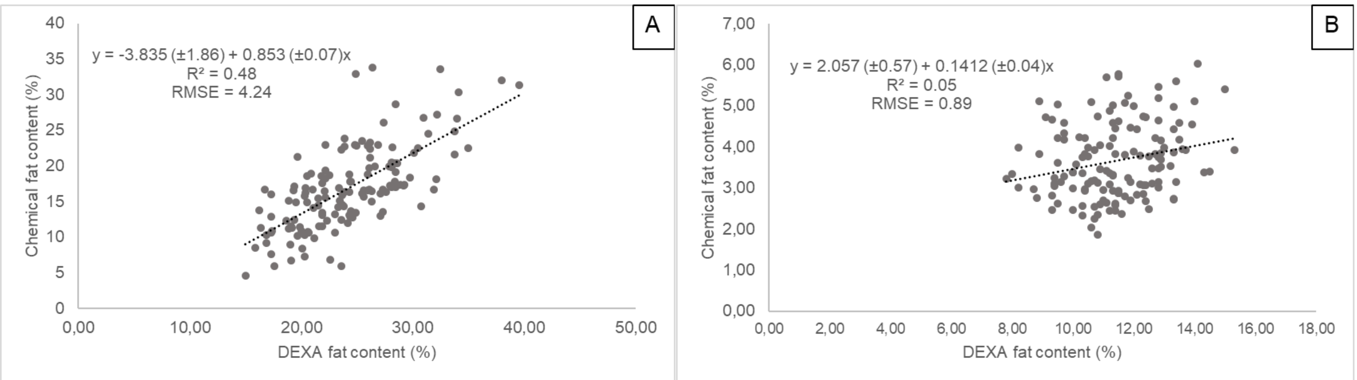

Figure 1: Linear regression between the fat content values predicted by DXA, on the x-axis, and the corresponding chemical analysis, on the y-axis, for steak with subcutaneous fat (A) and steak without subcutaneous fat groups. Estimated parameters such as coefficients of determination (R^2) and root mean square error (RMSE) are presented in the graphs.

IV. CONCLUSION

This study shows that DXA can predict total fat content in pork steaks, but not the intramuscular fat content. Its accuracy varies between low- and high-fat groups, with it performing best in high-fat steaks, and it can be useful for “precision labeling” of pork loins, allowing consumers to monitor the amount of fat in their packaged steaks.

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