# Technical Report

**Program and KPI:** Sub-program 1.2 KPI 3.11

**Report Title:** WAMMCO DEXA calibration


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## Abstract

The recent installation of the DEXA scanner at WAMMCO, Katanning, required the calibration of the system against computed tomography (CT), as has been undertaken at all previous DEXA sites around Australia.

100 lambs were selected from the MLA resource flock based at the Katanning research station, with a wide range of phenotypes and genotypes. These 100 lambs were slaughtered and scanned in the new DEXA apparatus as 'hot' carcasses, prior to entering a chiller. These 100 carcasses were CT scanned at Murdoch University as the gold standard carcass measurement.

The precision and accuracy measurements for fat, lean and bone were similar to previous DEXA sites after the algorithm adjustment, which was successfully conducted on the plastic phantoms supplied by Murdoch University. This adjusted algorithm produced results that are in line with the expected range of lambs through the scanner, with minimal outliers.



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# 1 Overview

201 lambs from the Meat and Livestock Australia (MLA) resource flock from the Katanning Research Station were slaughtered at WAMMCO, Katanning, in early August 2021. These lambs are of a known and varied phenotypic and genotypic range. All lambs were placed through the recently active DEXA scanner, and 100 of these were selected to be CT scanned at Murdoch University 1-2 days post-slaughter. The comparison between CT and DEXA predictions of carcass composition was assessed, with a synthetic phantom block being utilised to calibrate the WAMMCO DEXA to the algorithm used at the original BT DEXA in South Australia.

# 2 Methods

## 2.1 Resource Flock Lamb Selection

201 lambs were processed through the WAMMCO facility, with a spread of HCWT from 12.8 to 30.9 kg (mean 22.25kg) and GR of 1mm to 32mm (mean 9.65mm). 100 of these lambs were selected based on genetic and phenotypic markers to CT scan at Murdoch University, with their phenotypic measurements listed in Table 1. The spread of HCWT vs GR measurements can be seen in Figure 1. The CT values for the 100 lambs of the CT group are found in Table 2.

Table 1 - HCWT and GR measurements for both CT and non-CT groups of lambs

| | HCWT (kg) | | | | GR (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min | Max | Mean | SD | Min | Max |
| CT Group | 22.35 | 2.804 | 12.8 | 29.4 | 9.63 | 4.584 | 1 | 21 |
| Non-CT Group | 22.16 | 2.958 | 13.9 | 30.9 | 9.67 | 5.158 | 1 | 32 |

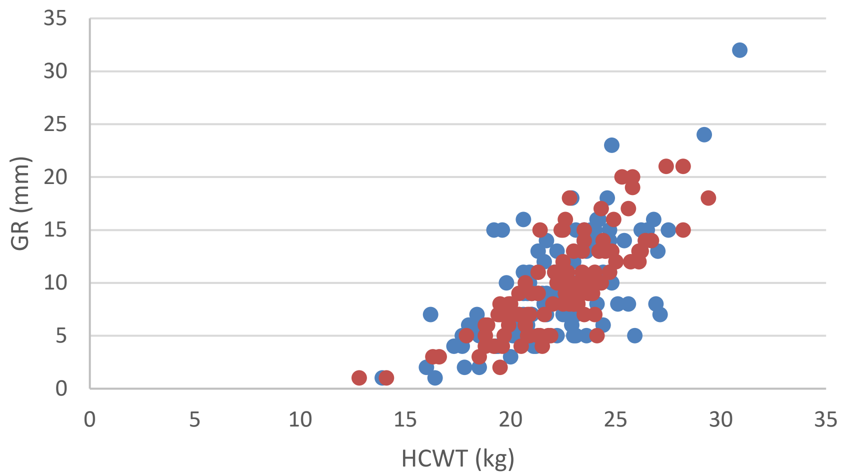


Figure 1 - HCWT and GR measurements off all lambs, displayed as lambs that were selected for CT scanning (orange marker) and non-CT scanning (blue marker)



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Table 2 - CT Fat %, CT Lean % and CT Bone % mean, standard deviation, minimum and maximum values for the CT group of 100 lambs

| CT Fat % | | | CT Lean % | | | CT Bone % | | |
|---|---|---|---|---|---|---|---|---|
| Mean ± SD | Min | Max | Mean ± SD | Min | Max | Mean ± SD | Min | Max |
| 22.55 ± 4.38 | 11.63 | 33.09 | 58.56 ± 3.23 | 51.61 | 68.71 | 18.89 ± 1.89 | 15.24 | 23.22 |

## 2.2 Synthetic Phantom Block and Algorithm Adjustment

The existing synthetic phantom is a plastic block that is comprised of 3 sections – 50mm Nylon-6, 25mm Nylon 6 / 25mm HDPE, and 50mm HDPE. This block has been scanned at all DEXA sites and has been successfully used to adjust algorithms at different sites to the original BT DEXA in South Australia.

The R values of all sections is calculated by the following equation:

$$R\ value = \frac{\ln\left(\frac{I_L}{4095}\right)}{\ln\left(\frac{I_H}{4095}\right)}$$

Where $I_L$ and $I_H$ are the attenuation values for the low and high energy detectors respectively. These R-values are compared to that of the values from the BT DEXA, and the gradient between them is determined.

Table 3 - R-values for each plastic type in the synthetic phantom between BT and WAMMCO

| | BT | WAMMCO |
|---|---|---|
| **HDPE** | 1.184513 | 1.147 |
| **HDPE / Nylon** | 1.206565 | 1.166 |
| **Nylon** | 1.223954 | 1.175 |

The gradient calculated is 1.036386. This is inputted into the R-value adjustment, which also calculates an intercept adjustment based on the relationship between the BT and WAMMCO Nylon R-values as per the equation:

$$New\ R\ value = 1.22371 - (\mathbf{1.209462462}) + (R * \mathbf{1.036386})$$

The thickness differential between the BT and WAMMCO sites is a function of the low energy image only. The calibration adjustment is calculated as a difference between the Nylon-6 thickness of the BT and WAMMCO sites, and this difference is applied to all pixels in an adjusted image according to the equation:

$$New\ Thickness = Old\ Thickness + (60 - Nylon\ Thickness)$$

The Nylon-6 Thickness at WAMMCO is calculated to be 65.947. This value is subtracted from the standardised thickness of 60 at BT and is then used to adjust thickness values for each WAMMCO pixel by -5.947.



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# 3 Results

## 3.1 Image Artefacts

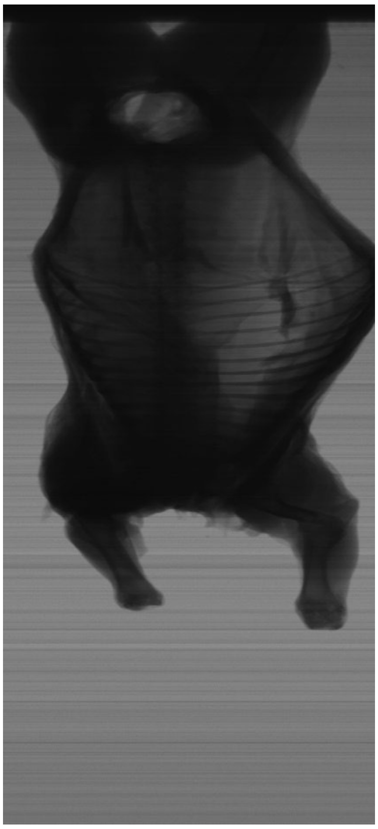

Figure 2 - Carcass 1401 showing image artefact

It should be noted that the first 28 rows of pixels from the top of each image is effectively attenuated by either a defective module, or an attenuating material in the line of the x-ray beam. This will have some impact on the predictions of the hind-limb pixels and should be ignored in any calculation specific to this region until the problem has been corrected.

There were no other artefacts noted on initial image analysis.

Table 4 - DEXA fat %, lean % and bone % for all lambs, before and after removal of artefactual portion of images

| DEXA Fat % | | | DEXA Lean % | | | DEXA Bone % | | |
|---|---|---|---|---|---|---|---|---|
| **Mean ± SD** | **Min** | **Max** | **Mean ± SD** | **Min** | **Max** | **Mean ± SD** | **Min** | **Max** |
| 22.77 ± 4.06 | 11.77 | 30.82 | 58.94 ± 2.89 | 53.22 | 66.76 | 18.28 ± 1.17 | 15.96 | 21.46 |

## 3.2 Fat Score and GR predictions vs CT predictions



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Palpated fat score directly predicted CT Fat % with poor precision, with $R^2$=0.27 and RMSE=3.87% (see Figure 3). GR measurement using a GR knife directly predicted CT Fat % better, with $R^2$=0.59 and RMSE=2.88% (see Figure 4). The addition of HCWT with GR in predicting CT Fat % was not significant.

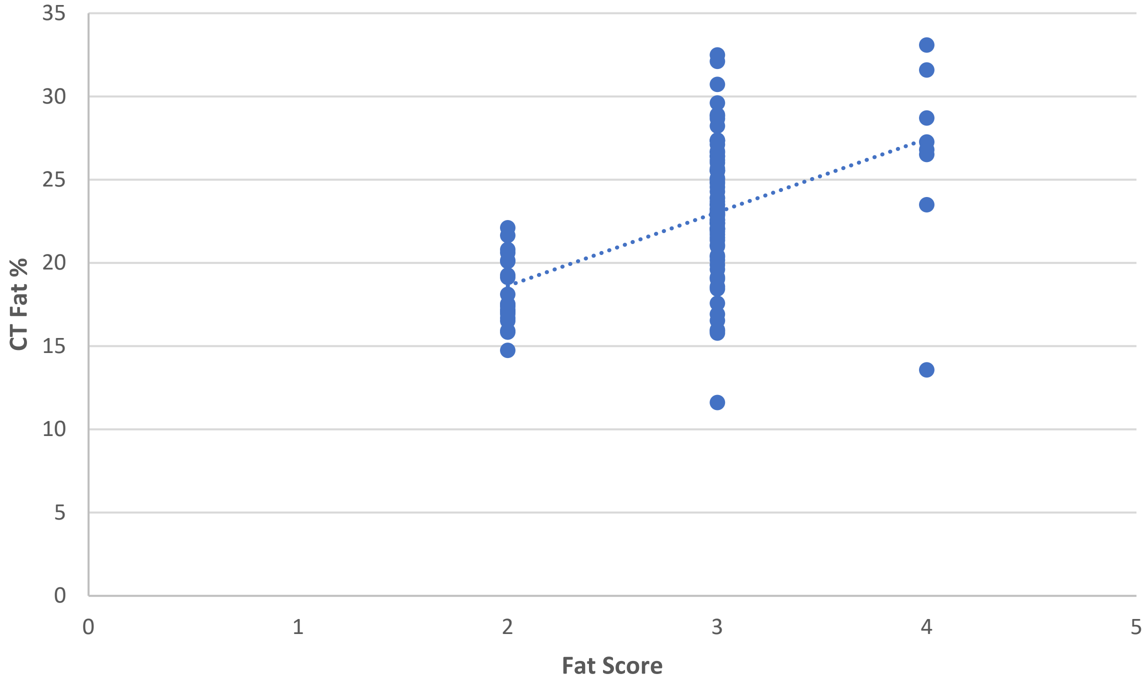


Figure 3 – Association between CT Fat % and Fat Score.

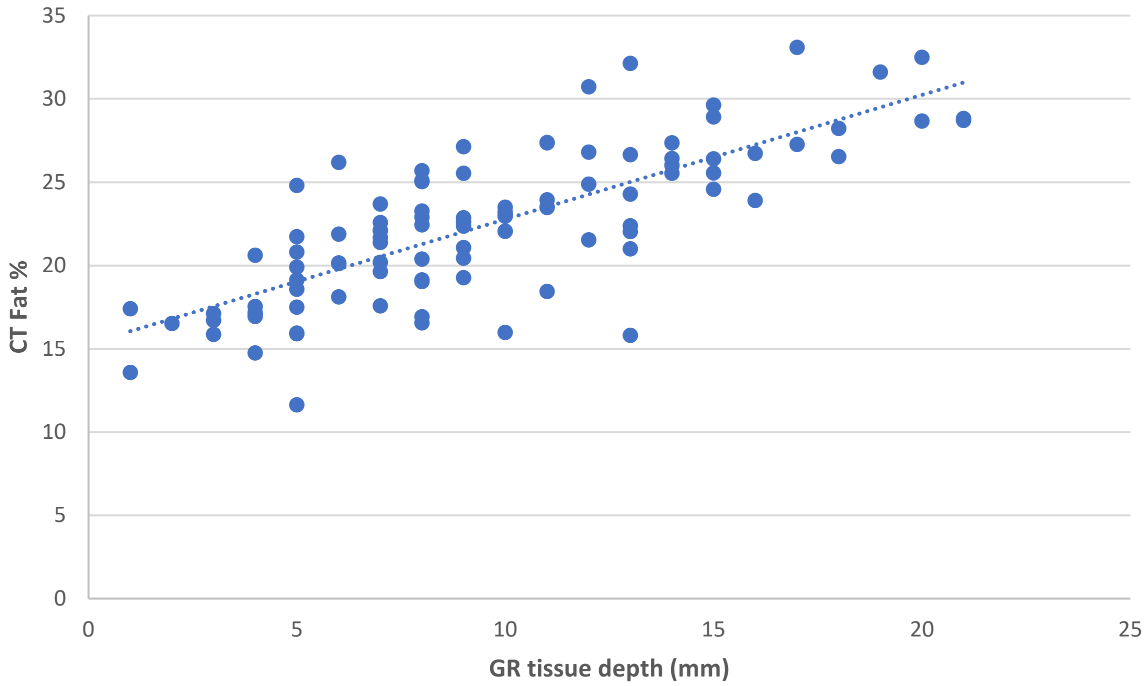


Figure 4 - Association between CT Fat % and GR tissue depth (mm)



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## 3.3 Calibrated DEXA predictions vs CT predictions

The DEXA predictions of CT Fat %, Lean % and Bone % (see Table 4) are of comparable precision to previous DEXA installed sites, which can be seen. There is a small slope and bias evident in the Fat % and Lean % predictions, which is far less than for CT Bone %. The exclusion of the artefact rows at the top of the image appears to slightly increase precision but was mostly affecting the bias values, with an improvement for Fat % and Bone % predictions, but a slight increase for Lean % (Table 4).

The precision and accuracy of the composition predictions can be visualised in Figures 5, 6 and 7.

Table 5 - $R^2$, RMSE, Slop and Bias values for all composition predictions after exclusion of top 30 rows of image

| | DEXA Fat % | DEXA Lean % | DEXA Bone % |
|---|---|---|---|
| **$R^2$** | 0.89 | 0.78 | 0.46 |
| **RMSE** | 1.46% | 1.52% | 1.39% |
| **Slope** | 1.02 | 0.99 | 1.09 |
| **Bias** | 0.22 | 0.38 | -0.60 |

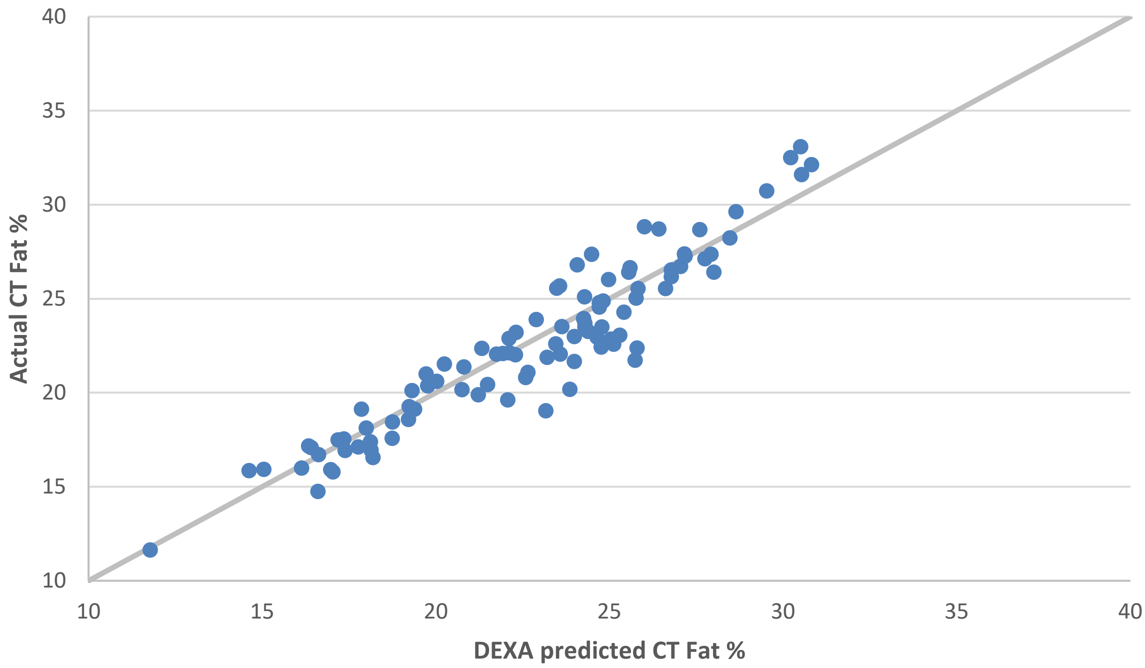


Figure 5 - DEXA Fat % predictions of CT Fat % after artefact exclusion from DEXA images



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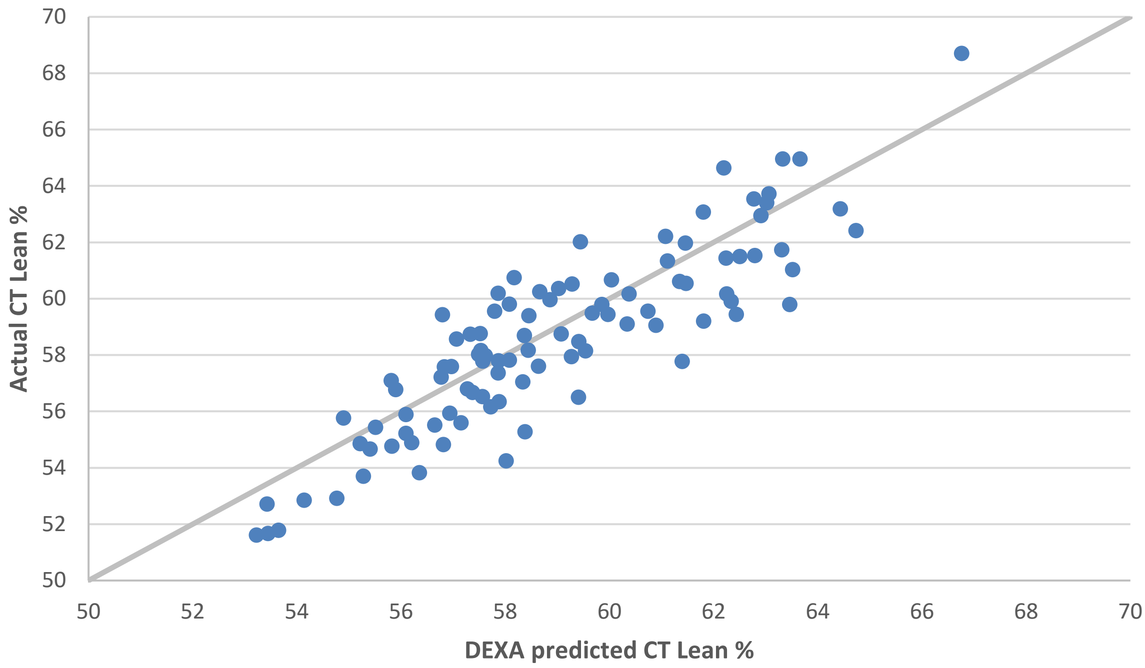


Figure 6 - DEXA Lean % predictions of CT Lean % after artefact exclusion from DEXA images

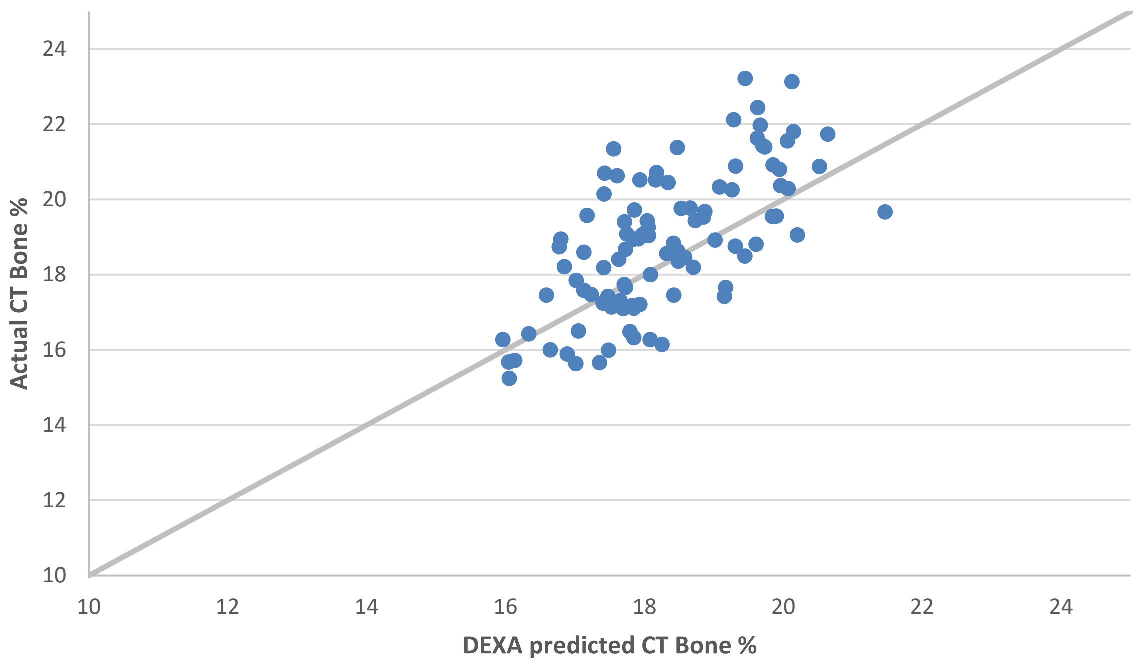


Figure 7 - DEXA Bone % predictions of CT Bone % after artefact exclusion from DEXA images

# 4 Deployment of new Algorithm

3 days of production was analysed with the new algorithm to assess mean and standard deviation of predictions of CT Fat, CT Lean and CT Bone %. These can be visualised in violin plots in Figures 8, 9 and 10 respectively.



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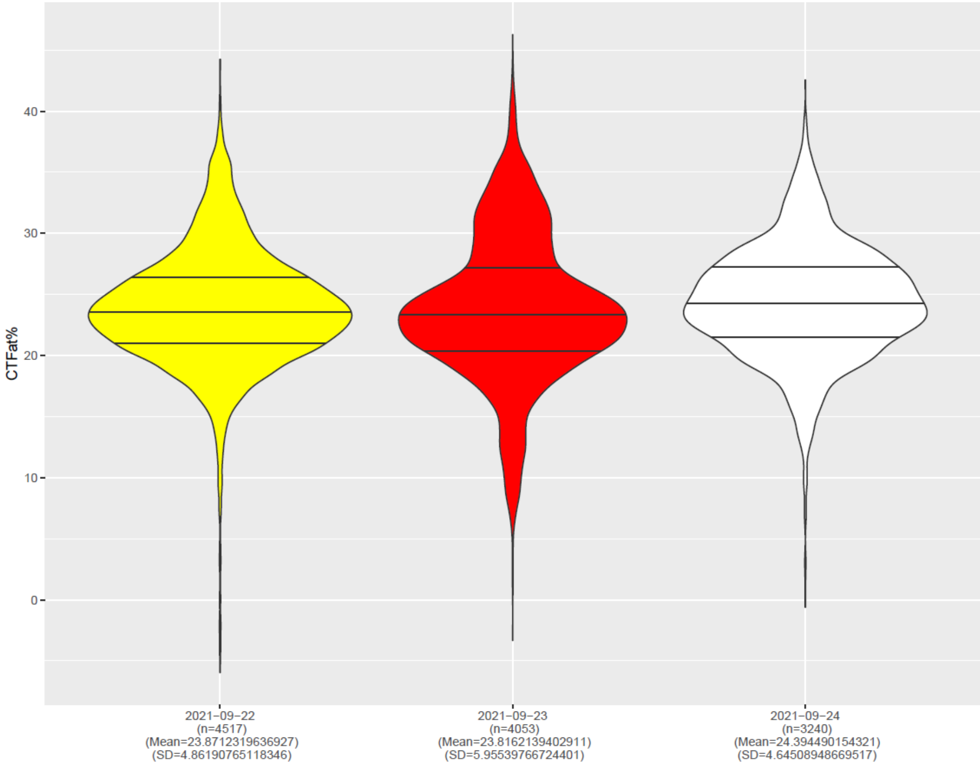


Figure 8 - Violin plots of DEXA predictions of CT Fat % across 3 days

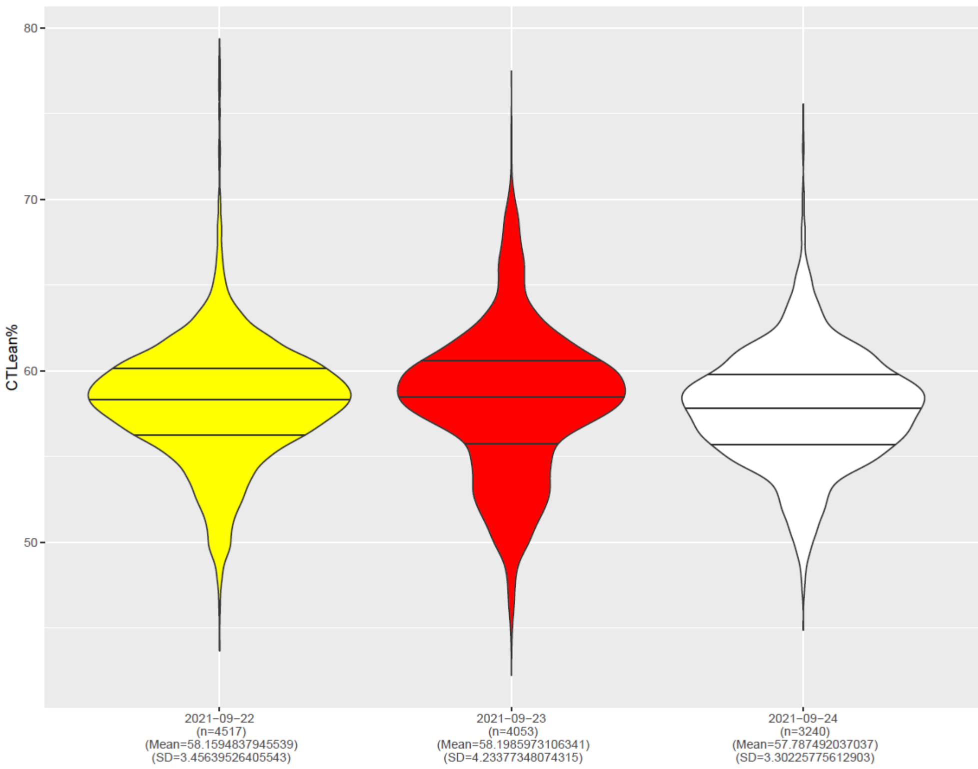


Figure 9 - Violin plots of DEXA predictions of CT Lean % across 3 days



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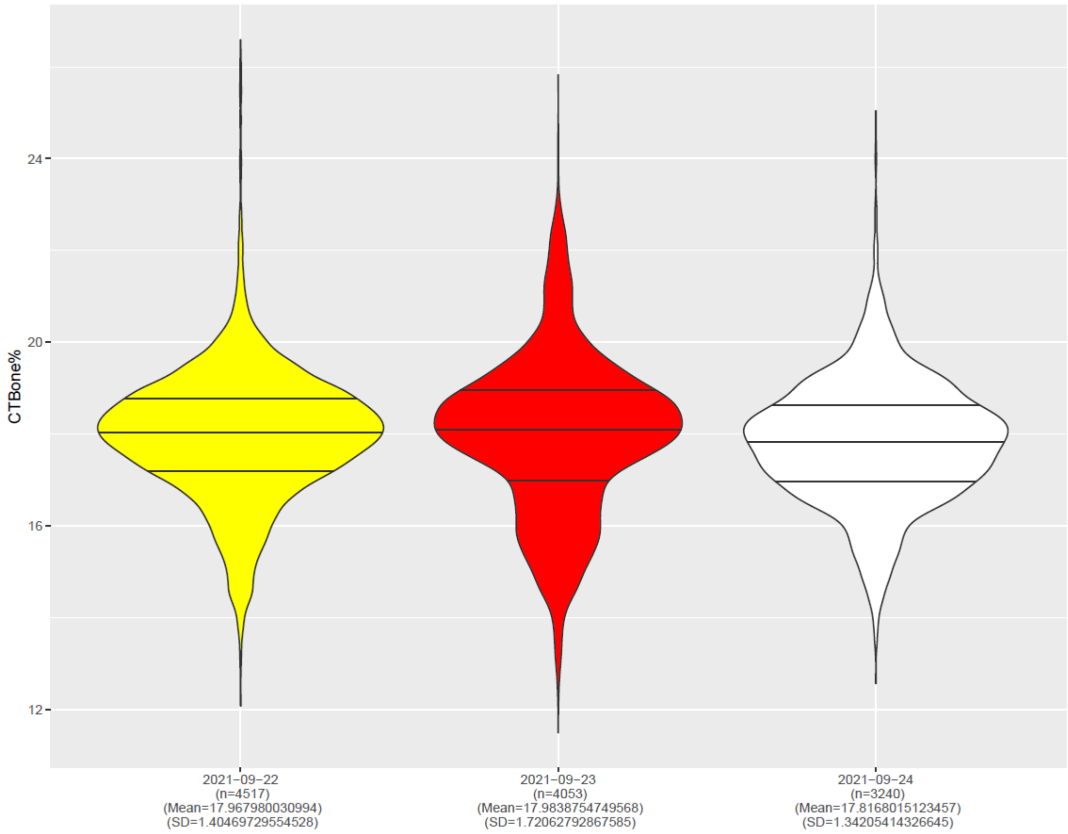


Figure 10 - Violin plots of DEXA predictions of CT Bone % across 3 days

# 5 Further Work

Further calibration would be preferred, using the Scott phantom that is scanned at the start of each production day. This phantom block has more calibration points, and will allow for a more dynamic calibration equation, which will be more powerful at reducing the minor slope and bias detected in this current calibration.

Regardless, the existing phantom calibration has allowed for a high level of precision, with a satisfactory level of accuracy. Confidence can be placed in the DEXA system's ability to rank carcasses on their DEXA fat % predictions. A further adjustment to this calibration algorithm will be recommended for initial rollout at WAMMCO to improve the existing slope and bias.

DEXA was able to predict CT Fat % with far higher precision than GR fat measurement with and without the addition of HCWT. More importantly, DEXA Fat % predictions were far more precise than fat scoring, which is the current standard at WAMMCO.


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