Non – invasive measurement of lamb carcase fat depth using a portable microwave system

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Non-invasive methods of measuring carcase fatness are important to underpin optimised carcase boning, producer feedback, and value-based trading. However, the suitability of these methods is dependent upon numerous factors including ease of use, safety, portability and accuracy at abattoir chain speeds (Scholz *et al*. 2015). A low-cost portable microwave system has been developed at Murdoch University for use in commercial abattoirs. Previous work (Marimuthu *et al*, 2018) has demonstrated the ability of microwave technology to predict fat depths in lamb carcasses, for one slaughter group with R-square (R^2) was 0.62 and a root-mean-square-error of the prediction (RMSEP) of 1.08mm. This study explores the ability of this microwave system to predict C-site fat depth of lamb carcases in commercial abattoirs across various slaughter groups.

Four groups totalling 381 mixed sex lambs were slaughtered at a commercial abattoir. These groups consisted of 105, 97, 59, and 120 lambs, with average carcase weights of 27.9±3.71kg, 27.6±3.88kg, 22.9±1.88kg, and 26.7±4.51kg, and average C-site fat depths of 3.6±1.76mm, 4.1±1.95mm, 3.5±1.40mm, and 4.0±1.86mm. Carcasses were scanned using the portable microwave device at the C-site approximately 60 minutes post-mortem. The prototype Microwave System operated at frequencies of 100 MHz to 6.5 GHz with output power of -10 dBm coupled with a prototype broadband Vivaldi patch antenna used for the measurement (Marimuthu *et al*. 2018). The reflected microwave signals were recorded at 20 MHz intervals across 321 frequencies. The magnitude of the calibrated and processed frequency domain signals was then used to predict the abattoir C-site fat depth. Partial Least Squares (PLS) Regression of components 2 with leave-one-out cross validation (open source machine learning software WEKA) were used for model construction.

The training and validation process were undertaken in two different ways. Firstly, as shown in Table 1(a), the predictions were trained in 3 kill groups and validated in the 4th. This process was repeated 4 times so that each slaughter group were sequentially left out of the training data set and used to validate the prediction. Secondly, data was randomly divided into 5 groups, balanced for HSCW and C-site fat depth as shown in Table 1(b). This contrasted with the previous sub-groupings which were unbalanced either by weight or fat phenotype. In this case the prediction models were trained in 4 groups (80% of the data) and validated in the 5th group (the remaining 20% of data). In all cases, R-square (R^2) and root mean square error of the prediction (RMSEP) demonstrate the precision of the validated prediction model, while slope and bias estimates represent the accuracy of the prediction. The bias is the difference between the predicted and actual values at the mean of the dataset. The average bias was calculated by determining the mean of the absolute bias values. The average slope was determined by calculating the mean of the absolute deviation of each slope estimate from 1.

Validation Group	N in validation	N in training	R^2	RMSEP	Bias	Slope
(a) Validation within actual kill groups						
13 Nov. 2017	105	276	0.59	1.26	-0.53	0.93
15 Nov. 2017	97	284	0.56	1.51	+0.74	0.93
04 May 2018	59	322	0.63	0.85	+0.01	0.99
01 June 2018	120	261	0.49	1.33	-0.13	1.13
	Average		0.57	1.24	0.35*	0.07**

Validation Group	N in validation	N in training	R^2	RMSEP	Bias	Slope
(b) Validation within groups balanced for C-site fat depth						
1	76	305	0.57	1.21	-0.01	0.90
2	76	305	0.52	1.25	-0.04	0.96
3	76	305	0.63	1.08	+0.02	1.05
4	76	305	0.66	1.06	+0.07	1.13
5	77	304	0.57	1.20	-0.01	0.93
	Average		0.59	1.16	0.03*	0.08**

*mean of the absolute values;
**value represents the mean of the absolute value of the slope deviation from 1.

Table 1. Precision and accuracy estimates for the prediction of C-site fat depth

The precision of the C-site fat depth prediction models was very similar when comparing models trained and validated in data balanced for carcase C-site fatness (Table 1(b)), with those trained and validated across different kill groups (Table 1(a)). In contrast, bias estimates were markedly different between the two validation methods, with markedly smaller bias in models trained and validated across datasets balanced for fatness. None-the-less, these bias estimates never exceeded 1mm. This study demonstrates the precision and accuracy of a non-invasive portable microwave system to predict C-site fat depth, which provided measurements that translated robustly across time and flocks of divergent phenotype.

References

A. M. Scholz, L. Bünger, J. Kongsro, U. Baulain and A. D. Mitchell (2015) *Animal* **9 (7)** 1250-1264
J. Marimuthu, J. H. Edwards and G.E. Gardner. (2018) *ICoMST 2018*, Melbourne, Australia