PREDICTING BEEF CARCASS ULTIMATE pH: OCULAR THERMOGRAPHY AND BLOOD PARAMETERS

Guilherme Agostinis Ferreira[1], Amanda Gobeti Barro[1], Natalia Nami Ogawa[1], Daniela Kaizer Terto[1], Giovanna Lima Silva[1], Natália Alves Pereira[1], Rafael Humberto de Carvalho[1], Ana Maria Bridi[1*]

[1] Department of Animal Science. State University of Londrina (UEL), Londrina, Brazil.

*Corresponding author email: ambridi@uel.br

I. INTRODUCTION

Brazil holds a prominent position in global beef production and export, boasting a significant cattle population primarily composed of Zebu breeds, adapted to the tropical climate. Despite its economic importance, the industry faces challenges such as the occurrence of dark, firm, and dry (DFD) meat, attributed to pre-slaughter stress. DFD meat not only diminishes quality but also affects consumer satisfaction and shelf life. To address this issue, noninvasive methods for DFD meat identification, such as infrared thermography (IRT), have garnered interest due to their potential for swift and accurate assessment. Therefore, the aim of this study was to investigate the use of IRT as a tool to identify DFD meat based on ocular temperature.

II. MATERIALS AND METHODS

This study was conducted in a Federally Inspected commercial slaughterhouse in Brazil, adhering to the prevailing regulations [1]. A total of 113 male Nellore bulls (aged 22–38 months) were included, with no batch intermixing during transport and unloading. Eye temperatures were measured within the stunning box without interfering with industry standard procedures. Ocular IRT images were captured using a Flir T440 camera. Each animal's right eye was framed at a 90º angle from 60 cm. FLIR TOOLS® software analyzed the IRT images to determine minimum (IRTmin) and maximum (IRTmax) temperatures. The carcasses final pH (pHu) was measured twice, between the 12th and 13th ribs in the *longissimus thoracis muscle*, using a professional pH meter, Hanna HI98163® (Hanna Instruments Inc., Barueri, Brazil), 48 hours post-mortem.

Blood samples were collected from the animals during bleeding, stored in 10 mL BD Vacutainers® tubes, and analyzed in duplicate using commercial kits. Glucose, CK, LDH and lactate were assessed with the Dimension® Xpand Plus system and respective kits. Cortisol levels were measured in plasma using a commercial cortisol ELISA kit, with absorbance read at 450 nm on an iMark™ Microplate Absorbance Spectrophotometer (Bio-Rad Laboratories Inc.). Data analysis utilized Jamovi® software, with significance set at $P < 0.05$. Linear and multiple regression models were employed to assess relationships between ocular thermal temperatures, blood parameters, and carcass pHu. Day of collection and batch were treated as random effects, with other variables (lactate, glucose, CK, LDH, cortisol) as covariates. Cross-validation, randomly allocating 70% for calibration and 30% for prediction, validated the dataset. Model adequacy was assessed through metrics including R2, adjusted R2, RMSE, RPD, and ANOVA-derived P-value.

III. RESULTS AND DISCUSSION

Descriptive statistics revealed stable environmental conditions during data collection [2]. Regression analyses demonstrated the predictive capabilities of IRT, either alone or in conjunction with blood parameters, in estimating carcass pH (Table 1). The first line of each set contains only IRTmax as a pHu predictor. For the calibration dataset, the R^2 values range from 0.84 to 0.88. Higher R^2 values

indicate that a larger proportion of the variability in the dependent variable is explained by the independent variables. The predictors IRT max + Lactate and IRT max + Glucose + Lactate had the highest R^2 values at 0.88. For the predicted dataset, as shown in the bottom section of the Table, the models retained their predictive power, albeit with a slight reduction in R^2 values compared to the calibration phase. The R^2 values range from 0.67 to 0.87. IRT max + Glucose + Lactate has the highest R^2 on the predicted dataset at 0.87, and an impressive RPD value of 2.6, suggesting excellent predictive capability. The RMSEP values for these models were relatively low, ranging from 0.104 to 0.152, indicating good accuracy in predicting pHu during the calibration phase. In both training and test datasets, lower RMSE values indicate better model performance. The models seem to perform well on the training data, but there is a slight increase in error when applied to the test data, which is common.

Table 1. Linear and Multiple regression of ocular IRT and beef quality traits and blood parameters to predict pHu of Nellore beef carcasses.

Calibration predictors	R^2	R^2 adjusted	RMSEC		*P*
IRTmax	0.84	-	0.0841		< 0.001
IRTmax + Glucose	0.85	0.84	0.0843		<0.001
IRTmax + Lactate	0.88	0.87	0.0739		< 0.001
IRTmax + Glucose + Lactate	0.88	0.86	0.0746		< 0.001
Predicted	R^2	R^2 adjusted	RMSEP	RPD	*P*
IRTmax	0.67	-	0.152	1.8	< 0.001
IRTmax + Glucose	0.74	0.69	0.144	1.9	< 0.001
IRTmax + Lactate	0.82	0.78	0.117	2.3	< 0.001
IRTmax + Glucose + Lactate	0.87	0.82	0.104	2.6	< 0.001

IRT max = infrared thermography maximum. R^2 = determination coefficient. R^2 adjusted = determination coefficient adjusted. RMSEC = root mean square error of calibration. RMSEP = root mean square error of prediction. RPD = residual Prediction Deviation.

IV. CONCLUSION

The study suggests that ocular IRT image, complemented by specific blood parameters, can effectively predict carcass pH in Nellore beef. The integration of lactate and glucose enhances model accuracy, highlighting the potential utility of IRT for noninvasive quality control in the meat industry.

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REFERENCES

1. Brasil (2021). Portaria nº 365, de 16 de julho de 2021. Aprova o Regulamento Técnico de Manejo Pré-abate e Abate Humanitário e os métodos de insensibilização autorizados pelo Ministério da Agricultura, Pecuária e Abastecimento. Diário Oficial da União, Edição Extra, Seção 1, n. 138-A, 1-4.
2. Ferreira, G. A., Barro, A. G., Bueno, C. E. M., Terto, D. K., Dos Santos, É. R., Ogawa, N. N., ... & Bridi, A. M. (2024). Non-invasive meat quality assessment: Exploring the potential of ocular infrared thermography to predict ultimate pH in Nellore beef cattle. Meat Science, 213, 109483.