71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

TRAITS TO TASTE: MODELLING BEEF PALATABILITY USING TRADITIONAL AND RAPID ANALYTICAL METHODS

Realini C.E.[1*], Zhang R.[1], Luo D.[2], Hocquette J.F. [3], Neveu A.[4], Polkinghorne R.[5], Dixit Y.[1], Reis M.M.[1], Ross A.B.[6], Ellies-Oury M.P.[1,3,7*]

[1] AgResearch Ltd, Te Ohu Rangahau Kai, Palmerston North, New Zealand; [2] AgResearch Ltd, Hamilton, New Zealand; [3] INRAE, Saint-Genès Champanelle, France; [4] IMR3GF, Warsaw, Poland; [5] Birkenwood Pty. Ltd., Murrurundi, Australia; [6] AgResearch Ltd, Lincoln, New Zealand; [7] Bordeaux Sciences Agro, Bordeaux, France

*Corresponding author email: carolina.realini@agresearch.co.nz and marie-pierre.ellies@agro-bordeaux.fr

I. INTRODUCTION

Consumer perception of beef quality is influenced by multiple factors, but eating quality remains the primary driver of preference. Traditional meat quality assessments, including pH, instrumental colour, shear force, cook loss, intramuscular fat, and fatty acid composition, are regularly used in meat science to predict the eating quality of meat and identify key traits influencing consumer palatability. However, these methods are time-consuming, labour-intensive, and require the use of hazardous chemicals, making them impractical for routine meat industry use. In contrast, rapid and non-invasive tools offer potential for assessment of beef eating quality on-line or at-line in meat plants, enabling accurate product classification into eating quality categories and supporting targeted branding, premium pricing, or further processing strategies based on predicted beef palatability. Near-Infrared Spectroscopy (NIRS) is an established rapid, non-destructive method for meat quality assessment [1], while the more recent Rapid Evaporative Ionization Mass Spectrometry (REIMS) enables rapid molecular profiling of meat [2]. These techniques offer speed and efficiency for the meat industry, but their standalone predictive power of the eating quality of beef, and the potential for improved accuracy when combined with traditional methods for research purposes, remains unexplored. This study evaluates the ability of traditional and rapid analytical methods, individually and in combination, to model beef palatability.

II. MATERIALS AND METHODS

The project (Reference: 15/092) was reviewed and approved by the University of Otago Human Ethics Committee. A broad range of beef consumer liking scores was obtained from 80 meat samples representing four distinct muscles (LT: *Longissimus thoracis*, GM: *Gluteus medius*, SM: *Semimembranosus*, SS: *Supraspinatus*) sourced from 20 New Zealand cattle across four different types (Friesian bulls; Angus-Cross steers, heifers, and cows). Consumer (n=180) liking was determined following the MSA (Meat Standards Australia) guidelines for meat preparation, cooking and sensory evaluation [3]. Eating quality scores were calculated as MQ4 (0-100) = Tenderness x 0.3 + Juiciness x 0.1 + Flavour x 0.3 + Overall Liking x 0.3. The following 4 individual datasets (from raw beef) and their combinations were used for modelling beef consumer liking scores (MQ4): IMF-FA (Intramuscular fat percent-Fatty Acids), MQ (Meat Quality: pH, L*, a*, b*, hue angle, chroma, shear force, and cook loss), NIRS (LabSpec, ASD Inc., Boulder, CO, USA: 350–2500 nm; 3 nm at 700 nm, 10 nm at 1400 nm and 2100 nm; illuminated area: ⌀ 25 mm, viewed area: ⌀ 15 mm), and REIMS (Waters Ltd, Wilmslow, UK) coupled to a quadrupole-time of flight mass spectrometer (Waters Xevo® G2 qToF, Waters), scanning between 50-1200 *m/z*. Random forest regressions were used for modelling the 80 MQ4 scores and all analyses were done using R 4.4.1 with the 'ranger' package. Performance metrics were calculated for each model (MAPE: Mean Absolute Percentage Error, RMSE: Root Mean Squared Error, and R^2: Coefficient of determination).

III. RESULTS AND DISCUSSION

The box plots for beef consumer liking by muscle demonstrate a broad range of MQ4 scores (Min. 26, Mean 52, Max. 71) and significant differences among muscles (Figure 1), reflecting inherent anatomical and composition variability. Figure 2 illustrates the performance of the final random forest model using all datasets indicating high agreement between predicted and actual MQ4 scores. From the original predictor datasets, including IMF-FA, MQ, and REIMS, 60–80% of their variables were retained in the model, indicating their strong contribution to the prediction of MQ4 (Table 1). However, only ~1% of the NIRS variables were retained in the model, suggesting a high degree of correlation among spectral data and a selection of only the most informative wavelengths. The predictive performance of random forest models varied across datasets (Table 1). The model incorporating all datasets (IMF-FA, MQ, NIRS, REIMS) achieved the highest accuracy, with highest R^2 (0.96) and lowest MAPE (5.64) and RMSE (3.23), indicating robust predictive capability. Among individual datasets, REIMS provided the best prediction accuracy (R^2=0.96) suggesting its effectiveness in capturing molecular signatures linked to beef

palatability, but higher MAPE and RMSE than the full model. IMF-FA also demonstrated strong predictive power (R^2=0.92), reinforcing the importance of IMF and FA composition in beef palatability. MQ alone showed a strong but weaker association with MQ4 (R^2=0.86) and improved the predicting ability of IMF-FA (R^2=0.93), achieving similar MAPE and RMSE to the full model. NIRS alone had a weaker predictive ability (R^2=0.82), likely due to the indirect nature of spectral data in capturing eating quality traits.

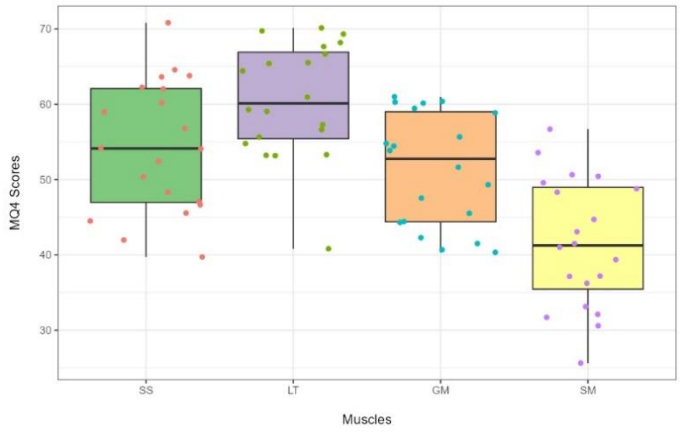


Figure 1. Beef consumer liking scores (MQ4: 0-100) by muscle (SS: *Supraspinatus*, LT: *Longissimus thoracis*, GM: *Gluteus medius*, SM: *Semimembranosus*).

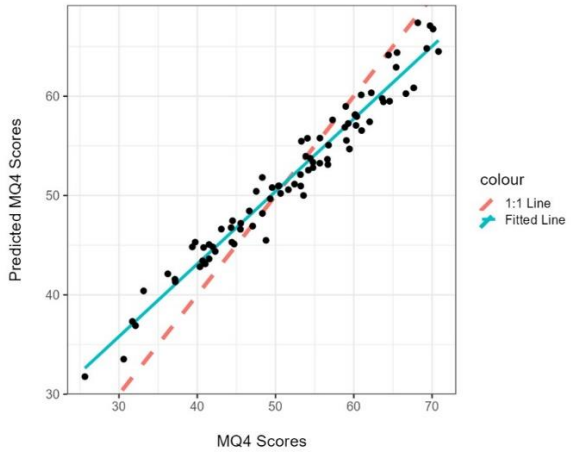


Figure 2. Performance of random forest model for predicting beef consumer liking scores (MQ4: 0-100) using all data sets.

Table 1. Number of original predictors and selected variables used for modelling MQ4 scores (consumer liking of beef) from individual datasets and their combinations, and performance metrics of the random forest models.

	No. variables		Performance metrics for random forest models[2]		
Data set[1]	**Predictors**	**Selected**	**MAPE**	**RMSE**	**R^2**
IMF-FA	42	25	6.16	3.65	0.92
MQ	13	9	7.35	4.20	0.86
NIRS	2152	10	8.73	4.96	0.82
REIMS	1201	994	7.21	4.14	0.96
IMF-FA+MQ	55	34	5.89	3.49	0.93
IMF-FA+MQ+NIRS	2207	44	6.82	3.89	0.93
IMF-FA+MQ+REIMS	1256	68	6.37	3.67	0.93
ALL	3408	77	5.64	3.23	0.96

[1] IMF-FA: Intramuscular fat percent-Fatty Acids, MQ: Meat Quality, NIRS: Near-Infrared Spectroscopy, REIMS: Rapid Evaporative Ionization Mass Spectrometry. [2] MAPE: Mean Absolute Percentage Error, RMSE: Root Mean Squared Error R^2: Coefficient of Determination.

IV. CONCLUSION

Combining all traditional and rapid analytical methods enhanced the prediction of beef palatability. While the integration of all datasets achieved the highest accuracy and lowest error terms, IMF-FA and MQ alone provided strong predictive power for research purposes, with no added value from including NIRS or REIMS. For industry use, both REIMS and NIRS showed potential as rapid, cost-effective tools for assessing beef eating quality, with REIMS demonstrating stronger predictive performance. However, further optimisation across muscles and production systems is needed to ensure robust industry application, enabling improved consumer satisfaction through quality-based processing and marketing strategies.

ACKNOWLEDGEMENTS

This research was part of the International Associated Laboratory - RUMQUAL project (Real time assessment and modelling of meat QUAlity from RUMinants) co-funded by INRAE and Bordeaux Sciences Agro in France and AgResearch in New Zealand (A28948). Research was supported by EU funded INTAQT project (N 101000250).

REFERENCES

1. Dixit, Y.; Pham, H.Q.; Realini, C.E.; Agnew, M.P.; Craigie, C.R.; Reis, M.M. (2020) Evaluating the performance of a miniaturized NIR spectrophotometer for predicting intramuscular fat in lamb. Meat Science 162.
2. Zhang, R.; Realini, C.E.; Middlewood, P.; Pavan, E.; Ross, A.B. (2022) Metabolic fingerprinting using Rapid evaporative ionisation mass spectrometry can discriminate meat quality and composition of lambs from different sexes, breeds and forage systems. Food Chemistry 386.
3. Watson, R.; Polkinghorne, R.; Thompson, J.M. (2008) Development of the Meat Standards Australia (MSA) prediction model for beef palatability. Australian Journal of Experimental Agriculture 48(11): 1368–1379.