**Title:** Developing chemometric models to classify eating quality of beef using algorithms produced by Rapid Evaporative Ionisation Mass Spectrometry (REIMS) and consumer sensory scores

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**Application:** REIMS output can successfully detect and categorise unique chemical fingerprints related to muscle, maturation, season and sensory quality of beef. Rapid evaluation of beef is valuable to industry as an objective method of classification. REIMS research highlights the potential for the implementation of an automated online method of assessing meat quality traits, the potential to forecast product demand and the opportunity for branding and marketing of products.

**Introduction**: Rapid Evaporative Ionisation Mass Spectrometry (REIMS) is a rapid ambient analytical technique without the need for sample preparation. Applications of REIMS include determination of biological tissue, food authenticity and more recently meat quality (Robson et al, 2022; Liu et al, 2024). Common traits used in evaluating sensory quality of red meat include tenderness, juiciness, flavour, and overall liking which are directly influenced by animal age, breed, sex and diet. Determination of beef muscle, maturation and season as well as discrimination of sensory eating quality using consumer taste panels and REIMS data are currently unknown. The aim of this study was to use REIMS and advanced chemometric modelling to uniquely connect REIMS data from four raw beef muscles, maturation, season and consumer sensory scores.

**Materials and Methods:** Welsh Beef samples (N=149) from four muscles; Tenderloin (TDR), Striploin (STR), Eye Round (EYE) and Feather blade (OYS), were collected from 31 carcasses across two seasons (summer and winter) after 7- or 21-day maturation post-slaughter. Consumer taste panels were conducted which evaluated tenderness, juiciness, flavour and overall liking. Beef samples were burned using a monopolar electrosurgical “iKnife” attached to the REIMS system (Waters Corporation, Wilmslow, UK) and a Xevo G2-XS QTof Mass spectrometer (Waters Corporation, Wilmslow, UK). Data were performed in sensitivity mode with continuum data acquisition in negative ionisation mode REIMS data was extracted using the Abstract Model Builder software and analysed using Simca 18 software. Muscle was classified into TDR, STR, EYE and OYS, while maturation and season was classified into 7- and 21-days and summer and winter. Consumer sensory scores ranged between 0-100 and classified meat quality into low (0-46), medium low (47-64), medium high (65-76) and high (78-100). MQ4 which represents the weighted combination of consumer scores of the four sensory attributes (tenderness, juiciness, flavour and overall satisfaction) was additionally classed into accepted (>40) and not accepted (<40). Models were calibrated, cross-validated and validated using an 80/20 calibration/validation training sample set.

**Results:** REIMS output and consumer sensory analysis successfully discriminated four beef muscles, in addition to 7- and 21-day maturation and season with an overall LDA model accuracy of 82, 100 and 96%, respectively.The most robust model for tenderness, flavour and juiciness were SVM where an overall model accuracy of 46, 39 and 43% was reported, respectively (Table 1). Similarly, the MQ4 SVM model classified for accepted or not accepted was reported at 85%. The most robust models for satisfaction, overall-liking and MQ4 (four rule classification) were LDA where an overall model accuracy of 45, 46 and 63%, respectively.

**Table 1:** Model accuracy for beef sensory traits according to class and model type using REIMS output

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | Model | Class | Accuracy (%) | | Overall accuracy (%) | Accuracy (%) | Overall accuracy (%) | | Accuracy (%) | Overall model accuracy (%) |
|  |  |  | Calibration | | | Cross-validation | | | Validation | |
| Tenderness | SVM | L | 100 | | 100 | 48 | 48 | | 72 | 46 |
| SVM | M-L | 100 | | 48 | 70 |
| SVM | M-H | 100 | | 48 | 72 |
| SVM | H | 100 | | 48 | 78 |
| Flavour | SVM | L | 100 | | 100 | 76 | 76 | | 72 | 39 |
| SVM | M-L | 100 | | 76 | 66 |
| SVM | M-H | 100 | | 76 | 68 |
| SVM | H | 100 | | 76 | 72 |
| Juiciness | SVM | L | 100 | | 100 | 45 | 45 | | 78 | 43 |
| SVM | M-L | 100 | | 45 | 66 |
| SVM | M-H | 100 | | 45 | 67 |
| SVM | H | 100 | | 45 | 76 |
| Satisfaction | LDA | L | 100 | | 100 | 39 | 39 | | 75 | 45 |
| LDA | M-L | 100 | | 39 | 64 |
| LDA | M-H | 100 | | 39 | 72 |
| LDA | H | 100 | | 39 | 78 |
| Overall liking | LDA | L | 100 | | 100 | 34 | 34 | | 76 | 46 |
| LDA | M-L | 100 | | 34 | 71 |
| LDA | M-H | 100 | | 34 | 71 |
| LDA | H | 100 | | 34 | 74 |
| MQ4 | LDA | L | 100 | | 100 | 48 | 48 | | 73 | 63 |
| LDA | M-L | 100 | | 48 | 96 |
| LDA | M-H | 100 | | 48 | 75 |
| LDA | H | 100 | | 48 | 81 |
| MQ4 | SVM | A | 100 | | 100 | 90 | 90 | | 85 | 85 |
| SVM | NA | 100 | | 90 | 85 |
| L - low  M-L – medium low | | | | M-H – medium high  H – high | | | | A – accepted  NA – not accepted | | |

**Conclusions:** REIMS can detect and categorise chemical information related to muscle, maturation, season and sensory meat quality. Model optimisation to reach a minimum of 70% overall accuracy is required. This study has identified the potential of REIMS as a complementary tool for evaluating meat quality, offering a fast, accurate, objective, and cost-effective method for the meat industry to ensure product safety, authenticity and quality.

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**References:** Liu, J., Birse, N., Álvarez, C., Liu, J., Legrand, I., Ellies-Oury, M.P., Gruffat, D., Prache, S., Pethick, D., Scollan, N., Hocquette, J.F. (2024). Discrimination of beef composition and sensory quality by using rapid Evaporative Ionisation Mass Spectrometry (REIMS). Food Chemistry 454, 139645.

Robson, K., Birse, N., Chevallier, O. and Elliott, C. (2022). Metabolomic profiling to detect different forms of beef fraud using rapid evaporative ionisation mass spectrometry (REIMS). NPJ Science of Food 6: 1.