

How to predict marbling

Prediction of marbling with a camera

Intramuscular fat (IMF) and marbling are important determinants of beef eating quality, namely tenderness, juiciness, and flavor. Their levels vary according to species, breed, muscle type, sex, age, and feeding regimen. Although chemical analysis provides reliable IMF measurements, it is time-consuming, labor-intensive, and destructive, limiting its use in industrial settings.

Visual marbling assessment by trained and accredited graders is widely used internationally, but it is costly and subject to variability both between and within graders. Portable imaging technologies could provide more consistent, reliable, and cost-effective alternatives to assess marbling and to support existing beef grading systems.

The Q-FOM™ Beef handheld camera, certified for use in Australia, offers a promising approach to automated marbling assessment. This study evaluated its ability to predict marbling scores in French beef cattle under commercial slaughterhouse conditions, particularly on carcasses quartered between the 5th and 6th ribs.

In the Meat Standards Australia (MSA) and Guaranteed Global Grading (3G) schemes, used to predict beef eating quality, marbling is visually assessed in the chiller by accredited graders. We evaluated the performance of the handheld Q-FOM™ Beef camera as an alternative to human grading for marbling assessment. Agreement between the camera and an expert grader was comparable to that observed between two accredited graders. On-screen visual assessment of marbling also met accreditation requirements, supporting its use as a reference method for developing reliable camera-based marbling assessment.

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Fig 1: The Q-FOM™ Beef handheld camera

A total of 420 beef carcasses from a French commercial slaughterhouse were selected. Following slaughter and chilling, carcasses were quartered between the 5th and 6th ribs for marbling assessment (ranging from 100 to 1190 in increments of 10). Marbling assessments were performed following a benchmark established by the Bovine Language Standards of UNECE (United Nations Economic Commission for Europe). Standards relating to marbling have been adapted for European cattle and consumers, thanks to extensive collaborative research conducted in Europe by the IMR3GF (International Meat Research 3G Foundation).

One expert grader independently assessed all 420 carcasses in the experiment. Of these, 377 carcasses were also evaluated by two 3G accredited graders, including the expert grader, providing a set of common evaluations for comparative analysis.

A subsample consisting of 100 carcasses was visually assessed by the expert grader both in the chiller and two months later on-screen from the captured images.

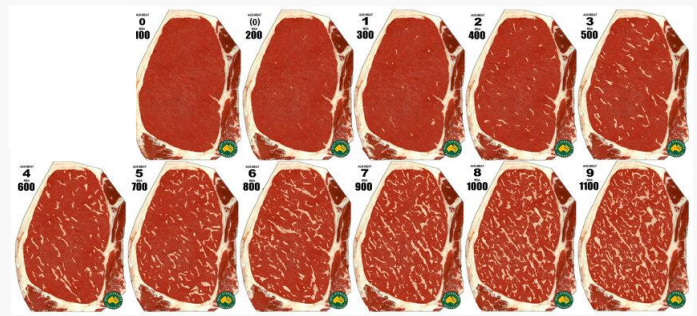
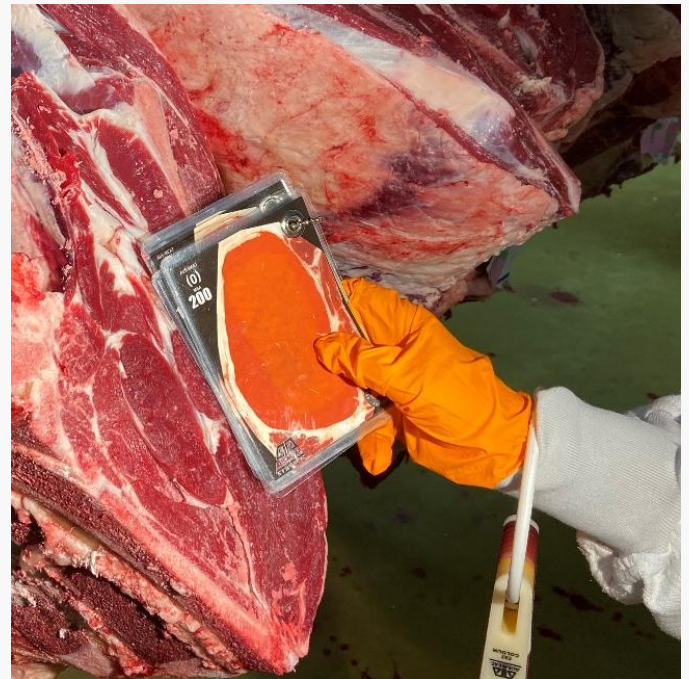


Fig 2: Grading of carcasses for marbling by human graders



Fig 3: Grading of carcasses for marbling using the Q-FOM™ Beef handheld camera

Visual assessment of beef marbling by trained and accredited graders is costly and can be affected by both inter-grader and intra-grader variability.

Portable imaging technologies offer a promising alternative for improving the consistency, reliability, and cost-effectiveness of marbling assessment.

The coefficient of determination (R^2) between marbling scores of the two accredited graders for 377 carcasses was 0.78 with a root mean squared error (RMSE) of 47.9.

The R^2 of determination between the marbling scores of the expert grader and the Q-FOM™ beef camera for 285 carcasses was 0.75 with a RMSE of 44.9.

For the grader-to-grader comparison, 75.9%, 97.1% and 100% of the values were within 50, 100 and 200 marbling points, respectively.

For the comparison between Q-FOM™ predictions and the expert grader, 78.6%, 96.8% and 99.7% of the values were within 50, 100 and 200 marbling points, respectively.

In conclusion, both the agreement between visual graders and that between the Q-FOM™ Beef camera and the expert grader demonstrated acceptable performance and met the accreditation criteria established in Australia.

A first observation is that the variability for marbling between scores from two accredited human graders is low but significant.

The Q-FOM™ Beef camera can predict marbling scores with good accuracy and precision for carcasses quartered at the 5th to 6th rib. These results are consistent with previous studies, who demonstrated the accuracy of the Q-FOM™ Beef camera in assessing marbling in beef carcasses quartered at the 10th to 13th rib.

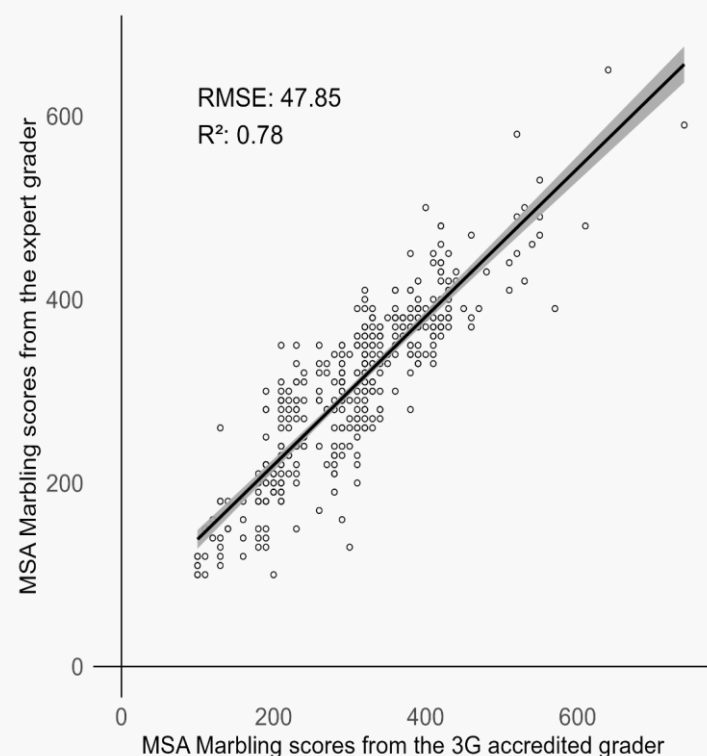


Fig 3: Relationship between marbling scores measured by the expert grader (Y axis) and the 3G accredited grader (X axis) for 377 carcasses. The regression line is shown with a shaded 95 % confidence interval, showing the precision of the relationship between the two graders.

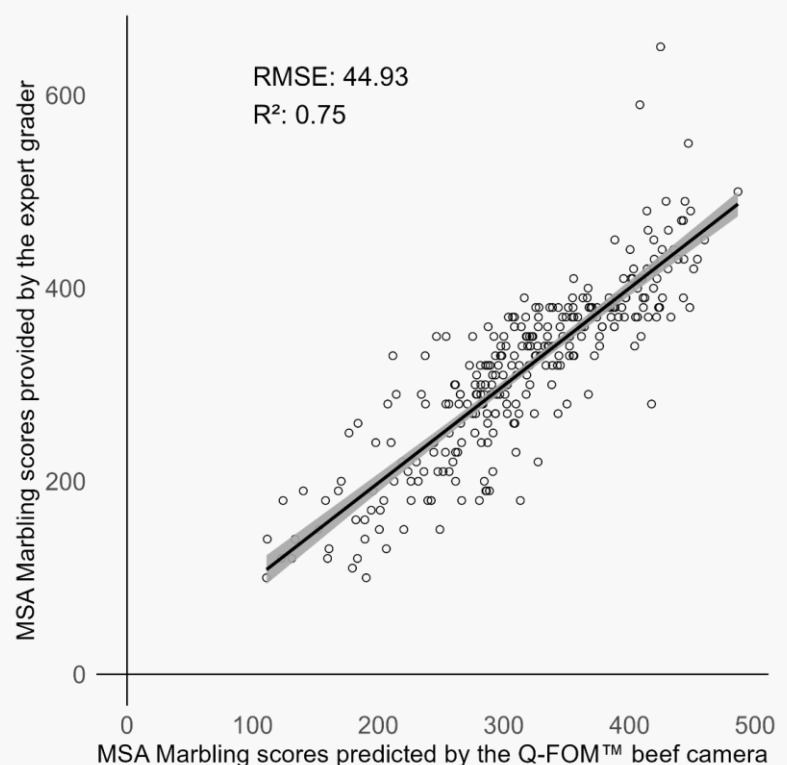


Fig 4: Relationship between MSA marbling scores predicted by the Q-FOM™ beef camera and the expert grader (N = 285 carcasses). The regression line includes a shaded 95% confidence interval, showing the variability and precision of the predictions relative to the expert assessments.

Additionally, 124 images from the Q-FOM™ beef camera were assessed on-screen by the expert grader. The R^2 of determination between the in-chiller and on-screen MSA marbling scores was 0.78 with a RMSEP of 48.7.

For the comparison between in-chiller assessment and on-screen image assessment, 79.8%, 96.8% and 100% of the values were within 50, 100 and 200 marbling points, respectively.

Thus, on-screen assessing met requirements for accreditation, and both in-chiller and on-screen visual assessments of MSA marbling score are acceptable input for developing a Q-FOM™ Beef marbling model.

A major achievement was to demonstrate, for the first time, that the Q-FOM™ Beef camera can accurately predict marbling scores in carcasses from cattle breeds typical of European production systems, when the carcasses are quartered between the 5th and 6th ribs, as is common practice in Europe.

The Q-FOM™ Beef camera proved effective under French beef production conditions, where marbling scores are generally lower than those observed in many other countries, particularly in Australia, where the MSA grading scheme was developed.

Both in-chiller and on-screen assessments by an expert grader proved reliable for developing the marbling calibration model for the Q-FOM™ Beef camera.

These findings highlight the camera's potential to improve the consistency and accuracy of marbling assessment in the European beef industry.

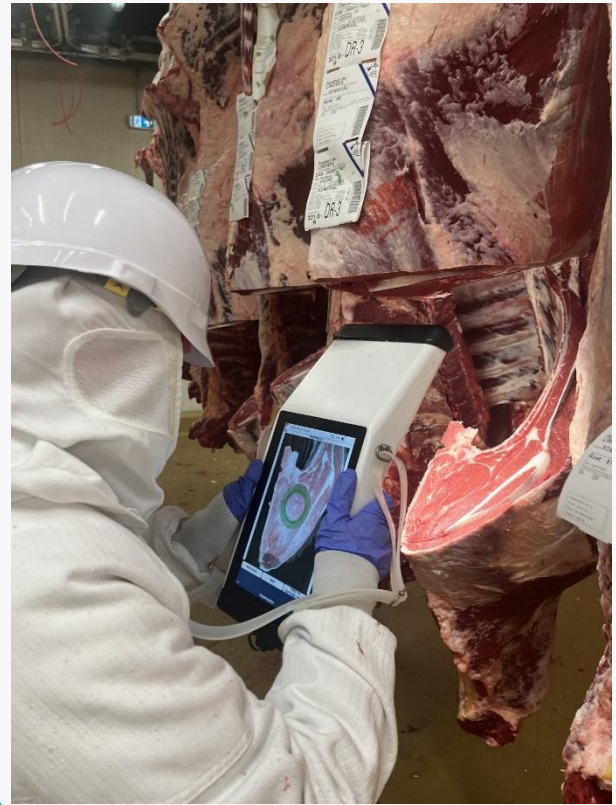


Fig 5: Capture of images in the chiller

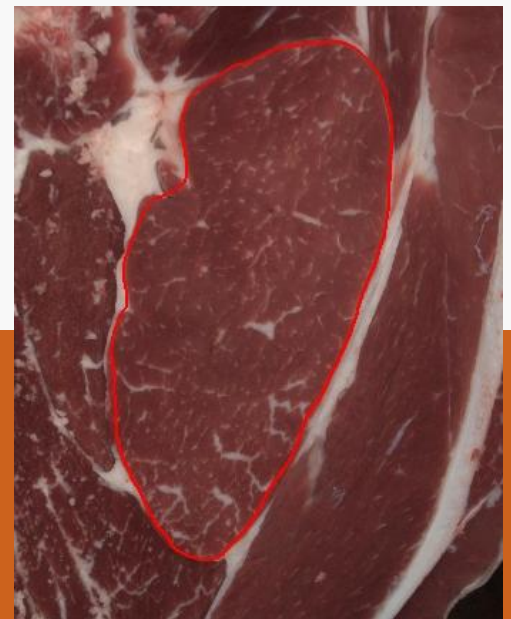


Fig 6: Image for on-screen marbling assessment

Mendes N., Christensen M., Kombolo-Ngah M., Faure P., Thoumy L., Neveu A., Barro A., Liu J., de Oliveira T., Ellies-Oury M.-P. ... Hocquette J.-F. (2025). Meat Science, 222, 109759,