3D mapping of Beef *m. longissimus* using near infrared spectroscopy changes and Mahalanobis distance

Per W. Hansen[1]
Lee Streeter[2]
Robert Burling-Claridge[2]
Mike North[2]
Carrick Devine[3]

[1]**EquatioNZ**
Kongens Lyngby, Denmark
Email: pwh@equationz.dk

[2]**AgResearch Ltd**
Ruakura Research Centre,
Hamilton, New Zealand.

[3]**HortResearch**
Bioengineering,
Ruakura Research Centre,
Hamilton, New Zealand.

Introduction

Non-destructive techniques such as near infrared (NIR) spectroscopy can be significantly correlated with tenderness but the question arises whether inherent variability influences results. The theory of sampling (Petersen, Minkkinen, & Esbensen, 2005) was invoked in order to understand meat variability. One cannot subdivide meat into fragments to consider the variation as it moves past a measurement device as the measurements are destructive. However, it is possible to consider the variation of a muscle along its length and across its width, i.e. 3D mapping, by measuring NIR spectral changes using a combination of Principal Component Analysis (PCA) and Mahalanobis distance (D) (Mahalanobis, 1936). It is suggested to use D as a measure of how representative a given location inside a muscle is for the whole sample (i.e. its similarity to the mean NIR spectrum).

The Mahalanobis distance is a distance measure that takes the variability along the axis of the data set into account. In practical terms it fits an N-dimensional hyper ellipsoid around the data set and measures the distance using that as a ruler. This is different from the normal Euclidean distance where all directions have the same influence, independent of their variance. The advantage of D is that it allows even minor variations in the N-dimensional space to contribute to the distance. This is very useful when combining with PCA, which derives the principal components (PCs) according to their covariance.

Objective

To determine the most representative portions of beef strip loin for meat quality and NIR studies

Materials & methods

Four pairs of beef *m. longissimus et lumborum* (LL) were removed from steers and wrapped in polyethylene cling film to prevent shortening (Devine, Wahlgren & Tornberg, 1999) and held at 15˚C to enter rigor mortis and age for 24 h.

The wrapped muscles, with an approximate circular cross section, were then positioned in a holder. A slice was removed from the rump end of the muscle and a fibre optic probe was moved across the face of the muscle and NIR recordings were obtained at 42 positions in a grid with spacing at 1.4 cm (Figure 1) across the face with a diode array unit from KES Analysis (NY, USA) covering the spectral range from 400 to 1700 nm. A 1.4 cm slice was removed and the process repeated, over the whole LL.

A PCA model was calculated. Standard Normal Variate (SNV) pre processing was applied to reduce light scatter effects. The optimal number of PCs used for calculating D was 11. For each animal, each 2D position appears up to 40 times (20 slices x 2 sides), so the averaging of D was carried out over 40 data points.

Results & discussion

Figure 1 D mean for the cross section of the muscle. Dark regions are the most representative. Numbers are grid number.

The average D values (D mean) were calculated and plotted in Figure 1. The central positions that are dark in colour are closest to the mean, i.e. positions that resemble the average meat sample most. Positions 17, 18, 19, and 26 appear to be the least variable on the meat surface.

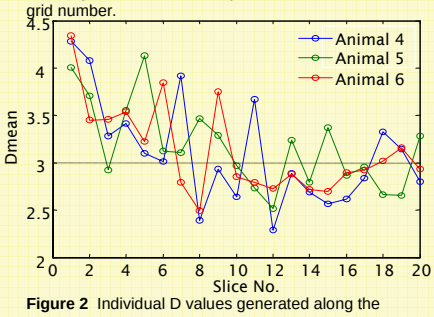

Figure 2 Individual D values generated along the length of the muscle (20 is the rump end).

The variation along the length, i.e. the variability between slices was determined with the resulting D mean (averaged over positions 17, 18, 19, and 26), is shown in Figure 2 for three animals. The average and standard deviations for the animals are shown in Figure 3. D mean is lower at high slice numbers (rump end).

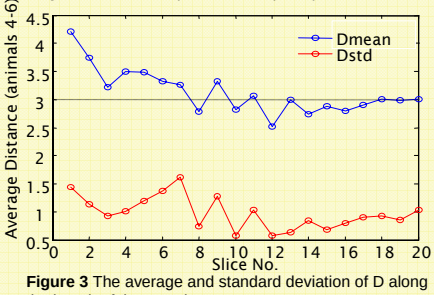

Figure 3 The average and standard deviation of D along the length of the muscle.

For the consistency required for NIR calibration or tenderness evaluation the centre of a piece of meat shows least variation. The least variability and best representation of a cut is in the region of slice 8-16 (11-22 cm from the rump end) (Figure 3). This suggests that many shear force measurements are required to characterise a piece of meat and that the most representative results are obtained in this region.

Conclusion

The central region of the strip loin cross section is the most representative, with the most representative lengthwise readings being obtained between 11 and 22 cm from the rump end.

References

Devine, C.E. Wahlgren, N.M. & Tornberg, E. (1999). Effect of rigor temperature on muscle shortening and tenderisation of restrained and unrestrained beef *m. longissimus thoracis et lumborum*. Meat Science, 51: 61-72.

Hansen, S. Hansen, T, Aaslyng, M.D. Byrne. D.V. (2004). Sensory and instrumental analysis of longitudinal and transverse textural variations in pork *longissimus dorsi*. Meat Science, 68: 611-629.

Janz, J.A.M., Aalhus, J.L., Dugan, M.E.R. & Price, M. A. (2006). A mapping method for the description of Warner-Bratzler shear force gradients in beef *longissimus thoracis et lumborum* and *semitendinosus*. Meat Science, 72: 79-90.

Mahalanobis, P. (1936). On the generalized distance in statistics. Proceedings National Institute of Science, 12:49-55.

McGlone V. A, Devine, C. E. and Wells, R. W. (2005). Detection of tenderness, post rigor age and water status changes in sheep using near infrared spectroscopy. Journal of Near Infrared Spectroscopy, 13:277-285.

Petersen, L., Minkkinen, P. & Esbensen, K. (2005). Representative sampling for reliable data analysis: Theory of sampling. Chemometrics and Intelligent Laboratory *Sy*stems 77:261-277.