



Use of Hyperspectral Imaging Technologies for Prediction of Beef Meat Quality

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Introduction

Hyperspectral imaging (HSI) is an emerging platform technology that integrates conventional imaging and spectroscopy to attain both spatial and spectral information from an object. In recent years, hyperspectral imaging has rapidly matured into one of the most powerful and fastest-growing non-destructive tools for food quality analysis and control. In the project, hyperspectral imaging technologies will be carried out for predicting eating quality of beef.

Many researchers have found that there is a relationship between eating quality of beef and corresponding sensory properties such as tenderness and flavour. The tenderness can be assessed by measuring the slice shear force (SSF) and the ultimate pH value is an important shelf-life and colour parameter. In the project, HSI has been employed to predict the SSF measurement and pH value of captured beef samples at 7 days and 14 days post mortem and the results are compared with the existing NIR spectroscopy.

Materials

Over 600 beef *M. longissimus thoracis* samples at 48 hours post mortem have been scanned in three abattoirs (200 per abattoir over two consecutive days), using both hyperspectral imaging system ($\lambda = 283.23 - 862.90$ nm) and NIR spectroscope ($\lambda = 350 - 2500$ nm). SSF and ultimate pH measures of steaks were collected by QMS at 7 days and 14 days post mortem.

Methods

- Excessive noises were removed from both HSI and NIR spectra, resulting in working spectra:
 - HSI: $\lambda = 490.42 - 862.90$ nm.
 - NIR: $\lambda = 501 - 2200$ nm.
- Samples were split into calibration [cal] (75%) and prediction [pred] (25%) datasets.
- Principal component analysis (PCA) was applied for feature reduction and extraction.
- Support vector machine (SVM) was employed to construct the prediction model.

Results

| Abattoir A | | | | | | | |
|-------------------|-------------------|--------|-----------------|-------------------------------|---------------------------------|--------------------------------|----------------------------------|
| | Days ^a | Method | PC ^b | R ² _{cal} | RSD _{cal} ^c | R ² _{pred} | RSD _{pred} ^c |
| pH _{ult} | 7 | HSI | 30 | 86.84 | 0.05 | 57.95 | 0.09 |
| | | NIR | 3 | 53.72 | 0.09 | 42.98 | 0.11 |
| | 14 | HSI | 20 | 85.55 | 0.05 | 49.48 | 0.11 |
| | | NIR | 2 | 61.29 | 0.08 | 36.35 | 0.13 |
| SSF | 7 | HSI | 30 | 30.03 | 41.27 | 31.70 | 38.41 |
| | | NIR | 45 | 35.51 | 41.79 | 35.32 | 39.56 |
| | 14 | HSI | 40 | 99.99 | 0.35 | 23.88 | 35.84 |
| | | NIR | 50 | 100 | 0 | 14.85 | 37.64 |

| Abattoir B | | | | | | | |
|-------------------|-------------------|--------|-----------------|-------------------------------|---------------------------------|--------------------------------|----------------------------------|
| | Days ^a | Method | PC ^b | R ² _{cal} | RSD _{cal} ^c | R ² _{pred} | RSD _{pred} ^c |
| pH _{ult} | 7 | HSI | 40 | 80.87 | 0.05 | 37.04 | 0.06 |
| | | NIR | 15 | 70.94 | 0.06 | 56.83 | 0.05 |
| | 14 | HSI | 20 | 98.85 | 0.01 | 32.34 | 0.08 |
| | | NIR | 4 | 53.03 | 0.08 | 39.31 | 0.08 |
| SSF | 7 | HSI | 40 | 56.74 | 35.15 | 14.41 | 40.37 |
| | | NIR | 10 | 39.16 | 40.96 | 9.19 | 41.31 |
| | 14 | HSI | 45 | 100 | 0 | 20.75 | 31.42 |
| | | NIR | 20 | 63.72 | 27.01 | 2.17 | 35.32 |

| Abattoir C | | | | | | | |
|-------------------|-------------------|--------|-----------------|-------------------------------|---------------------------------|--------------------------------|----------------------------------|
| | Days ^a | Method | PC ^b | R ² _{cal} | RSD _{cal} ^c | R ² _{pred} | RSD _{pred} ^c |
| pH _{ult} | 7 | HSI | 25 | 60.94 | 0.05 | 35.01 | 0.05 |
| | | NIR | 10 | 37.85 | 0.06 | 10.02 | 0.06 |
| | 14 | HSI | 10 | 22.55 | 0.07 | 12.15 | 0.07 |
| | | NIR | 4 | 21.92 | 0.07 | 8.11 | 0.07 |
| SSF | 7 | HSI | 20 | 100 | 0 | 32.27 | 32.70 |
| | | NIR | 15 | 97.17 | 7.55 | 11.87 | 39.68 |
| | 14 | HSI | 25 | 33.83 | 42.43 | 24.87 | 42.11 |
| | | NIR | 4 | 21.92 | 0.07 | 8.11 | 0.07 |

^a Days after slaughtered.

^b Number of principal components used in the regression.

^c Residual standard deviation.

Conclusions & Future Work

As shown in results, in most situations, it is indicated that hyperspectral imaging is a more promising technique for predicting meat eating quality than the NIR spectroscopy, resulting in a higher R²_{pred} and lower RSD_{pred}.

Even though HSI provides an attractive solution for the analysis of beef quality, the prediction results are relatively low.

More work needs to be done in next stages, some examples are:

- Other feature extraction strategies could be applied to the datasets to improve the predictive ability.
- Collect more tough samples to help the SSF ground truth distributed evenly so that there are enough samples in the datasets to fully develop models.
- Test another HSI system covering the NIR wavelengths.

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