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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 (λ = 283.23 – 862.90 nm) and NIR spectroscope (λ = 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: λ = 490.42 – 862.90 nm.
  - NIR: λ = 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 R^2_{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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