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Early prediction of *Semimembranosus* ultimate pH with Raman spectroscopy of pig carcasses

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Introduction

The ultimate pH (pH24) is a crucial meat quality parameter in the pork meat industry, but its measurement time is still an issue for slaughterhouses due to difficulties to keep up the required 18h post mortem (pm) time minimum. Raman spectroscopy showed the potential to predict pH24 of Semimembranosus when performed during chilling at 60 to 120 minutes pm [1] and on the slaughter line at 30 to 60 minutes pm [2]. The objective of the study is to validate the accuracy of the 671 nm emission Raman device developed by Schmidt et al. [3] to predict pork meat quality on a French pork population at the end of the slaughter line (30 min pm). The ability to predict the "jambon cuit supérieur" cooking yield and slicing defects has also been tested.

Materials & Methods

Raman spectrometer:

- 5.5 µm to 20.0 µm Horiba mid-infrared spectrometer
- Handheld probe with a 671 nm emission laser and optic fiber
- 15 sec integration time
- 7 spectra averaging per sample, on freshly cut *Semimembranosus* (SM)

Samples:

- 208 carcass randomly selected on the slaughter line and deviated to the veterinarian line
- Deviation time mean for Raman acquisition = 13 min
- A subpopulation of carcasses (n=73) was selected on ultimate pH (uniform pH distribution) for individual cooked ham processing

Reference meat quality parameters:

- pH1: early *post mortem* pH measured at 30 min (SM)
- pH24: ultimate pH measured at 24 h *post mortem* (SM)
- Drip loss: EZ method sampling on the internal side of the SM
- Cooking yield and « paste-like » slices rate (industrial cooked ham processing by Fleury Michon)

Spectral prediction of the meat quality was investigated with the PLS cross validation procedure (MATLAB software and Eigenvector toolbox)

Results

- No extreme pH values (PSE or DFD) in the calibration population
- High level data fitting in calibration for pH1 (R^2c=0.70) and pH24 (R^2c=0.82)
- … but robustness issue in cross validation due to the data distribution
- Raman ability to give an early prediction of pH24 is confirmed, accurate enough for industrial classification (R^2cv=0.45, rmsecv=0.12)
- The ability to predict « paste-like » slicing defect is noteworthy (R^2cv=0.41)
- Drip loss and cooking yield prediction were not accurate enough (R^2cv=0.22 and 0.25), deviation time variability could be involved (6 to 45 min)

Table 1: Meat quality reference parameters for Raman calibrations, mean and standard deviation (in brackets)

Sample population	n=	pH1	pH24	Drip loss (%)	Cooking yield (%)	« paste-like » slices (%)
total	208	6.42 (0.18)	5.64 (0.16)	5.6 (2.5)	-	-
Processed meat population	73	6.40 (0.19)	5.68 (0.16)	4.4 (2.6)	87.3 (3.3)	27.6 (26.7)

Figure 1 and 2: Handheld probe Raman spectrometer

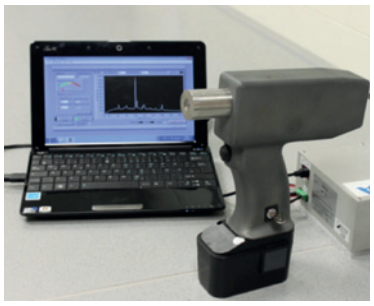

Figure 3: pH24 predicted from pre-rigor Raman spectra vs measured pH24

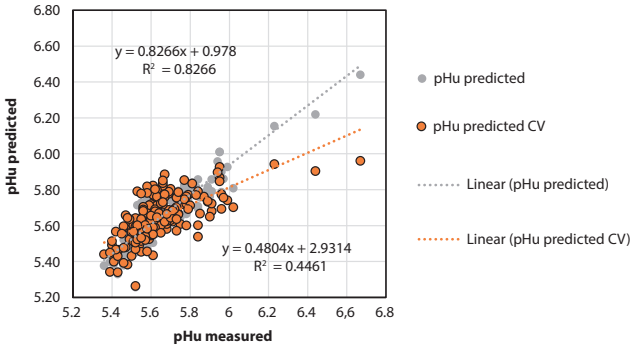

Table 2: Calibration (c), cross-validation (cv) and external validation (p) results for the prediction of the meat quality by Raman spectroscopy performed on pre-rigor *Semimembranosus*)

Sample population	n=	Nb of PLS factors	R^2c	R^2cv	rmsec	rmsecv
pH1	206	6	0.70	0.39	0.10	0.14
pH24		7	0.82	0.44	0.07	0.12
Drip loss (%)		6	0.65	0.22	1.5	2.2
Cooking yield (%)	73	7	0.93	0.25	0.9	2.9
« paste-like » slices (%)		8	0.96	0.41	4.9	20.8

Conclusion

The feasibility of an early prediction of pH24 on the slaughter line using a hand-held Raman spectrometer has been confirmed on a French carcass population. Raman spectroscopy could be a game changing technology in the way of sorting carcasses at slaughterhouse. To this end, a trial is planned in 2019 in order to improve the accuracy of pH24 prediction by enhancing the data distribution with DFD carcasses.