EARLY PREDICTION OF SEMIMEMBRANOSUS ULTIMATE PH WITH RAMAN SPECTROSCOPY OF PIG CARCASSES

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I. 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.

II. MATERIALS AND METHODS

A population of 208 carcass was randomly selected on the slaughter line and deviated to perform early pH (pH1, 30 min *pm*) and Raman measurements on *Semimembranosus* (freshly cut surface for Raman). Seven Raman spectra were collected per carcass (80 mW laser power, 15 s integration time) before returning on the slaughter line (13 min deviation time average). At 24 h *pm*, pH measurement and drip loss sampling (EZ method) were performed on the external surface of the *Semimembranosus*. A subsample of n=73 hams were also selected on pH24 (uniform distribution) for the needs of individual "jambon cuit supérieur" processing [4], and "paste-like" slicing defect were determined on the commercial product. Raman spectra were pre-processed with EMSC (order 5), 2-norm at 1000 cm^{-1} and mean centering. The pre-processed spectra were correlated with meat quality reference parameters with partial least-square regression using MATLAB 7.9.0 R2009b and Eigenvector PLS Toolbox 7.5. The number of latent variables (LV) was determined with random blocks cross validation procedure as the lowest number of LVs providing a clear reduction of the rmsecv.

III. RESULTS AND DISCUSSION

The calibration population (n=208) revealed no PSE meat (pH1<5.90), no DFD meat (pH24>6.2) and only 3 samples with high pH24 (6.0<pH24<6.2). The pH24 shows a major effect on drip loss (r=-0.65) whereas the correlation of pH1 with drip loss is low (r=-0.14, results not shown) due to the absence of PSE samples. This could reduce the model fitting level for meat quality parameters.

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

Sample population	pH1	pH24	L*	Drip loss (%)	Cooking yield (%)	"Paste-like" slicing defect (%)
Total (n=208)	6.42 (0.18)	5.64 (0.16)	48.7 (3.3)	5.6 (2.5)	-	-
Processed meat subpopulation (n=73)	6.40 (0.19)	5.68 (0.16)	48.5 (3.4)	4.4 (2.6)	87.3 (3.3)	27.6 (26.7)

Raman calibration shows satisfying results for pH1 prediction (R^2c=0.70) in agreement with previous work (R^2c=0.72 [2]) but a significant drop in the data fitting after cross validation indicates a robustness issue (R^2cv=0.39, table 1). This could result from the lack of PSE and DFD samples. PLS calibration model reveals a high R^2 level for the early prediction of pH24 (Rc^2=0.82), which is a major asset of the Raman spectroscopy of meat, confirming Rc^2 found in bibliography (R^2c=0.58 to 0.85, [1],[2]). The lack of robustness in cross validation is most likely due to a shortage of samples over pH 6.0 (figure 1), but the data fitting is stable in external prediction (R^2p=0.49).

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* (30 min *post mortem*)

Variable	n= (cal./val.)	n PLS factors	R^2_c	R^2_{cv}	R^2_p	$rmse_c$	$rmse_{cv}$	$rmse_P$
pH1	206	6	0.70	0.39	-	0.10	0.14	-
pH24	206	7	0.82	0.44	-	0.07	0.12	-
	(137/69)	6	0.81	0.45	0.49	0.07	0.12	0.12
L*	206	5	0.57	0.30	-	1.98	2.55	-
Drip loss (%)	206	6	0.65	0.22	-	1.5	2.2	-
	(137/69)	6	0.65	0.13	0.33	1.4	2.3	2.2
Cooking yield (%)	73	7	0.93	0.25	-	0.87	2.9	-
Paste-like slice ratio (%)	73	8	0.96	0.41	-	4.9	20.8	-

The accuracy for drip loss prediction is very low in cross validation ($R^2cv=0.22$) and external validation ($R^2p=0.33$, table 2); varying deviation time could be involved (from 6 to 45 min.). The cooking yield calibration is well fitted ($R^2c=0.93$) but robustness gap is still to investigate ($R^2cv=0.25$). The ability to predict "paste-like" slicing defect of processed meat, which is a big concern in the French market, is also noteworthy ($R^2c=0.96$, $Rcv=0.41$).

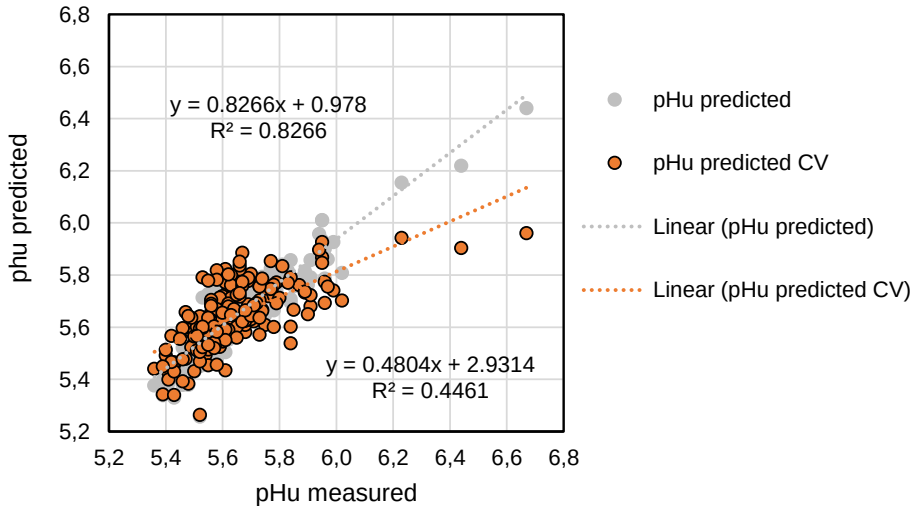

Figure 1. pH24 predicted from pre-rigor Raman spectra (30 min *PM*) versus pH24 measured with a pH-meter

IV. 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.

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