Validation trials for the prediction of water holding capacity of pork meat by vision and VisNIR spectroscopy

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I. INTRODUCTION

There is some focusing interest in the French pork meat sector to test new parameters for carcass grading in slaughterhouses, and water holding capacity evaluation could be the next parameter to be added to carcass weight and lean meat percentage. Many feasibility studies have been conducted at IFIP in the last ten years for the prediction of water holding capacity with vision systems, near infrared spectroscopy and more recently hyperspectral imaging systems. A large validation project is now needed to compare technologies, from accuracy, integration and traceability concerns. The aim of the DATAPORC project is to build robust prediction models involving 7 devices designed for industrial purpose and to validate them on a large population (carcasses, bone-in hams, or deboned hams, depending on the device design). Experiments were conducted in 4 slaughterhouses on a three-year period, with a total of 5562 carcasses. The project also deals with traceability concerns, in order to give consistent feedback to pig producers. This paper presents the results obtained in the first slaughterhouse on deboned hams with two technologies: Visible and Near InfraRed (VisNIR) spectroscopy with contact probe and color evaluation with vision system.

II. MATERIALS AND METHODS

A population of 1251 fresh pork hams were selected during 16 days of trials, according to the *Semimembranosus* ultimate pH (<5.5: n=241 / 5.51-5.7: n=435 / 5.71-5.90: n= 334 / >5.90: n=241). After deboning (24h *p.m.*), the inside of the *Semimembranosus* muscle was measured with a VisNIR spectrometer using a contact probe (ASDI Labspec4, 350-2500 nm). The CSB-Jamboflash vision system was used on the inside of *Semimembranosus* to produce calibrated L*a*b* data, and the built-in calibration was applied to perform the "PSE-like zone" defect grading [1]. The reference meat quality parameters were measured at 24h *postmortem* on the *Semimembranosus* muscle (ultimate pH, color L*a*b*, drip loss (EZ sampling, 48h draining [2])), and the subjective "PSE-like" zone grading was performed on entire deboned hams [3]. The last 6 days of trial were used to build the external validation data set (n=435), whereas the first 10 days were considered as the calibration data set (n=789). Multiple regression models were determined with RStudio (2022.12.0 version) using color data sets from CSB-Jamboflash. PLS and PLSDA models using VisNIR spectra were determined by random cross validation using Matlab 7.10.0 software (Natick, USA) and Eigenvector toolbox (Manson, USA).

III. RESULTS AND DISCUSSION

The meat quality level of samples (pH24=5.71, drip loss=3.9% and PSE-like zone frequency=17.2%) was representative of the standard population [4,5], despite the pH24 sorting process. The overall error of the PSE-like zone grading obtained with the vision system was low (11.5%) with limited false negative ratio (15.1%, table 1) confirming the robustness previously observed (17.1% of false negative, n=9584, [1]). The vision system correlations in external validation for pH24 and drip loss (r=0.65 and 0.66, respectively) were similar to correlations found with the colorimeter L* values (r=-0.67 and 0.64, respectively) showing that vision systems could take advantages of the prediction potential of color for meat quality prediction.

The VisNIR spectrometer PLS prediction models for pH24 and drip loss showed higher calibration R^2 than vision system with very low fitting losses in external validation (R^2_p =0.67 and 0.58 respectively).

The prediction errors were stable (cross validation vs external validation) revealing high precision level for VisNIR spectrometry. The PLSDA model for the PSE-like zone grading with VisNIR showed similar accuracy level (10.2% false negative) than vision system in external validation but was only tested in a single slaughterhouse, unlike the CSB-Jamboflash.

	Labspec4 (ASDI)							CSB-Jamboflash			
	calibration					External validation		Linear regression (n=789)		Prediction	
	(n=794)					(n=436)				(n=435)	
	Spectral treatment*	Nb PLS factor	R²c	R ² cv	rmsecv	R²p	rmse _p	R²	rmse	R²p	rmse _p
pH24	GLS weighting	2	0.73	0.65	0.13	0.67	0.14	0.55	0.15	0.42	0.17
Drip loss (%)	SNV	5	0.55	0.54	1.8	0.58	1.8	0.42	2.04	0.44	2.06
	Spectral treatment*	Nb PLSda factor	R²c	R² _{cv}	rmse _{cv}	False positive (%)	False negative (%)	Prediction (n=1251)			
								Fa pos (ılse Fal itive nega %) (۶		alse gative (%)
PSE-like zone (%)	1 st derivative	1	0.44	0.41	0.42	8.9	10.2	10.7		15.1	

Table 1 – prediction of meat quality of pork ham with VisNIRS (ASDI Labspec4) and Vision (CSB Jamboflash) applied on *Semimembranosus* muscle

*: smoothing+baseline correction+treatment

IV. CONCLUSION

This first data treatment extract from the DATAPORC project showed that proper calibrations of water holding capacity prediction with vision system and VisNIR spectrometry give enough accuracy in external validation for carcass batch grading. The VisNIR spectrometer accuracy is higher than vision system, but it needs meat contact and an operator. The deboned status of the meat here is clearly an advantage for the prediction but the traceability is difficult to maintain. The next DATAPORC data sets will compare these technologies on bone-in meat cuts or carcasses, with other muscle measurement opportunities but with easier traceability control.

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REFERENCES

- 1. Vautier, A., Gault, E., Girard, P. (2022). Entire male effect on the rate of destructured zones of pork hams. 68th International Congress of Meat Science and Technology, Kobe, Japan.
- 2. Rasmussen, A., Andersson, M. (1996). New method for determination of drip loss in pork muscles. 42nd International Congress of Meat Science and Technology, Lillehammer, Norway.
- 3. IFIP. 2005. Grille de notation du défaut "déstructuré" des muscles de la cuisse de porc. 4p.
- 4. Vautier, A., Loiseau, D., Richard, R. (2018). Identification de nouveaux facteurs amont de variation de la qualité technologique de la viande. Rapport d'étude, 28 p.
- 5. Lhommeau, T., Vautier A., Le Roux A. (2020). Observatoire pH et défaut déstructuré dans 5 abattoirs français en 2019. Rapport d'étude, 33 p.