PREDICTION OF TECHNOLOGICAL AND ORGANOLEPTIC PROPERTIES OF BEEF CUTS BY NEAR INFRARED SPECTROSCOPY

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Background

The meat is characterized by high heterogeneity. Nevertheless, the meat traders and the consumers expect a constant quality and an optimal quality / price ratio. The perception of meat quality depends on three criteria : tenderness, color and preservation ability -pH and water holding capacity (WHC)-. The actual techniques to determine these parameters are extremely time consuming, expensive and destructive. The development of a fast and non destructive technique on fresh intact meat would ensure a better objectivation of technological and sensory qualities and, as a result, a better price determination. Among the techniques described and considered in litterature, the near infrared (NIR) spectroscopy seems to be promising (Mitsumoto et al., 1991 ; Hildrum et al., 1995 ; Byrne et al., 1997 ; Devine et al., 1998 ; Monin, 1998).

Objectives

The aim of this study was to investigate the use of the NIR spectroscopy for prediction of technological and organoleptic properties of beef meat. In this work, two different spectral acquisition modes - transmission and reflection - were compared. In reflection mode, the predictive models on fresh cuts and freeze-dried meat samples were also confronted.

Methods

Muscle *Longissimus thoracis* (7-8-9 ribs) was removed from 48 cows (mean age = 68 months) and 67 bulls (mean age = 21 months) at 48 hours *post mortem.* On the basis of the European S.E.U.R.O.P. carcass classification, 35 % of cows belonged to the S3 class and 31% to the E3. For the bulls, 78% were classified in the S2 class, 10% in the E2 and 10% in the U3 class. Four 2.5 cm thick cuts of the *Longissimus thoracis* were used to measure technological (pH and WHC) and organoleptic (color and tenderness) qualities at 2 and 8 days *post mortem* by instrumental reference methods. The pH was measured on intact cuts by using an inserting combined pH electrode (Ingold ref 104063123) on a Knick 751 pH-meter. The Labscan II device (Hunterlab) was used to objectively measure CIE L* (brightness), a* and b* (color) parameters. The WHC was estimated by the drip loss and cooking loss determination. Drip loss was assessed as the percentage weight loss after 6 days storage in a plastic bag at 2°C ; cooking loss was measured as the percentage weight loss after cooking in an open plastic bag in a waterbath during 60 min at 75°C. Warner-Bratzler peak shear force (WBPSF) was determined with a Lloyd LR5K universal testing machine perpendicular to the muscle fibre direction on 1.25 cm diameter cores obtained from the raw or heated cuts.

Samples were taken at 2 and 8 days *post mortem* for NIR analysis with the Fourier Transform spectrometer Bomem MB 160D in the 800 to 2500 nm spectral range. The spectral acquisition in reflection mode was performed with the fiber-optic Axiom probe FDR-320 and the Bag SamplIR accessory was used for the transmission mode. Spectra were obtained in five different spots of the same sample and the average spectrum was calculated and used in the data analysis. Spectral acquisition on reflection mode was also performed on freeze-dried meat from a sample taken at 2 days *post mortem*.

The mathematical treatments were performed with the Grams/32 (Galactic) software. A PCA (Principal Component analysis) was first used to detect outliers. The mathematical pretreatments such as baseline correction, MSC, SNV, normalization or 1th and 2th derivatives were investigated and chosen on the basis of correlation analysis. The predictive models were calculated with the PLS (Partial Least Squares) algorithm and the number of terms determined by cross-validation.

Results and discussion

The criteria of model quality expressed by the Standard Error of Cross-Validation (SECV) and the Determination Coefficient of Cross-Validation (R^2cv) are shown in table 1. The predictive model of the pH from freeze-dried meat (SECV = 0.026 ; R^2cv = 0.65) was better than from fresh matter (SECV = 0.036 ; R^2cv = 0.40). The correlation between spectra and pH was higher in transmission mode (for example at day 2 : R^2cv = 0.50 *vs* R^2cv = 0.40). These values can be compared with the results of Mitsumoto et al. (1991) in which Standard Error of Calibration (SEC) was 0.07, Determination Coefficient of Calibration (R^2c) 0.34 in transmission mode and SEC = 0.05, R^2c = 0.55 in reflection.

For the WHC, the reflection mode showed a higher correlation. For example, the R^2cv for the cooking loss was 0.35 in reflection mode *vs* 0.25 in transmission. The prediction of WHC from spectra of samples at day 8 (SECV = 0.87 % and R^2cv = 0.55 for drip loss) appeared to be more acurrate than from spectra on samples taken 2 days *post mortem* (SECV = 0.99 % ; R^2cv = 0.35). Mitsumoto et al. (1991) reported SEC of 3.16 % and R^2c of 0.55 for the prediction of cooking loss in transmission mode and SEC of 3.17 % with R^2c of 0.59 in reflection mode.

On fresh meat, the predictive models for color parameters (CIE L* a* b*) were of lower quality in transmission mode (SECV of 2.41 % and R^2cv of 0.65 for L*). The more accurate prediction in reflection mode (figure 1 : SECV = 1.76 % ; R^2cv = 0.82) could be associated to the technique, the reference method being also performed in reflection mode but in the visible range. There were higher correlations coefficients between spectra and L* or b* (R^2cv = 0.82 and R^2cv = 0.73 respectively) than between spectra and a* (R^2cv = 0.44). Byrne et al. (1997) reported similar findings although they worked in the 750 to 1100 nm spectral range.

The spectra from the 2 days freeze-dried meat samples produced more accurate models for cooked meat WBPSF prediction (SECV = 8.87 N ; R^2cv = 0.39) than from fresh matter (SECV = 9.66 N ; R^2cv = 0.39). The 8 days spectra in reflection mode showed a higher correlation (SECV = 7.60 N ; R^2cv = 0.27) than in transmission (SECV = 8.32 N ; R^2cv = 0.22). As illustrated in Figure 2, the WBPSF tended to be underestimated in the high values and overestimated in the low values. Misumoto et al. (1991) reported R^2c of 0.64 in transmission mode and R^2c of 0.68 in reflection. Hildrum et al. (1995) observed a RMSEP of 10.8 N (Root Mean Squarred Error of Prediction) and a R^2 of 0.5 (Determination Coefficient) from NIR reflectance measurements. Byrne et al. (1997) reported a SEP of 7.75 N (Standard Error of Prediction) and a R^2 of 0.16 in reflection mode for 2 days spectra.

Conclusions

From these results, it can be concluded that the prediction of pH, CIE L*, a*, cooking loss and tenderness parameters was better from spectra on freeze-dried meat than on fresh matter. On fresh meat, color and WHC were better predicted by the reflection mode than the transmission. By contrast, the transmission showed a higher accuracy in predicting pH value. There were no significant differences between both spectral acquisition modes to estimate the WBPSF.

The NIR spectra collected on fresh meat showed good potentialities to predict CIE L* and b* parameters in reflection mode. For the others parameters, the accuracy of the predictive models seemed to be weak. The mincing of the meat sample before taking spectra could help to reduce heterogeneity. Since the regression models are not sufficiently accurate, classification techniques could be attempted.

Pertinent literature

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Table 1 Accuracy and precision of models from fresh meat in transmission and reflection modes and from freeze-dried matter in reflection – Mean ; SD (Standard Deviation) ; SECV ; R^2cv

Items	DAY 2								DAY 8					
	Reference method		Fresh meat				Freeze-dried meat		Reference method		Fresh meat			
			Reflection		Transmission		Reflection				Reflection		Transmission	
	Mean	SD	SECV	R^2cv	SECV	R^2cv	SECV	R^2cv	Mean	SD	SECV	R^2cv	SECV	R^2cv
pH	5.49	0.06	0.036	0.40	0.035	0.50	0.026	0.65	5.56	0.10	0.059	0.41	0.057	0.62
Drip loss (%)	4.6	1.3	0.99	0.35	1.11	0.32	1.02	0.32	4.6	1.3	0.87	0.55	0.96	0.48
Cooking loss (%)	31.6	2.5	2.00	0.35	2.13	0.25	1.82	0.44	30.3	2.3	1.67	0.42	1.75	0.26
CIE L* (%)	37	4.1	1.76	0.82	2.41	0.65	1.41	0.88	39	4.3	1.52	0.87	2.76	0.60
CIE a*	17.8	1.7	1.22	0.44	1.26	0.50	1.00	0.63	20.7	2.8	2.02	0.44	2.43	0.23
CIE b*	14.9	1.7	0.81	0.73	1.17	0.48	0.93	0.68	17.2	2.1	0.99	0.76	1.55	0.46
WBPSF on cooked meat (N)	51.1	12.4	9.75	0.29	9.66	0.39	8.87	0.39	40.4	10.1	7.60	0.27	8.32	0.22
WBPSF on raw meat (N)	23.6	7.1	5.72	0.20	no model		5.09	0.37	23.9	5.9	4.70	0.19	4.91	0.25

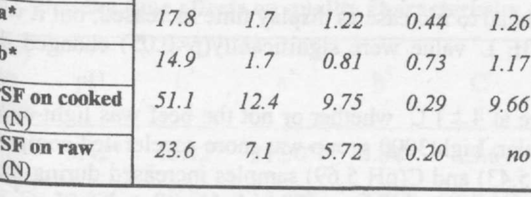

Figure 1 : Predicted *vs* measured CIE L* parameter (reflection mode, day 2, on fresh meat).

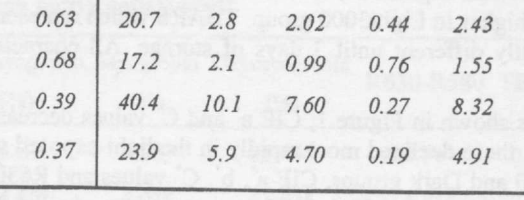

Figure 2 : Predicted *vs* measured WBPSF of cooked meat (transmission mode, day 2, on fresh meat).