NIRS analysis of different meat sample preparations from veal calves and panel test prediction

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***Abstract* — The aim of this study was to investigate the meat sample preparation methods and NIRS methodology to predict sensory scores of veal belonging to two ethnic groups and fed on different diets.**

Three preparations of *longissimus thoracis* samples, i.e., raw (RA), ethanol-prepared (ET), and freeze-dried (FD), were studied.

Thirty-two male calves, 16 Friesian (F) and 16 Crossbreeds (C), were fed milk replacer, maize silage and 65 kg/calf (L) or 100 kg/calf (H) of maize grain.

The meat analyses were: water, protein, fat, haem iron content, drip and cooking losses, colour, Warner-Bratzler shear (LAB), fatty acids profile (FA) and sensory evaluation on four attributes (Panel).

The samples were scanned by a LabSpec-Pro (ASD) portable (UV-Vis-NIRS: 350-2500 nm), the FD samples were also analysed by an electronic nose.

Chemometrics MPLS of the NIRS spectra and of LAB and FA were performed to get distance matrices between groups and prediction performances of Panel scores.

The matrices reached different R^2 levels: 0.65 (RA); 0.65 (ET); 0.62 (Panel); 0.42 (FD); 0.42 (LAB); 0.04 (FA) and 0.50 (E-nose of FD).

Clusters from NIRS of raw samples corresponded to the same pattern obtained by LAB and FA.

Prediction of Panel scores from the 32 veal calves were effective as R^2 cross-validation of ET specimens were: Visual 0.11, Flavour 0.68, Texture 0.68 and Global 0.53.

It was concluded that NIRS scan of RA samples anticipates results achieved by a wide set of laboratory analyses. NIRS analysis of ET samples exhibited strong predictive value of Panel scores.

Keywords— **NIRS analysis, sample preparations, sensory analysis.**

I. INTRODUCTION

The Near Infrared Reflectance Spectroscopy (NIRS) is a long established technology. Its development during the last four decades has opened new perspectives for a cheap, fast, and accurate quantitative and qualitative evaluation of the main organic constituents.

Apart from its rapidity, this physical technique is non-destructive, needs no chemical reagents and produces no pollutants.

NIRS is widely applied for quantitative analysis of chemical constituents, such as protein content, moisture and fats in cereals, feedstuffs and animal products.

In meat studies, NIRS investigated the main quality characteristics depending on ontogenetic, ethnic, technological and nutritional effects [1] [2].

Numerous attempts were devoted to improve the preparation, the preservation and the transport of samples by placing them in tubes containing ethanol [3] [4] [5]; furthermore, by this method the interferences due to the high water absorption bands can be reduced.

Meat researchers have long sought after non-destructive and objective techniques to predict meat quality.

The aim of this study was to investigate the ability of NIRS methodology to predict organoleptic characteristics of different preparations of veal samples from calves belonging to different ethnic groups and feeding plans.

II. MATERIALS AND METHODS

Three preparations of *longissimus thoracis* samples, i.e., raw (RA), ethanol-prepared (ET) [4], freeze-dried (FD) were studied.

Thirty-two male calves, 16 Friesian (F) and 16 Crossbreeds (C), were fed on milk replacer and maize silage; in addition they received 65 kg/calf (Low, L) or 100 kg/calf (High, H) of maize grain. The average age and weight of the animals at slaughter were 6 months and 276 kg. After slaughtering, a sample of *longissimus thoracis* was taken between the 8th T.V. and 1st L.V from the right side of each carcass.

The laboratory analyses (LAB), water, protein, fat, haem iron content, drip and cooking losses, colour, Warner-Bratzler shear, were described in previous papers [6] [7]. Besides, fatty acids profile (FA) was determined by gas chromatography [8].

A sensory evaluation of four attributes was performed and the results were pooled by 32 animals (A) and by 4 subgroups (S).

The samples were scanned by a LabSpec-Pro (ASD, Analytical Spectral Devices Inc., Boulder, CO) portable (UV-Vis-NIRS:350-2500nm). A set of 20 spectra were collected and then averaged per examination. The 2151 absorbance points of the NIRS spectra were mathematically pre-treated.

An Electronic Nose (EN) (AirSense) examined also the FD samples; the 300 points from 10 MOS sensors were aligned and treated as a spectrum. Dummy integers values for the between-4-subgroups matrices and main effects Genetic and Feeding were fitted by Modified Partial Least Squares (MPLS) method using WinISI II software, from Infrasoft International (ISI, State College, PA, USA). A cross-validation system was employed to assess the optimal number of latent variables to be included into the equations, permitting one passage for elimination of outliers (t>2.5; H>10). Chemometrics MPLS of the NIRS spectra, of EN traces and of LAB, FA and Panel scores were performed to get distance matrices between groups and prediction performances of Panel scores.

III. RESULTS AND DISCUSSION

The distance matrices showed different R^2 levels (Table 1). The classic analyses were not so efficient in differentiating among the 4 subgroups as the NIRS analysis did. The lowest reliability was reached for the FA profile (R^2=0.04). The LAB gave high resolution (0.42) and the Panel obtained the maximum (0.62). The E-nose was quite effective (0.50) but the NIRS of RA and ET showed the highest value (0.65) followed by FD (0.42). The main effects were differently appreciated by the various ensembles of variables and sample preparations.

The genetic factor clearly emerged in sensory evaluation (0.53), in E-Nose (0.63), in NIRS of RA and ET (0.60) but not in FD. The feeding factor was apparent in ET (0.64), FD (0.63), RA (0.52) and also in E-nose (0.40).

The univariate analysis of the sensory evaluation (Table 2) highlighted the importance of the genetic factor and a significant interaction GxF: in fact the subgroup HF showed high scores in Global, Visual, Flavour, and Texture preferences.

Prediction of sensory scores from the 4 Sub-groups (Table 3) was more accurate for ET specimens: Visual 0.90, Flavour 0.90, Texture 0.91 and Global 0.88. Also RA was effective.

The Animals records (A) were less effective in prediction mode, especially the visual scores. The results are in agreement with those of Masoero et al. [9] in rabbit meat, who significantly correlated panel scores to NIRS of ET: i.e. fibrousness (R^2=0.65), acceptability (0.64) and tenderness (0.56).

The clusters reported in Figure 1 show the differences between LAB (2-LC and 3-HF # 1-LF and 4-HC) and Panel (1-LF and 2-LC # 3-HF and 4-HC), a pattern which is replicated by RA, FD and ET.

E-nose distinguished the subgroup 4-HC from the others.

A recent review of Prieto et al. [10] indicates that NIRS showed high potential in predicting chemical meat properties and classifying them into quality classes. In contrast, NIRS was less effective in estimating technological and sensory attributes.

The ET preparation of muscle specimens has been particularly effective in this experiment in correlating the panel scores to NIRS of ET, according to the results of Masoero et al. [9].

In a previous experiment with cattle, Masoero et al. [11] observed a R^2=0.47 in prediction of the Panel scores from Warner-Bratzler values.

The NIRS analysis of ET samples showed similar results (R^2_{cal}=0.64; R^2_{val}=0.44). These are excellent values considering that it is not necessary to prepare the sample and the transport is very easy. Furthermore, it can observed that in a study regarding the discrimination of illegally treated veal calves by dexamethasone [12] the ethanol preparation of *longissimus lumborum* samples raised the R^2 to 0.84 in cross-validation mode.

Table 1 Multivariate R^2 PLS of the two main effects and average of the between 4-groups distance matrix

Effects	LAB	FA	Panel	RA	FD	ET	EN
Feeding	.26	.23	.00	.52	.63	.64	.40
Genetic	.15	.00	.53	.60	.12	.60	.63
Average	.42	.04	.62	.65	.42	.65	.50

Table 2 Univariate analysis of the sensory scores

Panel		Prob			Subgroups			
	SED	G	F	GxF	1-LF	2-LC	3-HF	4-HC
Global	.20	.00	.25	.02	6.43c	6.5c	6.9a	6.7b
Visual	.17	.21	.33	.05	6.50b	6.56b	6.70a	6.51b
Flavour	.24	.00	.55	.03	6.40b	6.65b	6.95a	6.8ab
Texture	.29	.00	.02	.01	6.28b	6.31b	7.04a	6.49b

Table 3 Performances of NIRS and E-nose of the 128 samples for the panel score evaluation, by repeated animal score (A, 32) or by repeated subgroups (S, 4)

Panel		SD	RA R^2cv	FD R^2cv	ET R^2cv	EN R^2cv	best RPD
Global	A	.26	.43	.23	.53	.27	1.8
	S	.19	.69	.34	.88	.69	2.9
Visual	A	.18	.32	.22	.11	.19	1.5
	S	.12	.80	.35	.90	.71	3.1
Flavour	A	.31	.44	.12	.68	.51	1.9
	S	.19	.53	.25	.90	.62	3.2
Texture	A	.40	.53	.15	.68	.38	1.9
	S	.28	.64	.35	.91	.60	3.2

RPD=Relative Predicted Deviation (Standard Deviation/Standard Error in cross-validation mode)

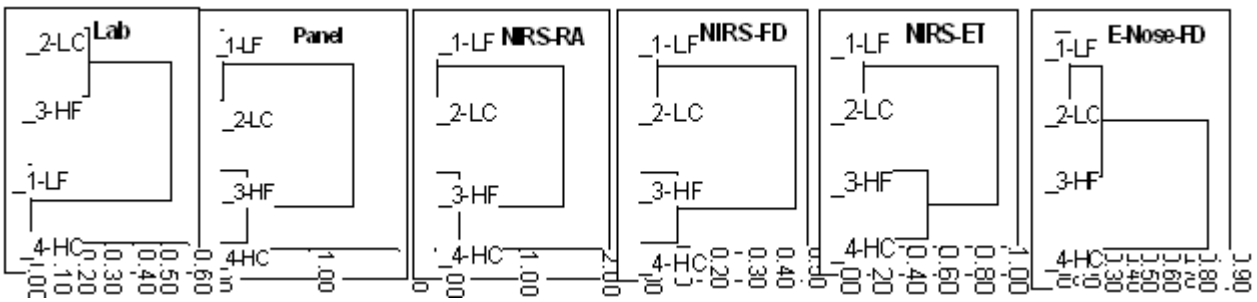

Figure 1 Average Cluster of the four groups based on the PLS matrices of distances in cross-validation mode, according to the NIRS spectra of the muscle (RA, ET, FD) and EN *vs.* the multivariate PLS of Lab and Panel

IV. CONCLUSIONS

The results of the present study confirm that NIRS scan allow to discriminate experimental groups and individuals, in many cases anticipating the multivariate differentiation of groups obtained by the laboratory analyses.

The specimens preparation by immersion in ethanol appears easy and rapid.

NIRS analysis of ethanol prepared specimens exhibits strong predictive value of Panel scores.

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