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Use of near infrared spectroscopy for assessment of beef quality traits

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ABSTRACT: Chemical and physical traits and fatty acid composition of meat samples from 148 Piemontese beef samples were predicted by near infrared spectroscopy. Coefficients of determination in calibration (R^2) ranged between 0.44 and 0.99 for chemical composition and between 0.02 and 0.98 for fatty acid (FA) profile, being in general more accurate for the major FA. The calibration results gave inaccurate prediction for cholesterol and collagen content and for most physical traits, such as Warner-Bratzler shear force, cooking loss, drip loss, colour (L, a, b) and pH.

Key words: NIRS, Meat quality, Piemontese beef cattle, Physical and chemical traits.

INTRODUCTION – Over the years, near infrared spectroscopy (NIRS) has been developed and applied in quality management of the beef meat products because it is a rapid, non-destructive and safe technique useful for simultaneous analysis. Common applications have included the quantitative prediction of chemical, textural, sensory, and physical properties of beef meat, with controversial results (Prieto *et al*., 2006, Yongliang *et al*., 2003). This study aimed to evaluate the prediction results of chemical and physical parameters, and fatty acids composition of Piemontese beef meat using NIRS technique.

MATERIAL AND METHODS – Samples of *longissimus thoracis* were collected from 148 young Piemontese bulls slaughtered in the same abattoir at 536±71 d of age with a carcass weight of 424±47 Kg. Meat samples were vacuum-packed and analysed for meat quality after a refrigeration period of 8±2 d at 4 °C. Measures of pH and color (CIE, 1976) were taken on the fresh meat samples; moisture, ether extract, ash and protein were determined according to AOAC (1984) on the freeze-dried samples. Fatty acids were determined through gas chromatographic analysis after lipid extraction (Folch *et al.,* 1957); cholesterol and collagen contents were determined according to Casiraghi *et al.* (1994) and Teerlink *et al.* (1989), respectively. Drip loss was calculated as difference between the sample weight at 24 h and that after hanging. Cooking losses and Warner-Bratzler shear force (kg/cm^2) were determined using procedures suggested by ASPA (1996). NIR spectra were obtained using a Foss NIRSystems 5000 system, with small ring cup cells on freeze-dried (FD) and fresh minced (FM) meat samples. Measurements were made in reflectance mode between 1,100 and 2,498 nm every 2 nm. The resulting spectra were stored as log (1/R) on WINISI II version 1.02 software. Calibrations were performed by modified partial least squares (MPLS) regression. To optimize calibration accuracy, the data were subjected to a variety of derivative transformations using common mathematical treatments and scatter correction treatments. Cross validation was performed during model development, whereby one-fourth of the calibration samples at a time were temporarily removed from the calibration set. The optimal number of factors (MPLS terms) for the different constituents was that which produced a minimum in overall error between modelled and reference values (standard error of cross validation).

RESULTS AND CONCLUSIONS – Summary statistics of meat quality traits are given in Table 1. Variation for all traits was enough to allow a correct calibration. Generally, chemical composition appeared consistent with the values reported for the Piemontese bulls by Russo and Preziuso (2002) and Destefanis *et al.* (2003), whereas drip loss percentages appeared higher in this study when compared to those found by Russo and Preziuso (2002) and by

Destefanis *et al*. (2003), ranging between 2.4 and 2.8, respectively. As expected, the oleic (C18:1n9ct) and palmitic (C16:0) were the main fatty acids in the meat, and accounted for nearly 50% of total fatty acid content.

Table 1. Descriptive, calibration and validation statistics for chemical composition, fatty acid content and physical properties of freeze-dried (FD) and fresh minced (FM) meat.

Traits	Mean ± SD	SEC[a]		R^{2b}		SECV[c]		1–VR[d]	
		FM	FD	FM	FD	FM	FD	FM	FD
Chemical composition, % FM									
Dry matter	25.15±1.22	0.24	0.25	0.96	0.92	0.35	0.26	0.91	0.91
Lipid	1.99±1.20	0.10	0.15	0.99	0.99	0.13	0.20	0.99	0.99
Ash	1.00±0.06	0.03	0.08	0.44	0.86	0.03	0.09	0.38	0.86
Protein	22.16±0.47	0.22	0.19	0.85	0.99	0.33	0.20	0.64	0.
Cholesterol mg/100g FM	56.33±3,20	2.61	6.73	0.18	0.58	2.90	7.90	0.01	0.43
Collagen mg/100g FM	18.43±5.30	2.70	7.48	0.56	0.74	3.05	8.52	0.44	0.67
Fatty acids, % FD									
C14:0	1.62±0.46	0.53	0.30	0.92	0.48	0.57	0.33	0.89	0.38
C15:0	0.27±0.25	0.15	0.10	0.38	0.10	0.16	0.10	0.35	0.08
C16:0	21.04±2.51	3.91	1.76	0.97	0.45	4.77	1.84	0.96	0.39
C17:0	0.69±0.14	0.23	0.11	0.91	0.29	0.24	0.11	0.90	0.22
C18:0	19.6±3.25	4.29	1.96	0.96	0.57	5.13	2.05	0.94	0.53
ΣSFA	43.44±4.46	6.97	2.35	0.98	0.67	8.15	2.46	0.97	0.64
C14:1	0.12±0.11	0.05	0.03	0.86	0.24	0.05	0.03	0.85	0.17
C16:1	1.58±0.47	0.58	0.26	0.93	0.57	0.73	0.27	0.89	0.51
C17:1	0.54±0.25	0.16	0.08	0.90	0.10	0.18	0.09	0.89	0.01
C18:1n9ct	29.08±5.11	4.89	1.29	0.98	0.92	6.06	1.80	0.97	0.83
C18:1n11tr	3.12±0.65	1.02	0.55	0.89	0.06	1.05	0.56	0.88	0.04
ΣMUFA	34.53±5.43	4.50	1.18	0.99	0.94	5.87	1.66	0.98	0.87
C18:2n6ct	11.81±4.71	3.15	1.71	0.69	0.80	3.27	1.98	0.67	0.73
C18:3n6	0.07±0.05	0.02	0.01	0.86	0.08	0.03	0.01	0.85	0.03
C18:3n3	0.37±0.15	0.18	0.10	0.59	0.15	0.19	0.10	0.56	0.13
C18:2n9t11	0.32±0.10	0.13	0.08	0.80	0.02	0.14	0.08	0.77	-0.02
C20:2	0.14±0.04	0.05	0.23	0.82	0.03	0.05	0.02	0.81	-0.04
C20:3n6	0.34±0.17	0.17	0.10	0.27	0.57	0.17	0.11	0.23	0.55
C20:4n6	1.55±1.03	0.73	0.42	0.02	0.74	0.73	0.52	-0.01	0.62
ΣPUFA	14.66±5.88	3.55	2.19	0.71	0.80	3.73	2.55	0.68	0.73
ω 6	13.76±5.79	3.43	2.18	0.66	0.79	3.63	2.54	0.62	0.72
ω 3	0.44±0.17	0.19	0.10	0.74	0.21	0.19	0.10	0.72	0.17
MUFA+PUFA/SFA	1.15±0.20	0.16	0.10	0.98	0.66	0.20	0.11	0.96	0.64
ω 3+ω 6/ΣPUFA+MUFA	0.29±0.10	0.04	0.03	0.82	0.88	0.04	0.04	0.79	0.82
Physical properties									
Shear force, kg/cm2	26.41±5.70	5.09	4.650	0.08	0.20	5.21	4.99	0.03	0.12
Cooking loss, %	23.8±3.55	1.20	1.123	0.19	0.22	1.27	1.18	0.10	0.15
Drip loss, %	3.87±1.72	3.31	3.386	0.10	0.04	3.50	3.44	0.01	0.03

[a]SEC = standard error of calibration. [b]R^2 = coefficient of determination in calibration. [c]SECV = standard error of cross validation. [d]1–VR= coefficient of determination of cross validation.

Polyunsaturated and monounsaturated fatty acids content was respectively higher and lower than those reported by Russo and Preziuso (2002) (14.66 vs. 6.14 and 29.08 vs. 49.42, respectively). The calibration and validation statistics are shown in Table 1. The determination coefficients in calibration (R^2) for chemical composition were better in the FD than in the FM meat, whereas for fatty acid the better values were evidenced in FM meat. The R^2 of FD meat ranged between 0.86 to 0.99 respectively for ash, lipid and protein. These results were similar to those reported by Prieto *et al*. (2006), but other authors found unsatisfactory correlations between the protein reference data and NIR spectra (Alomar *et al*., 2003, Cozzolino *et. al*., 2002). Conversely, calibration equation for cholesterol showed poor performance and gave unreliable prediction ($R^2 = 0.56$). Also for collagen content the prediction obtained by NIRS appeared unsatisfactory ($R^2 = 0.56$), and this is in agreement with results of others (Alomar *et al*., 2003, Prieto *et al*., 2006). The R^2 for FA composition ranged between 0.02 and 0.98 in FD meat. In general, the calibrations appeared more accurate for the major fatty acids, such as total SFA and MUFA, C16:0, C18:0, and C18:1n9ct. To this regard Berzaghi *et al*. (2005) pointed out that good relationships between spectral and chemical information for FA can be obtained with concentrations above of 0.5 g/100 g of FD. The R^2 of physical traits were very low, and this in agreement with results of other studies (Savenije *et al*., 2006). In particular, no relation was found between shear force and spectra, and this result is in contrast with data from other studies (Yongliang *et al*., 2003). In conclusion NIRS could be proposed as an adequate and rapid technology to assess chemical composition and fatty acid profile of the Piemontese meat, but not for main physical properties and for cholesterol and collagen meat contents.

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