MEASUREMENT OF COMPONENTS IN GROUND BEEF BY NEAR-INFRARED SPECTROSCOPY

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INTRODUCTION

At the moment in France, the composition of ground beef is regulated for 2 components : fat percentage and collagen percentage or more exactly, the collagen protein ratio. A French norm AFNOR NF V46.002 was created for the composition of ground beef and at present, its on-line control is a real problem for the French meat processing industry.
Conventional methods (above all chemical) exist to measure ground beef composition, but they are laborious and time-consumming, e.g. the Kjeldahl method for protein or the Soxhlet method for fat. The use of rapid and reliable method should allow a better control of ground beef composition and should improve the product quality.
The use of near-infrared for the measurements of meat components in beef or in pork has been previously reported . This study reports the test of a near-infrared (NIR) spectrophotometer, INFRATEC 1265, for the determination of moisture, fat, protein and especially collagen contents.

MATERIALS AND METHODS

Near-infrared spectrophotometer :
Measurements were made with a INFRATEC 1265, a near-infrared transmition spectrophotometer in the range 800-1100 nm. Each sample was measured 15 times. Readings were obtained for moisture, fat, protein and collagen percentage according to the calibrations previously established by the maker.

Samples :
2 groups of samples were used with different characteristics. The 1st group of 60 samples (G1) was made in the laboratory with a proportionnal mixture, from 0 to 100 %, of *biceps brachii* (rich in collagen) and of *triceps brachii caput longum* (low in collagen) in order to obtain a large range of variation in collagen content. The 2nd group of 50 samples (G2) were collected at random in serveral supermarkets.
Each sample of 150 g was homogenized in a Robot Coupe food processor. Samples were stored at 4° C until scanning. Then each sample was frozen until chemical analysis.
Reference methods :
After scanning, in order to compare NIR and chemical results, each sample was analysed according to standard method (AFNOR-1987) : Water content, 3 analysises by sample (norm NF V04.401) - Fat content, 3 analysises by sample (norm NF V04.403) - Protein content, 3 analysises by sample (norm NF V04.407) - Collagen content, 4 analysises by sample (Bonnet et Kopp - 1986). This method is based on colorimetric measurements of hydroxyproline.

Statistical processing of the results :
Data were analysed with SAS (1988) by linear regression in order to calculate the determination coefficient (R2) and the residual standard deviation (RSD). For each sample, the result of chemical analysis for each component was represented by the average of the analysises. It was possible to calculate the standard error linked to the chemical analysises.

RESULTS

Chemical results from standard methods are displayed in Table 1 for the 2 groups of samples. G1 showed a large range of collagen content, i.e. from 0.72 to 3.42 %,but the range of fat was relatively low. Conversely, G2 showed large ranges for each component. from 1.4 to 16.7 % of fat, from 17.7 to 22.31 % of protein and from 1.21 to 4.46 % of collagen.
The results of linear regression between NIR measurements and chemicals measurements for respectively the 1st and the 2nd group are displayed in Table 2.
For the group G1, R2 values were satisfactory for fat (R2=0.79) and collagen (R2=0.90). Errors of prediction were 0.16 for fat and 0.22 for collagen. RSD values were equal to standard deviations of chemical analysis.Concerning moisture and proteins, R2 values were very low, these could be explained by a low variation range of these 2 components.
For the group G2, R2 values were better than previously, 0.96 for moisture, 0.98 for fat and 0.82 for protein. These better results could be explained by the characteristics of the samples which had a larger variation range for each component. Concerning the errors of prediction, they are 0.58 for moisture, 0.60 for fat and 0.42 for proteins. For the collagen, the R2 values were lightly lower than previously (R2=0.76). It was the same for the error of prediction. One more time, the errors of prediciton were similar to standard deviations of chemical analysis.

CONCLUSION

These good results confirmed results previously reported by the bibliography. Except for the results for collagen, the best results were obtained with the group G2 because of a large variation range of each component. Perhaps, the NIR measurement of collagen was not specific enough in comparison to the other variation factors of composition, and then if the factors of variation were reduced, the results were better.Even if the range of collagen for G2 was similar with G1, R2 values and RSD values were lower in case of G2.

In case of group G1, where the samples were only made with only 2 muscles with a low variation of fat content, R2 and RSD values were better than with the group G2 where the samples were made with several different muscles with a large variation of fat content.

Concerning the errors of prediction from NIR measurements, they depended on the precision of this method but especially on the precision of standard methods. Because of the heterogeneousness of the products, the precision of chemical methods was limited. This is illustrated in Table 3. If R2 and RSD values calculated from one chemical analysis of collagen were compared with R2 and RSD values calculated from 4 chemical analysises of collagen, then R2 and RSD values were better with the average of 4 chemical analysis. Perhaps, if the number of chemical analysises was increased, the results could be more accurate.

In conclusion, the precision of NIR measurements are closely comparable with the precision of standard methods for each component. Moreover, INFRATEC measurements present many practical advantages for on line controls of ground beef composition. This technique is rapid, simple to use and allows the determination of components with only one measurement.
INFRATEC could allow French industrials to measure moisture, fat, protein and collagen contents at different stages of the ground beef process.

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REFERENCES :

AFNOR, CTSCCV - 1987. Recueil de normes françaises : contrôle de la qualité des produits de charcuterie salaisons et conserves de viandes. Ed. AFNOR.
ANDERSEN J. R., BORGGAARD C., NIELSEN T., BARTON-GADE P. A. - 1993. Early detection of meat quality characteristics : the danish situation. 39ème congrès des chercheurs en viande, Calgary (Canada).
BONNET M., KOPP J. - 1985. Détermination rapide de la composition de la viande (eau, lipides, protéines) par spectrophotométrie dans le proche infrarouge. Bull. Tech. C.R.V.Z. Theix, 60, pp 25-30.
CARTIER P. - 1991. Maîtrise de la qualité chimique du haché industriel : possibilités et limites du contrôle par échantillonnage. Rapport d'études INTERBEV. Ed. CIV.
OH E. K., GROBKLAUS D. - 1995. Measurement of the components in meat patties by near infrared reflectance spectroscopy. Meat Sci., 41, pp 157-162.
SAS institute Inc. - 1988. SAS/STAT user's guide, release 6.03 edition. SAS Institute Inc., Cary, NC, USA

TABLE 1

	G1 - Group of samples prepared at the laboratory			G2 - Group of samples from supermarkets		
%	Mean	SD	Range	Mean	SD	Range
Moisture	74.36	0.48	73.23 - 75.36	69.21	3.32	63.36 - 75.54
Fat	2.98	0.36	2.22 - 3.65	9.22	4.37	1.40 - 16.70
Protein	20.39	0.33	19.78 - 21.14	20.14	1.00	17.70 - 22.31
Collagen	1.98	0.72	0.72 - 3.42	2.49	0.65	1.21 - 4.46

SD : Standard Deviation

TABLE 2

	G1			G2		
%	R2	RSD	SD chemical analysis	R2	RSD	SD chemical analysis
Moisture	0.20	0.43	0.30	0.96	0.58	0.46
Fat	0.79	0.16	0.19	0.98	0.60	0.51
Protein	0.10	0.31	0.34	0.82	0.42	0.69
Collagen	0.90	0.22	0.16	0.76	0.27	0.21

RSD : Residual Standard Deviation

	R2	RSD
Analysis 1	0.62	0.35
Analysis 2	0.73	0.30
Analysis 3	0.67	0.34
Analysis 4	0.72	0.33
Average from 4 analysis	0.76	0.27

TABLE 3 : Comparison for collagen of R2 between NIR measurements and chemical analysises one by one, and their mean.