INVESTIGATION OF RABBIT CARCASS COMPOSITION AND EXPERIMENTAL EFFECTS BY NIRS OF DRIED MUSCLE

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SUMMARY

The NIR spectra of the meat products are representative of a widerange of substances. The aims of this experiment were to investigatethe ontogenetic relationships of the NIR spectrum of the musculartissue with meatiness and fatness of the carcass and also to perceivechemical modifications caused by experimental effects, i.e. afterclenbuterol treatment. In 55 meat rabbits aged 86.6 ± 3.7 days andweighing 2440 ± 336 grams the NIR spectra of freeze-dried integer andhomogenized longissimus dorsi lumborum (LD) and homogenized hindlegmuscles (HL) dried by two freeze-dryers, were calibrated andcross-validated to meatiness traits by removing few outliers. Themeat/bone ratio of the hindleg was calibrated with R^2c 0.77 and 0.60,and cross-validated with R^2cv 0.40 and 0.33 respectively from LD andHL, while the bone percentage was fitted with R^2c 0.62 and 0.58, andR^2cv 0.23 and 0.40 . Other tissues and correlative traits were fittedwith similar or less accuracy, except the fatness (R^2c 0.7-0.9). Theability of the NIRS to discriminate individual clenbuterol treated (1ppm) vs untreated was demonstrated by a R^2c 0.91 and R^2cv 0.75 from LDand 0.86 and 0.72 from HL. The muscle origin was fitted with R^2cv 0.97.The tool had power to investigate together chemical and ontogeneticrelationships.

Introduction

The Near Infrared Reflected or Transmitted Spectra of the meatproducts are representative of a wide range of substances: minerals ,moisture, fat, protein and collagen (Chevalier et al., 1990). After afirst direct endeavour to calibrate many rabbit's traits from the skinof living rabbits (Masoero et al. 1992) it was attempted anunconventional use of the NIRS: not as direct analytical instrument butas indirect tool to perceive some fixed experimental effects and bodycomposition. A quick developement of cooperative researches involving458 freeze-dried muscles from 338 animals (preliminarily reported inMasoero et al., 1994) advanced knowledges in rabbits experiments. Thistrial was conducted to evaluate the correlativity of NIR spectra with:i) the ontogenetic relationships of meatiness and fatness , and: ii)the discrimination of beta-adrenergic agonists (BAA) treated fromuntreated individuals, by perceiving chemical as well as inducedontogenetic modifications.

Materials and methods

Fifty-five albino rabbits were reared in single wired cages since43 to 81 days being fed with a commercial diet (156 g/kg crude protein,156 g/kg fiber). Five groups of rabbits were constituted and fedrespectively: 1) ad libitum untreated; 2) restricted untreated; 3)restricted and treated with Clenbuterol (SIGMA C-5423) at 1 ppm; 4)restricted and treated with genystein at 20 ppm ; 5) restricted andtreated with 100 ppm of Trifolium mediterraneum extract: the withdrawlasted 5-6 days. The groups 1,2,4,5 were pooled as untreated (UNT) vsthe group 3 (BAA). On the 43th day of the study, animals weresubmitted to ultrasound scan by a Dynamic mod. Concept 500 device overthe hair cut loin to measure the deep of LD at the points 10, 35 and 60mm from the hip's tip; then they were stunned and killed by cervicaldislocation and exsanguination. The carcass was refrigerated at +4 C° for 20 hours, then submitted to hindleg dissection (Blasco et al.,1993); two longitudinal samples of 20 g each of LD alternatively freezedried intact or previously homogenized for 6" were obtained. Carcassanalysis involved separation of the humerus and dissection of thehindleg as muscle, bone (femur and tibia) and other tissues. Themuscles of the hindleg were homogenized for 30", then two samples ofeach were submitted to two different freeze-dryers, workingrespectively from -47 to +45 C° during 72 hours, as for LD, and from-40 to +20 C° overnight. The freeze-dried muscles (LD and HL) wereground for 20" in a domestic

coffee-mill. The weight of water in themuscles was estimated by loss after the longest freeze drying. Afterstabilization of residual moisture oven drying overnight at +40 C° thesamples were then submitted to a NIRSystems 4500 Model in a rotatingcup. The spectra from 1300 to 2400 nm were mathematically transformed(as 1,4,4,1 of log 1/R), then fitted to the laboratory values or to aconventional dummy variables (1 or 2 for BAA treatment discrimination)by the standard NIRS-2 (ver. 2.05) software . The chief chemometricmethod used was the Modified Partial Least Squares (PLS), whileMultilinear Regression (MLR) was also adapted to identify some relevantwavelengths. The limits for rejection of extraneous observations werefixed at t>2.4 (regression) and H of Mahalanobis > 7 (spectral distancefrom gravity centre). Only one passage was allowed in the datasets forremoving few outliers. The internal cross-validation was performed bysix groups.

Statistical Analysis of the data was performed by the SAS (1985) GLMprocedure with a monofactorial multivariate linear full model including29 variables, fitted to BAA (as dummy value 2) or UNT(=1) values. By astepwise multilinear regression model the most significant variables
($P<0.15$) were identified.

The i.m. fat and the protein contents of LD, on d.m. basis, werepredicted by NIRS using two previous unpublished PLS equations (R^2cv0.97 and 0.96 ; SEP 0.63 and 0.93%), obtained in similar 40 samples ofLD removed of aponevrosis, homogenized, then freeze-dried 72 hours.

Results and discussion

The table 1 reports the clear effects of the BAA treatment on thebody composition. The dressing percentage was largely increased,mainly because a strong reduction of the skin, which included thesubcutaneous fat layer. The skeleton was insignificantly affected,according to a general rule well assessed on a between species basis,while major modifications involved muscles and other tissues (fat plustendons): the net result was a significant raising of 8% in themuscle/bone ratio of the hindleg. A strong fat reduction (-40 to -44%)occurred in the hindleg region (intermuscular fat plus tendons) and inthe carcass depots; the i.m. fat contents of LD was also reduced(-19%). Water contents of LD was significantly increased according toa parallel raising of the protein while in the HL the water increasewas more pronounced: this fact can explain observed higher coolinglosses.

Ability of the NIRS to be related with ontogeny (table 1) wasverified for meatiness and fatness. Muscle/bone ratio of the hindlegwas predicted with R^2c 0.77 and 0.60 from LD and HL, but decreased toR^2cv 0.40 and 0.33; one reason was an appreciable NIRS evaluation ofthe strongly correlated bone percentage ($r=-0.976$). The musclepercentage was already moderately calibrated only in LD, but not in HL.This correlativity of the NIRS with some skeleton components alsorecurred in previous experiments with 338 rabbits (Masoero et al.,1994). The fatness of the carcass was clearly identified by NIRSmethod, especially from HL, but it did not appear to be responsible ofthe possibility of estimation of meatiness because independency of thetwo traits.

The table 2 evidences the covariation of all the characters in thediscrimination of the individual BAA treated. When all the 29variables were fitted to 52 complete objects, 85% of the variance wasexplained, but a selected set of 12 variables (the most representativebeing skin, muscle percentage and water concentration in HL)accounted for 83% . The NIRS direct discrimination of the treatment wasmaximum from LD (R^2c= 0.91) and it was also high from HL (0.86); thesechemometric relationships were quite stable, having cross-validationR^2cv values of 0.75 or 0.72. The role of specific wavelengths involvedin the BAA treatment discrimination did not show any accounting formore than 38% (1728 nm in HL), but the pattern between muscles wasdifferent. Furthermore, the first vibration disappeared after theovertones: this is typical of NIR analyzed by MLRegression, but PLSmethod can linearly capitalize all significant spectral variationsavoiding overfitting. Nevertheless we tried useful information aboutsome specified wawelengths which were able to resume a significant partof spectral covariance with traits, i.e.: the 1848 in LD and the 1708in HL which explained respectively 30% and 48% of the variation in theskin percentage, and 48% and 75% of the variation in water contents ofhindleg muscles. This last finding is interesting because the originalmoisture was almost entirely removed before NIRS processing anddiseappeared from spectra, thus it supports the hypothesis of anontogenetic relationship. Other components of the fibres (for LD), orof the whole region of muscles (from epimisium, aponevrosis and tendonsfor HL) not analyzed in this experiment could have been determinated ina down to up investigation which limits are a priori fixed at an highlevel because strong discriminability of different ontogenetic status.

Previous (unpublished) knowledges about a strong spectral distinctionof muscle types were dramatically confirmed in this experiment becausethe PLS distinction of LD from HL muscles raised a probability of 98%by

PLS method, and the most implicated wavelengths were the 1818 nm,which oneself resumed 84%, and the jointed 2038 and 1338 nm whichexplained 92% of the differences.

Conclusions

The NIR spectroscopy of dried muscles may be interesting not only forscientific, but also for production purposes. Discrimination ofdrastic ontogenetic and chemical modifications may be an indirect toolto guarantee the stability of sure meats, while future (and also past"freeze-stocked") experiments ougth to include spectroscopic NIR study,which can be very easily expanded at low cost. If the NIR spectroscopyis of informative or of really predictive value it will be recognizedby other combined researches.

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