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# PROTEIN, FAT AND MOISTURE CONTENT OF RETAIL CUTS OF RABBIT MEAT EVALUATED WITH THE NIRS METHODOLOGY

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**Abstract:** Thirty commercial rabbit carcasses weighting 836-1413 g were sealed in the Spanish market and were retailed according to the WRSA norms to obtain four parts: fore legs, thoracic cage, loin and hind part. The loin was separated into abdominal walls, *Longissimus dorsi* (LD) muscles and spine cut; hind legs and sacrum were separated from the hind part. Each joint was carefully dissected to separate edible meat from bone. Meat of each of the 210 samples (180 from joints and 30 representing meat from the whole carcass) was ground and was scanned by NIRS reflectance in quadruplicate; the four spectra from each sample were averaged. 36 samples were selected according to spectra characteristics and chemically analysed for crude protein, crude fat and moisture content and then used for re-calculating some previously obtained equations of calibration. With the new equations, the chemical composition of the 174 samples not analysed was determined. Meat from the fore legs had 20.2% of protein, 7.4% of fat and 71.2% of moisture; thoracic cage meat had 18.7%, 12.8% and 66.9% respectively; LD muscle: 22.1%, 1.2% and 75.6%; abdominal walls 20.9%, 7.6% and 70.1%; spine meat: 20.7%, 7.9% and 70.0%; hind leg meat: 21.2%, 3.0% and 74.7%; meat from the whole carcass: 20.8%, 7.1% and 71.2%. Correlation analysis indicates that meat from the fore leg is a good predictor of the chemical composition of the whole carcass meat (r = 0.82 for crude protein, r = 0.92 for crude fat and r = 0.95 for moisture).

**Key words:** chemical composition, meat, rabbit, NIRS.

## INTRODUCTION

Rabbit meat is usually considered as low fat meat compared with red meats (Dalle Zotte, 2002). However, information available from chemical composition of rabbit meat is extremely variable, lipid composition ranging from 3.6% (Ouhayoun *et al.*, 1981) to 8% (Altmann and Dettmer, 1986). Even in official Spanish publications aimed at nutritional specialists, values of 5.2% of lipids (Ministerio de Sanidad y

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CONSUMO, 1999) or 7.6% (MAPA, 2001) are found. This could be due to the study of different parts of the carcass in the different investigations. Chemical meat composition is studied in the *Longissimus dorsi* (LD) muscle, where colour (PLA *et al.*, 1995), collagen (OUHAYOUN and DALLE ZOTTE, 1996), texture (COMBES *et al.*, 2001) and sensorial analysis (JEHL and JUIN, 2001) are often measured. In other cases the meat comes from the dissection of the hind leg, previously dissected to estimate the meat to bone ratio of the carcass. Moreover, carcasses analysed could be from animals of different weight and age (OUHAYOUN and DELMAS, 1989), breed (PLA *et al.*, 1998), sex or degree of maturity (PILES *et al.*, 2000).

Chemical composition of each part of the carcass has not been studied hitherto. Besides, it would be interesting to predict chemical composition of the whole carcass from results of partial dissection, so these are the objectives of the present study.

## MATERIALS AND METHODS

Thirty rabbit carcasses were acquired in 7 of the main food chain stores in Spain. Carcasses ranged between 800 and 1400 g, including head, liver and kidneys, thoracic viscera and a small part of the tarsus in the hind legs, which is left in the carcass after slaughter to facilitate the slaughter tasks. All these parts of the carcasses were separated in order to obtain the reference carcasses. Carcasses were dissected according to WRSA norms. After separating the dissectible fat (perirenal, scapular and inguinal deposits) carcasses were cut up to obtain the technological joints: fore legs, thoracic cage, loin part and hind part (BLASCO and OUHAYOUN, 1996). Also, from the loin part, abdominal walls and LD muscles were separated and the remaining portion was called “spine”. The hind part was cut up to separate the hind legs from the sacrum (*Os sacrum* and first *caudal vertebrae*).

Each joint obtained was carefully dissected in order to separate bone from meat. Bone includes cartilage and small portions of meat between vertebra, ribs, kneecaps and other parts not easily removable by dissection, equivalent to those pieces of

meat not easily removable when meat is eaten by the consumer. Meat includes intermuscular fat and tendons. Meat obtained from each portion was homogenised by a domestic mincer, and the 180 samples of meat (six samples from each animal) were scanned between 1100 and 2498 nm with a monochromator (model 5000, NIRSystem INC., Silver Spring, MD, USA) equipped with a transport module. Two sample round cups with quartz windows of 3.8 cm of diameter were filled from each sample and two spectra, rotating 90 degrees each cup were recorded. For each carcass half of the meat of each retail cut and half of its fat deposits were homogenised to estimate composition of the meat of the whole carcass and was scanned as above. Four reflectance spectra of each sample were averaged and used to evaluate the protein, lipids and moisture content.

Thirty-six of the 210 samples were selected based on their spectral properties using the programs CENTER and SELECT of the WINISI v 1.04 software (Intrasoft International, LLC) and sent for reference analysis of moisture, ether extract and nitrogen (AOAC, 1984). A new calibration was obtained with these spectra, together with other 97 used in a previous calibration in our laboratory. Multivariate regression equations were obtained by modified partial least squares (MPLS) using the mathematic treatments 0, 0, 1, 1; 1, 4, 4, 1 and 2, 5, 5, 1 with and without SNV and Detrend and the best equations were selected attending to: determination coefficient of cross-validation ($r^2$), RPD= SD/SECV and RER= Range/SECV, SD being the standard deviation and SECV the standard error of cross-validation.

The new equations were applied to the 174 samples not analysed to estimate the protein, total lipids and moisture content. On the total of the 210 samples, basic statistics and correlations were estimated by the PROC MEAN and PROC CORR of the statistical package SAS (SAS, 1997).

## RESULTS AND DISCUSSION

Table 1 shows the carcass traits. The head represents 9% of the commercial

carcass, which is a lower value than of the 10.1% found by OUHAYOUN (1989) in commercial carcasses of 1285 g of weight. It is difficult to explain this difference since those animals were 10 weeks old and the head is an early-growth organ. The percentage of thoracic viscera that represents 2.4% of the commercial carcass, a higher percentage than the 1.9% obtained by OUHAYOUN (1989), whereas the value for liver and kidneys (5.8 and 1.2%, respectively) is lower than the 8.6% found in the French carcasses. The liver weight was notably lower than that found in previous works (PLA and CERVERA, 1997) bred in similar conditions, but in some cases liver is presented separately packaged and could be incomplete, therefore this could explain some of the low values and large variability found in the weight of this organ. This lower percentage of liver in the commercial carcass might explain why the percentage of reference carcass respect to the commercial carcass (81.7%) was slightly higher

**Table 1**: Carcass traits weight (g) of commercial rabbits in Spain (n=30).

| | Mean | SD | Range | CVx100 |
|---|---|---|---|---|
| Chilled Carcass | 1031 | 137 | 836-1413 | 13.3 |
| Head | 93 | 37 | 83-107 | 39.8 |
| Liver | 60 | 19 | 29-103 | 31.7 |
| Kidney | 12.3 | 2.2 | 9.0-19.5 | 17.9 |
| Thoracic Viscera | 25.0 | 3.6 | 19.0-35.0 | 14.4 |
| Reference Carcass | 842 | 118 | 664-1194 | 14.0 |
| Inguinal Fat | 4.3 | 3.8 | 0.0-16.5 | 88.4 |
| Scapular Fat | 3.7 | 2.3 | 0.0-9.4 | 62.2 |
| Perirenal Fat | 13.2 | 8.5 | 2.0-40.0 | 64.4 |
| Fore Leg | 141 | 16 | 111-185 | 11.4 |
| Thoracic Cage | 97 | 15 | 76-138 | 15.5 |
| Loin | 259 | 41 | 199-388 | 15.8 |
| Hind Part | 321 | 39 | 263-435 | 12.2 |

SD: standard deviation, CV: coefficient of variation.

than the 79.3% found in French commercial carcasses (OUHAYOUN, 1989), the 79.7% in Italian carcasses (NIZZA *et al*., 2001) or the 79.0% in Polish carcasses (RESTELLI and TANGORRA, 2001).

Dissectible fat percentage with respect to the reference carcass was 2.5%. The large variability in dissectible fat content of the carcasses stands out (Table 1), especially the inguinal deposit. However this deposit is frequently removed together with the skin in a variable proportion after slaughter. Perhaps a harmonisation of the criteria would help to compare results in future works, with previous complete removal of fat deposits, and including them not as a part of the carcass but as a part of the skin.

Retail cuts are less variable (Table 1). Retail cuts percentages obtained with respect to the reference carcass were 16.8% for the foreleg, 11.6% for the thoracic cage, 30.9% for the loin part and 38.2% for the hind part. These results agree with those found in works previously carried out in our laboratory (PLA and CERVERA, 1997; PLA *et al.*, 1998).

The parameters corresponding to equations of NIR calibration for rabbit meat are shown in table 2. For crude fat and moisture $r^2$ is greater than 0.90 indicating excellent quantitative information (SHENK and WESTERHAUS, 1996). Moreover, RPD is higher than 3 and RER is higher than 10, indicating that these equations are good predictors.

For crude protein the value of $r^2$ is 0.76 and indicates good quantitative information (SHENK and WESTERHAUS, 1996), while the value of RPD lesser than 3 could be a consequence of the narrow range of variation of this variable. A RER index near to 10 indicates that the equation is capable of predicting with accuracy near to one tenth of the range that could be acceptable for this application (WILLIAMS and SOBERING, 1996).

Accuracies for predicting fat, moisture and protein, are better than those found

in previous works (PLA, 1996) using a filter instrument. Prediction for fat is only a little worse, but prediction of protein is more accurate than those obtained on freeze-dried meat (MASOERO *et al.*, 1994).

The chemical composition of the meat is shown in table 3 and evidences great differences among portions as DOORNENBALL (1971) found in pigs and PRYOR and WARREN (1973) found in sheep. Percentage of fat in the LD (1.2%) is very low when comparing with the other portions studied, because this is the leanest muscle of the carcass and the only fat considered was the intramuscular. This value is higher than those obtained in other experiments (PLA *et al.*, 1996); but smaller than that found in chicken breast meat (RABOT *et al.*, 1996). On the other hand, the fattiest portion is the thoracic cage, which includes the neck, with very important intermuscular fat deposits.

The protein content of the fresh meat is similar in the main retail cuts and is lower only in the thoracic cage because of its higher fat content. The present values are similar to those found in previous works or in those for other groups (METZGER *et al.*, 2003).

Rabbit meat is considered as a lean meat (OUHAYOUN, 1992) and its fat percentage (7 %) is very small compared with other meats such as pork, beef or lamb (ENSER *et al.*, 1996) but higher than is commonly considered for rabbit meat. It is unusual to completely dissect the different parts of the carcass and to analyse the meat. For

**Table 2**: Statistical parameters of the equations of NIR calibration corresponding to chemical components of rabbit meat

| Parameter | N | Min-Max | SD | SECV | $r^2$ | RPD | RER |
|---|---|---|---|---|---|---|---|
| Crude Protein | 128 | 17.9-23.5 | 0.97 | 0.61 | 0.76 | 1.61 | 9.31 |
| Crude Fat | 116 | 0.33-14.6 | 2.87 | 0.49 | 0.98 | 5.91 | 29.42 |
| Moisture | 132 | 63.6-76.8 | 2.66 | 0.52 | 0.98 | 5.14 | 25.39 |

N: number of samples, SD: standard deviation, SECV: standard error of cross validation, $r^2$: coefficient of determination of cross-validation, RPD: SD / SECV, RER: range / SECV.

**Table 3:** Chemical components (g / 100 g edible meat) of edible meat of different carcass portions and of the whole reference carcass (RC) (n=30).

| | g /100g RCW | g edible meat /100 g part | | Mean | SD | Min-Max | CVx100 |
|---|---|---|---|---|---|---|---|
| Fore legs | 16.85 | 80.6 | Crude protein | 20.15 | 0.72 | 18.98-22.01 | 3.6 |
| | | | Crude fat | 7.43 | 2.76 | 3.12-13.81 | 37.2 |
| | | | Moisture | 71.23 | 3.23 | 63.94-76.90 | 4.5 |
| Thoracic cage | 11.64 | 51.5 | Crude protein | 18.69 | 1.19 | 16.04-20.8 | 6.4 |
| | | | Crude fat | 12.82 | 4.97 | 4.90-22.25 | 38.8 |
| | | | Moisture | 66.86 | 4.88 | 56.96-76.06 | 7.3 |
| LD muscle | 11.53 | 100.0 | Crude protein | 22.10 | 0.59 | 20.76-22.99 | 2.7 |
| | | | Crude fat | 1.20 | 0.36 | 0.62-1.94 | 30.0 |
| | | | Moisture | 75.63 | 0.89 | 73.81-77.86 | 1.2 |
| Abdominal walls | 6.63 | 100.0 | Crude protein | 20.91 | 0.75 | 19.46-22.60 | 3.6 |
| | | | Crude fat | 7.56 | 3.84 | 2.21-19.65 | 5.1 |
| | | | Moisture | 70.13 | 4.38 | 57.18-76.95 | 6.2 |
| Spine portion | 12.63 | 52.1 | Crude protein | 20.68 | 0.69 | 18.99-22.21 | 3.4 |
| | | | Crude fat | 7.93 | 4.33 | 2.02-23.24 | 54.6 |
| | | | Moisture | 70.03 | 4.68 | 53.59-77.04 | 6.7 |
| Hind leg | 35.77 | 83.0 | Crude protein | 21.24 | 0.49 | 20.38-22.47 | 2.3 |
| | | | Crude fat | 3.03 | 1.01 | 1.32-6.10 | 33.3 |
| | | | Moisture | 74.66 | 1.28 | 71.85-76.96 | 1.7 |
| Whole RC | | 77.9 | Crude protein | 20.78 | 0.51 | 19.73-21.89 | 2.5 |
| | | | Crude fat | 7.09 | 2.82 | 2.01-13.27 | 39.8 |
| | | | Moisture | 71.18 | 3.06 | 64.36-76.78 | 4.3 |

RCW: reference carcass weight, LD: Longissimus dorsi, SD: standard deviation, CV: coefficient of variation.

**Table 4:** Coefficients of correlation between chemical components of meat of different portions and the whole carcass.

| | Crude protein | Crude fat | Moisture |
|---|---|---|---|
| Fore leg | 0.82 | 0.92 | 0.95 |
| Thoracic cage | 0.49 | 0.84 | 0.87 |
| LD muscle | 0.58 | 0.82 | 0.78 |
| Abdominal wall | 0.68 | 0.84 | 0.88 |
| Spine portion | 0.66 | 0.88 | 0.91 |
| Hind leg | 0.66 | 0.86 | 0.92 |

example, PLA *et al.* (1996) did not dissect the thoracic cage or the spine. So the values for the chemical composition of meat of the whole reference carcass are not usually referenced.

As table 3 shows, the chemical composition of meat of the fore leg is very similar to those of the whole reference carcass. The correlation coefficients for the chemical components between the different portions and the reference carcass (Table 4) are very high for the fore leg and are near to 1 in case of crude fat and moisture. As a consequence the chemical composition of meat of the dissected fore leg is a good predictor of the chemical composition of the meat of the whole carcass. This chemical composition could be estimate from the equations of prediction shown in Table 5. As expected, prediction was very good.

**Table 5**: Prediction of the percentage of crude protein, crude fat and moisture in the carcass of the rabbit from the chemical composition of the fore leg.

| | Intercept | Slope | $r^2$ | RSD |
|---|---|---|---|---|
| Crude protein | 8.995 | 0.585 | 0.67 | 0.303 |
| Crude fat | 0.111 | 0.939 | 0.85 | 1.128 |
| Moisture | 7.400 | 0.895 | 0.90 | 1.015 |

$r^2$ = coefficient of determination; RSD = standard deviation of the residuals.

As a conclusion, a dissection of the fore leg, that is relatively easy, and the analysis of this meat, could be used in the future for characterise the meat of the whole carcass.

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