# *IN VIVO* RABBIT CARCASS COMPOSITION AND *LONGISSIMUS DORSI* MUSCLE VOLUME PREDICTION BY REAL TIME ULTRASONOGRAPHY

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## ABSTRACT

The real-time ultrasonography (RTU) was used to measure *in vivo* the *Longissimus dorsi muscle* (LM) volume and to predict carcass composition of 63 New Zealand White X Californian rabbits. Animals were scanned between $6^{th}$ and $7^{th}$ lumbar vertebrae with RTU equipment with a 7.5 MHz probe, then weighed and slaughtered. Chilled carcass and reference carcass weight (RCW) were recorded and carcass dissected into meat, bone and total dissectible fat. The LM volume measured by *in vivo* RTU (LMVU) was calculated by multiplying the LM area obtained *in vivo* by RTU between the $6^{th}$ and $7^{th}$ lumbar vertebrae by the loin length measured on live animals by palpation on bone anatomical basis of the end points. Equivalent measurements to those taken *in vivo* were obtained on the carcass and the LM volume was measured using a digital image analysis (LMVC) and directly in loin LM muscle by Archimedes principle (LMVAr). Single regression equations were used for the estimation of carcass composition and LM volume (LMVC and LMVAr) using the LMVU measurement as independent variable. The carcass and *in vivo* measurements were also compared by ANOVA. The live weight varied from 1200 to 3410 g (average 2093 g) and the RCW from 472 g to 1773 g (average 997 g). Bone and total dissectible fat represented 78.0, 16.4 and 5.5% RCW, respectively. The LM measurements in carcass and *in vivo* by RTU were not significantly different for LM area and LM volume (LMVC). The LMVAr (57.4 $cm^3$) was lower ($P<0.05$) than LMVC (64.5 $cm^3$) and LMVU (65.5 $cm^3$). Carcass and *in vivo* loin lengths differed significantly, being the carcass lower (11.2 cm; $P<0.05$) than the *in vivo* measurement (12.4 cm). Regression equations showed a strong relationship ($P<0.001$) between LMVU and the correspondent volume in carcass ($r^2=0.811$ and 0.796 for LMVC and LMVAr, respectively). LMVU was also useful in predicting the amounts of carcass tissues ($r^2=0.801$, 0.718 and 0.414 for meat, bone and total dissectible fat weight). Lower determination coefficients were obtained between LMVU and carcass tissues expressed in percentage of RCW ($r^2$ from 0.003, $P>0.05$ to 0.329, $P<0.001$). In conclusion, carcass LM volume may be predicted from the loin length and LM area measurement obtained *in vivo* from a RTU scan between the $6^{th}$ and the $7^{th}$ lumbar vertebrae, and the amount of carcass tissues can be predicted from LM volume measured *in vivo* by RTU.

**Key words**: Real time ultrasonography, Carcass, *Longissimus dorsi* volume, Rabbit.

## INTRODUCTION

In animal science information about carcass or body composition is an important tool for studies of nutrition, physiology and genetics. Body composition or the carcass traits are usually determined by comparative slaughter followed by chemical analysis or dissecting and weighing the body tissues (Fuller *et al.*, 1994). These procedures are expensive, laborious and destructive (*i.e.* an animal can be used only once). The use of *in vivo* techniques to predict carcass or body composition is a common approach in animal science to overcome these difficulties (Szabo *et al.*, 1999). The real time ultrasonography (RTU) is one of the most widely used techniques for *in vivo* prediction of carcass or body composition in cattle, swine, sheep or goat (Stouffer, 2004). Some reports have also shown the ability of this technique for the evaluation of does body composition (Pascual *et al.*, 2000; Quevedo *et al.*, 2005; Cardinali *et al.*, 2007). However, the application of RTU for rabbit carcasses evaluation is rare and little information is available on the ability of this technique in describing carcass traits of rabbits. Thus, the objectives of the current work were to evaluate the *in vivo* RTU measurements in assessing loin *Longissimus dorsi* (LM) muscle volume and to predict the carcass composition of rabbits.

## MATERIALS AND METHODS

### Animals and management

This experiment took place in the experimental facilities of the University of Trás-os-Montes and Alto Douro (Department of Animal Science). Sixty three rabbits (New Zealand White X Californian) were appraised for carcass composition, RTU and carcass measurements. After weaning (5 weeks of age) they were fed *ad libitum* with a commercial pellet diet (crude protein, 16.3%; ether extract, 3.3%; neutral detergent fibre, 32.3% and ash, 10.5% on dry matter basis) and had free access to water. The rabbits were housed in pens (12 rabbits/$m^2$) on deep litter in an air-conditioned closed building with temperature and light provided to simulate light and temperature schedule in commercial conditions.

### Live and carcass traits

Animals were slaughtered between 70 and 90 days of age and live weight (LW) was recorded without prior fasting. After slaughter chilled carcass weight (CCW) and reference carcass weight (RCW) (Blasco and Ouhayoun, 1996) were obtained. The reference carcass was cut in technological joints (fore leg, thoracic cage, loin and hind part) according to Blasco and Ouhayoun (1996). All the joints were dissected, and meat weight (MW), bone weight (BW) and total dissectible fat weight (TDF) were obtained.

### Loin area and length measurements *in vivo* by RTU

Prior to slaughter rabbits were restrained and ultrasound images for RTU measurements were taken over the lumbar region between $6^{th}$ and $7^{th}$ lumbar vertebrae. The fur at measurement site was clipped close to the skin and shaved. A gel was used as a coupling medium. The measurements sites were identified and the images were taken using a 7.5 MHz linear probe (UST-5512U-7.5) attached to an Aloka SSD 500V real time scanner. During the RTU measurements the probe was placed perpendicular to backbone over the LM muscle. Once a satisfactory image had been obtained, it was captured on a video printer (Aloka SSZ-303E) for image analysis. The printed images taken were digitized and RTU measurements were determined by image analysis using the NIH Image J software (http://rsb.info.nih.gov/ij/). The LM area was obtained from a RTU image between the $6^{th}$ and the $7^{th}$ lumbar vertebrae. All images were acquired and analysed by the same operator. The *in vivo* linear measurement of loin between the last dorsal and the $7^{th}$ lumbar vertebrae was obtained for volume determination. The exact position of the end points for loin length measurement was identified on animal by palpation on bone anatomical basis of the end points.

### Loin area and length measurements on carcass

The cut point between the $6^{th}$ and $7^{th}$ lumbar vertebrae as pointed out by Blasco and Ouhayoun (1996) for carcass division was used to take carcass measurements equivalent to those taken *in vivo* by RTU. For this purpose, a digital camera (Nikon Coolpix 900) was used to capture an image of the LM plane between the $6^{th}$ and $7^{th}$ lumbar vertebrae and after image analysis with the Image J software the LM area was taken. The length of loin was directly taken on the carcass.

### Volume calculation

The LM volume (LMV) was calculated by multiplying the LM areas obtained by *in vivo* with RTU and in carcass by the loin lengths measured *in vivo* by RTU and on carcass, respectively. Thus it was defined the LMVU and LMVC for *in vivo* and carcass LM volume, respectively. The LM volume measured on carcass was also determined according to the Archimedes' principle (LMVAr). The right LM muscle of loin was submerged in water and the water volume displaced by this action was measured.

**Statistical analysis**

Carcass composition and carcass LM volume were estimated by single regression equations using the LMVU measurement. The simple regression equations were evaluated by the coefficients of determination ($r^2$) and residual standard deviation (rsd). The carcass and *in vivo* measurements were analyzed by ANOVA with LW as covariate. Mean differences were performed using Tukey test with a predetermined significance level of P<0.05. All analyses were performed using SAS (v. 8.2; SAS Inst., Inc., Cary, NC, USA).

## RESULTS AND DISCUSSION

Mean, standard error (SE), range and coefficient of variation (CV) for LW, and carcass traits of rabbits are presented in Table 1

**Table 1**: Mean (standard error, SE), range and coefficient of variation (CV) (n= 63)

| Trait | Abbreviation | Mean (SE) | Range | CV (%) |
|---|---|---|---|---|
| Live weight (g) | LW | 2093 (63.1) | 1200 - 3410 | 23.9 |
| Commercial carcass weight (g) | CCW | 1133 (39.9) | 561 - 1940 | 28.0 |
| Reference carcass weight (g) | RCW | 997 (37.4) | 472 - 1773 | 29.8 |
| Carcass composition | | | | |
| Meat weight (g) | MW | 781 (31.0) | 349 - 1424 | 31.5 |
| Bone weight (g) | BW | 160 (4.78) | 92.6 - 254 | 23.8 |
| Total dissectible fat (g) | TDF | 55.0 (2.80) | 21.8 - 94.5 | 40.4 |
| Meat weight (%) | MW | 78.0 (0.30) | 73.1 - 81.9 | 3.0 |
| Bone weight (%) | BW | 16.4 (0.24) | 12.6 - 20.4 | 11.4 |
| Total dissectible fat (%) | TDF | 5.5 (0.20) | 2.8 - 8.6 | 28.3 |

The LW varied from 1200 to 3410 g, with a CV=23.9%. This LW range reflects on the CCW and RCW variation having similar values for CV (28.0 % for CCW and 29.8 % for RCW). Overall, the meat, bone and dissectible fat contents are similar to those previously reported by Pla *et al.* (1998), Hernandez *et al.* (2006) in studies where the rabbits exhibit a LW close to those used in the present work. The TDF was the carcass component that exhibits more variation (CV=40.4%). This is an expected finding due the LW range studied. As expected, the variation observed for the carcass components percentage was lower than the variation observed for their amounts. Actually, expressing amounts as percentage removes some of its variation what it is particularly noticeable for MW.

The mean, standard error (SE), range and coefficient of variation (CV) for loin length and LM measurements obtained in carcass and *in vivo* are summarized in Table 2. The LM measurements both in carcass and obtained *in vivo* by RTU are not significant different (P>0.05) for LM area and LMVC. Although there is a tendency (P=0.061) for larger LM area on carcass than LM area obtained by RTU and the LMVAr was lower (P<0.05) than LMVC and LMVU. This finding can be attributable to differences in LM shape along all dorsal length of this muscle (Korn *et al*., 2005) which has implication on LM volume. Actually, it was observed an increase of LM volume from the thoracic vertebrae to the lumbar vertebrae (Silva *et al*., 2007). Significant difference between carcass and *in vivo* loin length measurements was observed, being the carcass lower (P<0.05) than the *in vivo* measurement. The difference observed for lengths was an expected result since the live animal has skin and fur. Furthermore, even with extreme care, the measurements *in vivo* were taken with difficulty what can introduce inaccuracy in these lengths. The accuracy of these two lengths measurements was fundamental since they were employed in LM volume calculations.

**Table 2**: Mean (standard error, SE), range and coefficient of variation (CV) for loin length and LM measurements obtained in carcass and *in vivo* (n= 63)

| | | Measurement | | | |
|---|---|---|---|---|---|
| | | Loin length (cm) | LM area ($cm^2$) | LM volume ($cm^3$) | |
| Carcass | Mean (SE) | $11.2^a$ (0.20) | $5.7^a$ (0.21) | LMVC | $64.5^a$ (3.3) |
| | Range | 8.7 - 15.5 | 2.8 - 9.9 | | 25.0 - 147.4 |
| | CV (%) | 14.2 | 28.9 | | 40.0 |
| | Mean (SE) | | | LMVAr | $57.4^b$ (2.8) |
| | Range | | | | 24.5 - 110.2 |
| | CV (%) | | | | 38.6 |
| *In vivo* | Mean (SE) | $12.4^b$ (0.24) | $5.2^b$ (0.17) | LMVU | $65.5^a$ (3.0) |
| | Range | 9.5 - 17.1 | 2.7 - 8.5 | | 27.2 - 135.8 |
| | CV (%) | 15.2 | 25.9 | | 36.8 |
| SEM | | 0.166 | 0.104 | | 1.162 |
| Probability | | 0.001 | 0.001 | | 0.001 |

SEM- standard error of mean; Means with different letters on the same row differ significantly (Tukey test)

Estimation of carcass MW, BW and TDF and carcass LM volume was achieved by simple regressions with LMVU as independent variable. The r² and the rsd of the regressions obtained are presented in Table 3. The potential of LMVU as predictor of the amounts of carcass components and LM carcass volume measurements was high (r² between 0.414 and 0.811; P<0.001). This can be partially explained by the strong correlation observed between body weight and carcass composition (P<0.001). However, the potential of LMVU to predict the percentage of carcass tissues was clearly lower (r² between 0.003, P>0.05 and 0.329, P<0.001), due to the low variation of the percentage of carcass composition traits. Other authors reported similar results with other species when ultrasonic measurements *in vivo* were used with the same purpose of the present study (Maghoub, 1988; Silva *et al*., 2007). In rabbits, Szendrö *et al*. (1992) pointed out that X-ray computer tomography system was suitable to estimate the amount of loin muscle *Longissimus dorsi* (*r*=0.80). The resolution power of the equipment is a key issue as discussed, among others, by Young *et al*. (1992). This is particularly important when the area of LM is low, as is the case of small animals (rabbits). The use of image analysis witch allows a resolution of 0.2 mm and a 7.5 MHz probe that allow the identification of the lateral boundaries of the LM contributed for the results we obtained. This may explain the high correlations between the LM volume measurements and may have supported the prediction ability of RTU as observed by Stouffer (2004) in cattle.

**Table 3**: Coefficients of determination ($r^2$), residual standard deviations (rsd) of the prediction equations for carcass composition and LM carcass volume measurements (LMVC and LMVAr) using LM volume by RTU measurement as independent variable

| Traits | $r^2$ | rsd | Probability |
|---|---|---|---|
| Carcass composition | | | |
| Meat weight (g) | 0.801 | 110.7 | <0.001 |
| Bone weight (g) | 0.718 | 20.3 | <0.001 |
| Total dissectible fat (g) | 0.414 | 17.2 | <0.001 |
| Meat weight (%) | 0.176 | 2.2 | 0,006 |
| Bone weight (%) | 0.329 | 1.5 | <0.001 |
| Total dissectible fat (%) | 0.003 | 1.6 | 0.693 |
| LM volume | | | |
| LMVC ($cm^3$) | 0.811 | 11.3 | <0.001 |
| LMVAr ($cm^3$) | 0.796 | 10.1 | <0.001 |

## CONCLUSIONS

This study shows that it is possible to predict LM volume from the loin length and the LM area measurement from a RTU scan between the 6th and the 7th lumbar vertebrae. It can be also conclude that the amount of carcass tissues can be predicted by using LM volume measured *in vivo* by RTU. Results issued from this study encourage the use of *in vivo* RTU to predict carcass traits. However further research is needed to improve the RTU practicability and the image analysis for extensive use in rabbits, since other attributes such as the mobility, the easy to use and the non-invasive ability are already well established for this technique.

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