Technical Note

Real-time ultrasound to predict rabbit carcass composition and volume of *longissimus dorsi* muscle

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ABSTRACT - Real-time ultrasonography (RTU) was used to measure the *longissimus dorsi* muscle (LM) volume *in vivo* and to predict the carcass composition of rabbits. For this, 63 New Zealand White × Californian rabbits with 2093±63 g live weight were used. Animals were scanned between the 6th and 7th lumbar vertebrae using an RTU equipment with a 7.5 MHz probe. Measurements of LM volume were obtianed both *in vivo* and on carcass. Regression equations were used for the prediction of carcass composition and LM volume using the LM volume measured obtained with RTU (LMVU) as independent variable. Carcass meat, bone and total dissectible fat weights represented 780, 164 and 56 g/kg of the reference carcass weight, respectively. Regression equations showed a strong relationship between LMVU and the correspondent volume in carcass. Furthermore, LMVU was also useful in predicting the amounts of carcass tissues. It is possible to predict LM volume in the carcass using the LM volume measured *in vivo* by RTU. The amount of carcass tissues can be predicted by the LM volume measured *in vivo* by RTU.

Key Words: bone, fat, imaging, muscle volume, ultrasonography

Introduction

In animal science, information about carcass or body composition is an important tool for studies of nutrition, physiology and genetics. Body composition or 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.*, the 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; Teixeira, 2008). Some reports have also shown the suitability of this technique for the evaluation of body composition in rabbits (Pascual et al., 2000; Quevedo et al., 2005; Cardinali et al., 2008).

The developments of *in vivo* measures that are closely associated with measures considered most important in describing the muscularity of a rabbit carcass will be required for application in genetic improvement programs

or simply in economic carcass evaluation (Silva et al., 2009). However, the application of RTU for evaluation of rabbit carcasses is rare and little information on the usefulness of this technique in describing carcass traits of rabbits is available. Thus, the objectives of this study were to evaluate the *in vivo* RTU measurements in assessing loin *longissimus dorsi* (LM) muscle volume and to predict the carcass composition of rabbits.

Material and Methods

This experiment took place in the experimental rabbit facilities of the Animal Production Department at UTAD, Vila Real. The experimental study was conducted according to principles and guidelines of the European Communities Council Directive No. 86/609/EEC and local regulations. Rabbits (New Zealand White × Californian) were kept in a closed air-conditioned building maintained at 18–23 ºC and with a day/night cycle of 12/12 hours (light from 07h00 to 19h00). One hundred and twenty rabbits were weaned at 35 days of age and between this date and the slaughter they were randomly housed in 12 collective deep litter pens with 10 rabbits of both sexes (0.6 × 1.4 m; 12 rabbits/m^2).

After weaning, they were fed a commercial pellet diet (crude protein, 163 g/kg; ether extract, 33 g/kg; neutral detergent fibre, 323 g/kg and ash, 105 g/kg on dry matter basis) *ad libitum* and had free access to water. Sixty-three rabbits of both sexes were ramdomly selected for carcass composition, RTU and carcass measurements. To obtain live weight variation, animals were slaughtered between 70 and 90 days of age. Live weight was recorded without prior fasting. After slaughter, chilled carcass weight and reference carcass weight (Blasco & Ouhayoun, 1996) were obtained. The reference carcass was cut in technological joints (fore leg, thoracic cage, loin and hind part) according to Blasco & Ouhayoun (1996). All the joints were dissected, and meat weight, bone weight and total dissectible fat weight were obtained.

Prior to slaughter, rabbits were restrained and ultrasound images for RTU measurements were made over the lumbar region between 6th and 7th 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 obtained 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 perpendicularly to the backbone over the LM. 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 software NIH Image J (http://rsb.info.nih.gov/ij/).

The LM area was obtained from a RTU image between the 6th and the 7th 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 7th lumbar vertebrae was obtained for volume determination. The exact position of the end points for loin length measurement was identified on the animal by palpation on the bone anatomical basis of the end points.

The cut point between the 6th and 7th lumbar vertebrae as pointed out by Blasco & Ouhayoun (1996) for carcass division was used to make carcass measurements equivalent to those obtained *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 6th and 7th lumbar vertebrae and after image analysis with software Image J, the LM area was obtained. The length of the loin was directly measured on the carcass.

The LM volume was calculated by multiplying the LM areas obtained *in vivo* with RTU and on the carcass by the loin lengths measured *in vivo* by RTU and on

carcass, respectively. Thus, the real-time ultrasound and digital image analysis techniques for *in vivo* and carcass LM volume were defined, respectively. The LM volume measured on carcass was also determined according to the Archimedes principle. The right LM of loin was submerged in water and the water volume displaced by this action was measured.

Carcass composition and carcass LM volume were estimated by single regression equations using the *in vivo* real-time ultrasound 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 live weight as covariate. Mean differences were analyzed using the Tukey test with a predetermined significance level of P<0.05. All analyses were performed using SAS (Statistical Analysis System, version 8.2).

Results and Discussion

Live weight varied from 1200 to 3410 g, with a coefficient of variation (CV) of 23.9% (Table 1). This live weight range reflects on the chilled carcass weight and reference carcass weight variation having similar values for CV (28.0% for chilled carcass weight and 29.8% for reference carcass weight). Overall, the meat, bone and dissectible fat contents are similar to those previously reported by Pla et al. (1998) and Hernandez et al. (2006) in studies where the rabbits exhibit a live weight close to those used in the present study. The total dissectible fat was the carcass component that showed the greatest variation (CV = 40.4%). This was an expected finding due the live weight range studied.

The LM measurements both on carcass and obtained *in vivo* by RTU are not significantly different (P>0.05) for LM area and LM volume measured using digital image

Table 1 - Descriptive statistics for traits of live and carcass weights and carcass composition[1]

Trait	Mean (SE)	Range	CV (%)
Live weight (g)	2093 (63.1)	1200 - 3410	23.9
Commercial carcass weight (g)	1133 (39.9)	561 - 1940	28.0
Reference carcass weight (g)	997 (37.4)	472 - 1773	29.8
Carcass composition			
Meat weight (g)	781 (31.0)	349 - 1424	31.5
Bone weight (g)	160 (4.78)	92.6 - 254	23.8
Total dissectible fat (g)	55.0 (2.80)	21.8 - 94.5	40.4
Meat weight (g/kg)	780 (30)	731 - 819	3.0
Bone weight (g/kg)	164 (24)	126 - 204	11.4
Total dissectible fat (g/kg)	56 (20)	28 - 86	28.3

[1] n = 63.
SE - standard error; CV - coefficient of variation.

analysis (Table 2). The LM area on carcass was larger than the LM area obtained by RTU (P = 0.061) and the LM muscle measured by the Archimedes principle was lower (P<0.05) than LM volume measured using digital image analysis and LM volume measured by *in vivo* real-time ultrasonography. This finding can be attributable to differences in the LM shape along all the dorsal length of this muscle (Korn et al., 2005), which has implications on the LM volume. In fact, an increase of LM volume from the thoracic vertebrae to the lumbar vertebrae was observed (Silva et al., 2007).

Significant difference between carcass and *in vivo* loin length measurements was observed; the loin length measured on the carcass was lower (P<0.05) than those obtained *in vivo*. 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 made with difficulty, which can bring about inaccuracy in these length measurements. The accuracy of these two length measurements is fundamental since they were employed for the calculations of the LM volume.

Estimation of carcass meat weight, bone weight, total dissectible fat weight and carcass LM volume was done by simple regressions with real-time ultrasound evaluation as independent variable.

The potential of real-time ultrasound as predictor of the amounts of carcass components and digital image analysis measurements was high (r^2 between 0.414 and 0.811 (Table 3); P<0.001). However, the potential of real-time ultrasound to predict the percentage of carcass tissues was clearly lower (r^2 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 have reported

similar results with other species when ultrasonic measurements *in vivo* were used with the same purpose as the present study (Maghoub, 1988; Silva et al., 2007).

In rabbits, Szendrö et al. (1992) pointed out that an X-ray computer tomography system was suitable to estimate the weight of the 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 small, as is the case of small animals (rabbits). The use of image analysis which allows a resolution of 0.2 mm and a 7.5 MHz probe that enable the identification of the lateral borders of the LM contributed for the results obtained. This may explain the high correlations between the LM volume measurements and may have supported the prediction suitability of RTU with *in vivo* prediction of carcass traits

Table 3 - Coefficients of determination (R^2) and residual standard deviations (RSD) of the prediction equations for carcass composition and *longissmus dorsi* (LM) muscle carcass volume measurements (with a digital image analysis and the Archimedes principle) using the *longissmus dorsi* muscle volume by real-time ultrasonogoraphy measurement as independent variable

Trait	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 (g/kg)	0.176	2.2	0.006
Bone weight (g/kg)	0.329	1.5	<0.001
Total dissectible fat (g/kg)	0.003	1.6	0.693
Longissmus dorsi muscle volume			
LMVC (cm³)	0.811	11.3	<0.001
LMVAr (cm³)	0.796	10.1	<0.001

LMVC - LM volume measured using a digital image analysis; LMVAr - LM muscle measured by the Archimedes principle.

Table 2 - Descriptive statistics for traits loin length and measurements of the *longissimus dorsi* muscle (LM) obtained on carcass and *in vivo* (n= 63)

		Measurement			
		Loin length (cm)	LM area (cm²)	LM volume (cm³)	
Carcass	Mean (SE)	11.2a (0.20)	5.7a (0.21)	LMVC	64.5a (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	57.4b (2.8)
	Range				24.5 - 110.2
	CV (%)				38.6
In vivo	Mean (SE)	12.4b (0.24)	5.2b (0.17)	LMVU	65.5a (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

LM - *longissimus dorsi*; SE - standard error; CV - coefficient of variation; SEM - standard error of the mean; LMVC - LM volume measured using a digital image analysis; LMVAr - LM muscle measured by the Archimedes principle; LMVU - LM volume measured by *in vivo* realt-time ultrasonography.
Means followed by different letters in the same column differ significantly (Tukey test).

as observed by Stouffer (2004) and Teixeira (2008) in the main farm species. In fact, this is an important advantage compared with traditional slaughter methods, since it can be used with animals of slaughter and breeder animals.

Further research is needed to improve the RTU applicability and the image analysis for extensive use in rabbits, since other attributes such as mobility, ease of use and non-invasiveness are already well-established for this technique.

Conclusions

It is possible to predict the *longissimus dorsi* muscle volume from the loin length and the *longissimus dorsi* area measurement from a real-time ultrasonography scan between the 6th and the 7th lumbar vertebrae. The amount of carcass tissues can be predicted by using *longissimus dorsi* volume measured *in vivo* by real-time ultrasonography. The results from this study encourage the use of *in vivo* real-time ultrasonography to predict carcass traits which could be deployed for selection purposes.

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