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Ultrasonographic *in vivo* estimation of back fat depth and *Longissimus dorsi* area in Iberian pigs

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Abstract. Real-time ultrasound is a useful technology for measuring carcass composition in live animals and to select future seedstock for carcass merit. Therefore, the objective of this study was to evaluate the use of ultrasound to predict the amount of fat and muscle in Iberian pigs. A total of 163 Iberian pigs were ultrasonically scanned one day before slaughter, and carcass composition was also determined in the slaughterhouse. Ultrasound and carcass traits included the three lays of back fat and *Longissimus dorsi* (LD) area, at the 10^{th} and 14^{th} rib levels. Data were analyzed by regression and correlation procedures using SAS. Results indicated a positive correlation between ultrasound and carcass traits at both rib levels. Regression results indicated that ultrasound measurements had smaller values than carcass measurements. Correlations between ultrasound back fat measurements and carcass, ham, and foreleg weights were positive, but they were negative with respect to LD weight. The highest correlation with LD weight was LD area at the 14^{th} rib level.

Keywords. Ultrasound – Iberian pigs – Back fat – *Longissimus dorsi.*

Estimation échographique* in vivo *de l'épaisseur de la graisse dorsale et de la surface du* Longissimus dorsi *chez les porcs Ibériques

Résumé. *Les ultrasons sont un outil valide et économique pour mesurer la composition de la carcasse des animaux vivants et sélectionner les futures reproductrices. Ce travail évalue l'utilisation des ultrasons pour prédire la quantité de tissu gras et musculaire chez le porc Ibérique. 163 porcs Ibériques ont été échographiés un jour avant l'abattage, et ultérieurement on a étudié leurs carcasses à l'abattoir. Par ultrasonographie, et ultérieurement sur la carcasse, on a mesuré l'épaisseur des trois couches de graisse dorsale et la surface du* Longissimus dorsi *(LD), au niveau du dixième et du quatorzième espace intercostal. Les données ont été analysées par des procédures de régression et corrélation de SAS. Les résultats obtenus montrent une corrélation positive entre les mesures par ultrasons et celles de la carcasse au niveau de la dixième et la quatorzième côte. Les résultats de la régression montrent que les mesures ultrasoniques sont sous-estimées par rapport à celles de la carcasse. Les corrélations entre les mesures ultrasoniques de la graisse dorsale par rapport au poids de la carcasse, au jambon, et à l'épaule étaient positives; mais elles étaient négatives par rapport au poids du filet. La mesure la plus corrélée au poids du filet a été la surface du filet dans la quatorzième côte.*

Mots-clés. *Ultrason – Porc Ibérique – Graisse dorsale – Longissimus dorsi.*

I – Introduction

The Iberian pig breed has a traditional production system linked to natural resources, since pigs are finished grazing on pastures and acorns. This system produces meat with a high percentage of intramuscular fat and a high proportion of monounsaturated fatty acids (Ventanas *et al*., 2006), thus providing excellent sensorial and healthy properties to the cured products, which are the source of a thriving meat industry and a renowned quality certification. However, to reach this high percentage of intramuscular fat, animals also deposit a large amount of fat (around 90 mm thick). There is an important genetic variation in swine for fat deposition traits, thus enabling the possibility of selecting superior individuals for intramuscular fat with lower levels of subcutaneous fat (Newcom *et al*., 2005). However, measuring carcass traits in live animals for selection purposes is not an easy task. Ultrasonography has been used to develop predictive equations for estimating intramuscular fat in live cattle (Wilson *et al*., 2001), and in pigs (Newcom *et al*., 2002). *In vivo* ultrasound estimates for loin area and fat thickness in Duroc pigs were very reliable (Newcom *et al*., 2002, 2005). The objective of this study was to assess the capabilities of ultrasound for measuring back fat thickness and loin area in the Iberian pig in order to develop a predictive method for meat yield, thus relating variables measured with ultrasound in the live animal with those taken in the carcass after slaughter.

II – Materials and methods

Animals: For this study, 163 Iberian pigs of the red *("Retinto"*) strain were used. Animals were raised indoors in standard commercial conditions up to 25 Kg of body weight (BW). After this period, animals were raised outdoors in extensive conditions and fed a concentrate in a restricted diet (as usual in this traditional system) up to 12 months of age. At this age, animals were divided in five groups and started an "ad libitum" feeding period with different types of food: One group was fed only pasture and acorn; the second was fed pasture and acorn up to 135 kg of BW and then finished with a standard, commercial concentrate; the third group was fed pastures, acorn and standard concentrate at the same time; the forth group was fed standard concentrate; and the fifth group was fed a commercial concentrate having a high level of oleic acid to imitate acorn composition. Animals were fed for a period of 2.5 to 3 months and were slaughtered after reaching 135 kg of BW (135 to 175 kg range). To allow for a thorough study of carcasses, no more than 20 animals at a time were slaughtered.

Ultrasound image collection: One day before slaughter, pigs were ultrasonically scanned to measure body composition, using an Aloka 500 apparatus (Aloka Holding – Europe, Switzerland) and a 3,5 MHz, 12 cm long probe. Ultrasound images were collected by placing the probe perpendicular to the loin a two different rib levels: one image was taken between the 10th and 11th ribs (10th intercostal space), and the other was taken just behind the last (14th) rib. A soft, rubbery adaptor made of Superflap® was used between the animal and the probe to allow for an adequate contact despite of the curved back surface. Images were digitalized and stored in a computer. Image measurements were done afterwards by using the Biosoft® software (Biotronics inc., Ames, IA, USA). For each image, loin area and thickness of the 3 backfat (BF) layers were measured. The ultrasound ("u") measurements, taken at the 10th intercostal space and behind the last rib, respectively ("10", "14"), were the following: external ("E") back fat layer (EBFu10 and EBFu14); middle ("M") layer (MBFu10 and MBFu14); internal ("I") layer (IBFu10 and IBFu14); external + middle ("EM") layers (EMBFu10 and EMBFu14); and total ("T") backfat thickness (BFu10 and BFu14).

Carcass data: After slaughter, carcass weight (CW) and weight and yields of commercial cuts (ham, foreleg and loin) were measured. In addition, a portion of loin containing 4 chops (spanning from the 11^{th} to the14^{th} ribs) was extracted from the carcass and used to measure back fat layers thickness and loin area at the two already mentioned rib levels.

Variables were analyzed by using correlation and regression procedures in SAS.

III – Results and discussion

The correlation coefficients between the ultrasound variables and the corresponding carcass variables at the two rib levels are presented in Table 1. The variables with a higher correlation were middle BF layer (r = 0.72 and 0,61) and total BF (r = 0.67 and 0,66) for the 10th intercostal space ("10") and last space ("14"), respectively. Prior estimates of BF10 gave correlations of 0.55 (McLaren *et al*., 1989) and 0.93 (Turlington, 1992). The correlation coefficient between ultrasound and carcass loin area was 0.36 and 0.41 for the 10-11 intercostal space and last rib space, respectively. This correlations are similar to those reported by Daza *et al*. (2006) in Iberian pigs. Correlations reported by Moeller (1998) and Lopes *et al*.

(1987) range between 0.27 and 0.73. In general, the correlations from our study are slightly lower than those from the literature, maybe because larger slaughter weights result in these correlation being lower (Daza *et al*., 2006). In addition, we found in our study that Iberian pigs show a wide variation in loin section shape, so that the internal fat layer is sometimes hard to measure as accurately as expected *in vivo* and in the carcass. Nevertheless, considering that carcass measurements also have an associated error, the magnitude of the correlations indicate that ultrasonography can be a good alternative to measure live animals for selection purposes, as indicated by Moeller *et al*. (1998).

Table 1. Correlations between ultrasound and carcass measurements in the two anatomical locations

Rib level	EBFuc	MBFuc	IBFuc	EMBFuc	Bfuc	Aluc
10th	0.56	0.72	0.39	0.72	0.67	0.36
14th	0.27	0.61	0.33	0.60	0.66	0.41

Backfat layers: EBFuc=external; MBFuc=middle; IMBFuc=internal; EMBFuc=external+medial; BFuc=total backfat. ALuc=*Longissimus dorsi* area.

Tables 2 and 3 depict, for the two rib levels, the correlations between ultrasound ("u") or carcass ("c") measurements and the weights and yields of meat cuts, namely Foreleg Weight (FW), Ham Weight (HW), Loin Weight (LW), Foreleg Yield (FY), Ham Yield (HY) and loin yield (LY).

Table 2. Correlations between ultrasound measurements (u) and the carcass, foreleg, ham and loin weights and yields

	EBFu10	MBFu10	IBFu10	BFu10	Alu10	EBFu14	MBFu14	IBFu14	BFu14	Alu14
CW	0.25	0.38	0.29	0.43	0.15	0.29	0.27	0.22	0.33	0.21
FW	-0.03	0.03	0.09	0.04	0.23	0.13	-0.08	-0.01	-0.03	0.18
HW	0.24	0.09	0.03	0.13	0.24	0.21	0.10	-0.07	0.07	0.23
LW	-0.15	-0.44	-0.34	-0.47	0.36	-0.09	-0.36	-0.26	-0.37	0.43
FY	0.05	-0.33	-0.30	-0.33	0.15	-0.05	-0.19	-0.37	-0.30	0.08
HY	-0.30	-0.38	-0.21	-0.42	0.11	-0.15	-0.40	-0.26	-0.41	0.00
LY	-0.23	-0.53	-0.42	-0.58	0.20	-0.20	-0.41	-0.31	-0.45	0.25

Backfat layers: EBFu=external; MBFu=middle; IMBFu=internal; EMBFu=external+medial; BFu=total backfat. ALu=*Longissimus dorsi* area. CW=carcass weight; FW= foreleg weight; HW= ham weight; LW= loin weight; FY= foreleg yield; HY= ham yield; LY= loin yield.

Table 3. Correlations between carcass measurements (c) and the carcass, foreleg, ham and loin weights and yields

	EBFc10	MBFc10	IBFc10	BFc10	Alc10	EBFc14	MBFc14	IBFc14	BFc14	Alc14
CW	0.40	0.44	0.40	0.59	-0.10	0.15	0.49	0.06	0.46	-0.04
FW	0.05	0.14	0.22	0.21	0.05	0.10	0.11	-0.08	0.06	0.11
HW	0.39	0.18	0.19	0.31	0.03	0.20	0.26	-0.17	0.13	0.02
LW	-0.20	-0.46	-0.35	-0.53	0.64	-0.03	-0.39	-0.022	-0.46	0.58
FY	0.08	-0.26	-0.19	-0.24	0.16	0.11	-0.21	-0.32	-0.35	0.06
HY	-0.034	-0.29	-0.16	-0.36	0.17	-0.03	-0.36	-0.16	-0.40	0.18
LY	-0.32	-0.58	-0.47	-0.69	0.58	-0.08	-0.53	-0.21	-0.58	0.49

Backfat layers: EBFuc=external; MBFuc=middle; IMBFuc=internal; EMBFuc=external+medial; BFuc=total backfat. ALuc=Longissimus dorsi area. CW=carcass weight; FW= foreleg weight; HW= ham weight; LW= loin weight; FY= foreleg yield; HY= ham yield; LY= loin yield.

Any of the measurements have a correlation above 0.4 for FW, HW, and FY. In particular, LW had correlations above 0.40 with MBFu10, BFu10, and ultrasound loin area-14. In addition, HY has correlations above 0.4 MBFu14, BFu10 and BFU14 and LY with MBFu10, MBFu14, BFu10, BFu14 and IBFu10. Carcass measurements had larger correlations than ultrasound measurements, specially for loin area, contrarily to results reported by Daza *et al*. (2006). It can be concluded that ultrasound backfat measurements have similar prediction abilities than carcass backfat, but this was not the case for ultrasound loin areas.

Table 4 describes the statistics of individual regressions between carcass and ultrasound variables, which serve to evaluate the prediction ability and the possible bias of each ultrasound variable. Together with high values of R2, the closest the intercept to zero and the slope to 1, the better the prediction ability. Regression resulted as expected, thus corroborating the correlation results. In addition, these results indicate that ultrasound loin areas and total backfat underestimated carcass loin areas and total backfat. However, it is important to consider that carcass measurements also carried measurement errors.

Table 4. Regression of carcass to ultrasonic measurements for backfat layer variables and loin area at two anatomical locations (10th and 14th rib levels).

VARIABLES	N	R^2	Intercept	Slope
EBFu10	156	0.31	0.84	0.72
EMBFu10	139	0.63	1.97	0.82
BFu10	156	0.51	2.32	0.77
ALu10	118	0.35	4.22	0.82
EBFu14	153	0.07	0.96	0.43
EMBFu14	152	0.35	2.09	0.69
BFu14	141	0.56	2.92	0.72
ALu14	119	0.22	9.7	0.91

Backfat layers: EBFu=external; MBFu=middle; IMBFu=internal; EMBFu=external+medial; BFu=total backfat. ALu=*Longissimus dorsi* area.

In conclusion, the results of this study are in agreement to results reported by other authors working with Iberian pigs. Ultrasound technology seems a good tool to measure live Iberian pigs. However, considering the heavy slaughter weights, the large backfat thickness and the loin shape variability shown by Iberian pigs, this technology needs to be readjusted to increase its accuracy for this breed.

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