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Relationship between pig carcass characteristics measured in live pigs or carcasses with Piglog, Fat-o-Meat'er and computed tomography

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ABSTRACT

Lean meat percentage (LMP) and fat and muscle thickness are important carcass quality parameters for both industry and pig farmers. The objectives of this experiment were as follows: (1) to study the relationship between ultrasounds (US) and computed tomography (CT) linear measurements of fat and muscle thickness in live pigs and measurements taken in carcasses at the slaughter plant with reflectance equipment (Fat-O-Meat'er-FOM); (2) to find an equation to estimate the LMP on a farm using the US device in live animals (between 70 and 120 kg); and (3) to compare this LMP with those obtained in carcasses with CT, FOM and manual dissection. For this purpose, 155 live pigs from different commercial crosses and sexes were evaluated with the US device (Piglog) and CT, and subsequently, their carcasses were evaluated with FOM and CT and subsample was dissected according to the European Reference Method. Correlations among fat thickness, muscle depth and LMP were high among all devices (between 0.565 and 0.965), and the biases were the lowest between devices in terms of LMP. The prediction of LMP *in vivo* using Piglog is possible with a prediction error of 2.01%. Thus, it can be concluded that these technologies are suitable for the carcass evaluation of live pigs and carcasses.

1. Introduction

Carcass characteristics such as fat thickness, muscle depth and lean meat percentage (LMP) are important parameters used to evaluate carcass quality and to determine an appropriate market. A minimum fat thickness, usually measured either with a ruler or subjectively by a trained operator, is required to select and classify hams for drying and curing. Carcass LMP, together with weight, is used to pay the producer. On the slaughter line, LMP may be estimated by means of carcass measurements taken by different types of equipment. These devices make use of either ultrasound (Ultrafom and Autofom, Carometec, Herlev, DK), reflectance (Fat-O-Meat'er-FOM, Carometec, Herlev, DK; Hennessy Grading Probe-HGP, Hennessy Grading Systems Ltd., Auckland, NZ; Capteur Gras Maigre-CGM, Sydel, Lorient, FR), vision (VCS2000, e+V Technology GmbH, Oranienburg, DE) or linear measurements in the midline of the carcass (Pomar et al., 2008; Engel et al., 2012; Font i Furnols and Gispert, 2009). The carcasses are calibrated using either dissection as a reference, which is time consuming and expensive, or technologies such as computed tomography (CT), which has been allowed as a reference LMP calibration method by the EU since 2008.

LMP is an important parameter used in pig carcass evaluation and is used to improve productivity and to establish the carcass value. Carcass evaluation can be performed on farms in live pigs using non-invasive technologies, usually based on ultrasound (US). Real-time ultrasonography is a non-invasive technology that allows for the determination of carcass quality (Václavovský et al., 2002) in terms of fat thickness, muscle depth and LMP in live pigs. Its relatively low cost and the availability of portable US devices that can be used on-farm has led ultrasound measurements to be incorporated into genetics programmes for pork carcass quality improvement in many parts of the world (Kernerová et al., 2006).

Currently, CT is also available as a non-invasive technology that allows the non-destructive analysis of the body composition of carcasses or live animals as they growth. CT scans produce images based on the density-dependent X-ray attenuation values of various tissues. However, compared to US devices, CT is a non portable and expensive tool.

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It is important to determine the within and between accuracy of a particular device's fat and muscle thickness measurement and LMP estimation (Olsen et al., 2007; Nissen et al., 2006; Font-i-Furnols et al., 2016). Additionally, it is interesting to understand how the measurements taken *in vivo* or at the slaughter plant compare among the different types of equipment (Fortin et al., 2003; Youssao et al., 2002a).

The objectives of this experiment were as follows: (1) to determine the relationship between US and CT linear measurements of fat and muscle thickness in live pigs and measurements taken in carcasses at the slaughter plant with reflectance equipment (Fat-O-Meat'er-FOM); (2) to find an equation estimating LMP on-farm based on US data taken from live animals (between 70 and 120 kg), and (3) to compare this LMP with those obtained in carcasses with CT, FOM and manual dissection.

2. Material and methods

2.1. Animals

A total of 155 pigs from two experiments were used in this study (Carabús et al., 2015):

1. Experiment 1: 75 gilts from three different commercial crosses (n=25/commercial cross): Duroc × (Landrace × Large White)-DU_LA, Pietrain × (Landrace × Large White)-PI_LA and an industrialized line Landrace × Large White-LA_LW. Five animals from each cross were evaluated at 70 and 100 kg target body weight (TBW), and 15 animals per cross were evaluated at 120 kg TBW. After the *in vivo* evaluation, the pigs were slaughtered, and their carcasses were measured.
2. Experiment 2: 80 pigs from Pietrain×(Landrace×Duroc)-PI_DU crosses from four different sexes (20 pigs/sex): females-FE, castrated males-CM, entire males-EM and immunocastrated males-IM. Four pigs from each sex were evaluated at 70 and 100 kg TBW, and 12 pigs per sex were evaluated at 120 kg. After the *in vivo* evaluation, the pigs were slaughtered, and their carcasses were measured.

All animals were raised and fed at an experimental farm at IRTA, Monells, Catalonia, Spain. Several evaluations were performed on live pigs and carcasses (either on all animals or on a subsample of them) with the objective of determining the fat and muscle thickness: on-farm US measurements and CT scans of live pigs and CT scans and a reflectance measurement using FOM of carcasses. The number of animals of each cross, sex and TBW is presented in Table 1.

2.2. Ultrasound measures

US scans were performed on-farm using a PIGLOG 105 (Carometec A/S, Herlev, DK), which is an A-mode ultrasound device, thus, a one-dimensional presentation of a reflected sound wave in which echo amplitude is displayed along the vertical axis and eco delay (depth) along the horizontal axis. The echo information derives from tissue interfaces along a single line in the direction of the sound beam. Measurements were calculated based on reflection curves from eight sound waves emitted tissues when using a transducer of 4 MHz of frequency. The reflected wave, after returning to the measuring device, is transformed into an electric pulse and it is interpreted to obtain backfat and muscle thickness measures. Fat (GLRUS) and muscle (MLRUS) thickness values were collected by placing the probe perpendicular to the left loin at the last rib level, 4–6 cm from the vertebral column. US measurements were obtained while pigs are within the scale, and gel was applied to the skin to facilitate measurement. After that, pigs were moved to the CT room placed at New Technologies Centre (Building A) of IRTA, Monells, to be scanned.

Table 1
Number of pigs evaluated with each device by sex, genotype and target body weight (TBW).

Cross-sex	TBW	Live pigs		Carcasses		
	kg	US	CT	FOM	CT	Dissection
LA_LW – FE	70	5	4	5	3	5
	100	5	3	5	5	4
	120	15	15	15	14	7
PI_LA – FE	70	5	5	5	3	4
	100	5	5	5	4	4
	120	15	15	15	15	5
DU_LA – FE	70	5	2	5	3	5
	100	5	4	6	5	4
	120	15	14	14	14	6
PI_DU – FE	70	5	5	4	5	0
	100	4	4	0	4	0
	120	11	10	11	11	1
PI_DU – EM	70	4	4	4	4	0
	100	5	5	1	5	0
	120	10	10	8	10	0
PI_DU – IM	70	3	3	3	3	0
	100	4	4	2	4	0
	120	12	12	8	12	7
PI_DU – CM	70	4	4	2	4	0
	100	4	4	1	4	0
	120	12	12	8	12	0
Total		*138*	*144*	*127*	*144*	*52*

FOM: Fat-o-Meat'er; CT: computed tomography; US: ultrasound device Piglog.
FE: female; EM: entire male; IM: immunocastrated male; CM: castrated male.
DU_LA: Duroc×(Landrace × LargeWhite); PI_LA: Pietrain×(Landrace×LargeWhite); LA_LW: Landrace×LargeWhite; PI_DU: Pietrain×(Landrace×Duroc).

2.3. Computed tomography scanning procedure

Live pigs of different weights were scanned using CT. The pigs were fasted for a minimum of eight hours and were weighed before being scanned *in vivo*. Intramuscular sedation with azaperone (0.1 mg/kg BW), ketamine (0.2 mg/kg BW) and intravenous sedation with propofol (0.22 mg/kg BW) were administered to the pigs before scanning to anaesthetize them. Intravenous sedation was used only at 100 and 120 kg TBW. CT scanning was performed using a General Electric HiSpeed Zx/i with the following acquisition parameters: axial, 140 kV, 145 mA, 10 mm-thickness and 512×512 matrix (Carabús et al., 2015). Whole-body scans were performed; however, for the present study, only the image obtained from the level of the last rib was used. After scanning, the animals were slaughtered at IRTA experimental abattoir. All methodology used was approved by the IRTA Ethical Committee.

After slaughter, all the carcasses were fully CT-scanned using the same parameters detailed for live pigs but with helical images taken instead of axial ones (explained in detail in Font i Furnols et al., 2009).

2.4. Computed tomography image analysis

The CT image analysis was carried out with VisualPork software, developed by the University of Girona (Catalonia, Spain) and IRTA (Boada et al., 2009; Bardera et al., 2012).

From images taken from the last rib level in live pigs, fat thickness and muscle depth were determined in a line perpendicular to the skin at a point on the lateral side of the left loin (lateral backfat thickness -MLR_{CT}), approximately at 4–6 cm from the midline. This area was also used for the US measurements (Fig. 1).

The lean meat percentage (LMP_{CT}) was determined from all the CT