Impact of pig population (light or heavy) on computed tomography (CT) and dissection relationship for lean meat percentage measurement

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Value for industry

- According to the EU regulation (EC n°1249/2008), all pig carcasses must be classified according to an approved classification method. The approval of a classification method consists in a calibration trial against a lean meat percentage (LMP) measurement reference method.
- The latest version of the EU regulation considers three different LMP measurement methods: total dissection of the left half carcass, partial four joint EU dissection carried out according to the Walstra and Merkus method (Walstra and Merkus, 1996). Total LMP measurement with a computed tomography (CT) scanner may be used, provided that the CT method of choice has been shown by the user to be equivalent to total dissection.
- The objective of this work is to achieve a new step in the definition of the terms of use of the CT in a calibration trial.

Background

Today, using CT as reference method for LMP measurement in a calibration trial is extremely complicated. Indeed the regulation does not specify the terms required to prove the equivalence between CT measurement and dissection. So these terms are discussed by the European experts in Brussels. The main requirement should be a good accuracy of the CT method involved. It must give results as close as possible as dissection results. Different EU countries research teams have already compared CT measurement (with different methods) and dissection (total or partial). According to all of these studies, the correlation between dissection and CT method is very high (r around 0.9) and the RMSEP in a case where the CT predicts the dissection is quite low (RMSEP around 0.5-1%) (Christensen and Boggard, 2005; Judas *et al.*, 2006; Romvari *et al.*, 2006; Font–i-Furnols *et al.*, 2009; Daumas and Monziols, 2011).

These teams have proved that the methods they have used has an equivalent precision to that of dissection (correlation and RMSEP). However, despite this, it appears that the EU experts consider that an alternative criteria must be met before CT can be accepted as a replacement for dissection. This criteria is the validity of the method on any pig population. So if dissection is assumed to be independent on the pig population studied, CT is not. In the end, even if a CT method has been proven to give extremely close results to the dissection ones on a previous trial, using it in a calibration trial requires at the expert demand additional dissections to show that the method is still valuable.

Why work is needed?

The main objective of this work is to demonstrate that a CT method is, as the dissection is assumed to be, independent of the sample. Such a study is needed to completely validate the use of CT as a reference method for the measurement of body composition as a replacement for dissection.

Methods used

This study was carried out during a calibration trial designed for the approval of grading methods in Italy. The Italian pig population was a unique occasion to achieve such a study. Indeed the Italian pig population is composed by 90% of “heavy pigs” and 10% of “light pigs”.

In the Italian Protected Designation of Origin (PDO) production of heavy pigs, different male breeds are used as stud boars: Large White or LW boar (11%); Landrace or L boar (2.4%); cross-breed 19.2%); hybrid boar (67.4%). Heavy pigs are slaughtered at 9 month age and about 160 kg live weight (+/ - 10%). Carcass weight ranged from 115kg to more than 150 kg. "Light" pigs are mainly Pietrain pigs slaughtered at about 120kg-130kg live weight with a carcass weight from 95kg to 110 kg. We can consider in this scheme that "light" pigs are closed to the classical European pig when the heavy pigs are typical Italian pigs.

100 carcasses were used in the study,25 heavy female pigs, 25 heavy castrated male pigs, 25 light female pigs and 25 light castrated male pigs . After 24h of chilling, the left half carcasses were prepared, cut into the four main joint (ham, shoulder, loin and belly) and dissected according to the procedure of Walstra and Merkus (Wastra and Merkus, 1996). Total weight and dissected muscle weight for each joint were recorded. And the reference LMP was calculated. We will call it the LMPEU.

Carcase size in heavy pigs was too large for the scanning zone of the CT, so all of the right half carcasses were cut according to the typical Italian cut into 5 joints, completely different from the EU joints and corresponding to the entire carcass minus the cheek.

All of these five joints were weighed, placed over a Styrofoam radio transparent support and analyzed by CT. The CT scanner used was a Siemens emotion duo (Siemens, Erlangen, Germany). The protocol of image acquisition had the following parameters : tube voltage 130 KV, tube current 40 mAs, FOV 500 mm x 500 mm, matrix 512 x 512, slice thickness 3 mm, spiral mode and reconstruction filter B30s (soft tissues).

Image analysis was performed automatically using software developed in C# (Monziols *et al.*, 2013) as described elsewhere (Daumas and Monziols, 2011). The examination table was removed from the image by an automatic ROI (region of interest) selection algorithm. The segmentation of the muscle voxels on the images was performed by a simple threshold between 0 and 120 Hounsfield unit (HU). The muscle weight of the joint was measured by multiplying the number of thresholded voxels by the voxel size (0.98x0.98x3) and a density fixed at 1.04 (ICRU, egpg).

A CT measure of lean meat percentage (LMPCT) was then calculated by dividing the sum of the muscle weights of the 5 joints measured by CT, by the sum of the total 5 joints weights. Statistical analysis was performed with the ANOVA and the generalized linear model procedures of R 2.14.1 (R core development team, 2008).

Results obtained

The table 1 shows the results of the half carcass weight, dissected LMP of the left half carcass and LMPct of the right half carcass for each population:

	heavy pigs		light pigs		population effect
	mean	Std	Mean	std	
left side weight (kg)	69,9	5,4	47,2	3,4	***
LMPEU	53,8	3,6	60,6	2,9	***
LMPCT	57,7	3,7	65,9	3,04	***

Table 1. Populations left half carcasses weights, LMPCT and LMPEU.

This table shows that there is a big difference between the two pig populations, the left half carcass is heavier, and both LMP measures shows that heavy pigs are largely fatter than light pigs. Furthermore we can see an important difference for both types between the two LMP measurements.

The main objective was to compare the relationship between LMPEU and LMPCT, so figures 1 and 2 present the results of a LMPEU prediction by LMPCT for each population.

Figures 1 and **2** show a high correlation between LMPCT and LMPEU. Furthermore residual standard errors around 1 are acceptable.

The main question was if there is a difference between these two relationships. In order to answer the question we pooled all data and use a different regression model in adding the population type and used the following model: LMPEU ~ LMPCT * population type .

The **figure 3** shows the result of this model.

Figure 1. Relationship between LMPCT and LMPEU for heavy pigs.

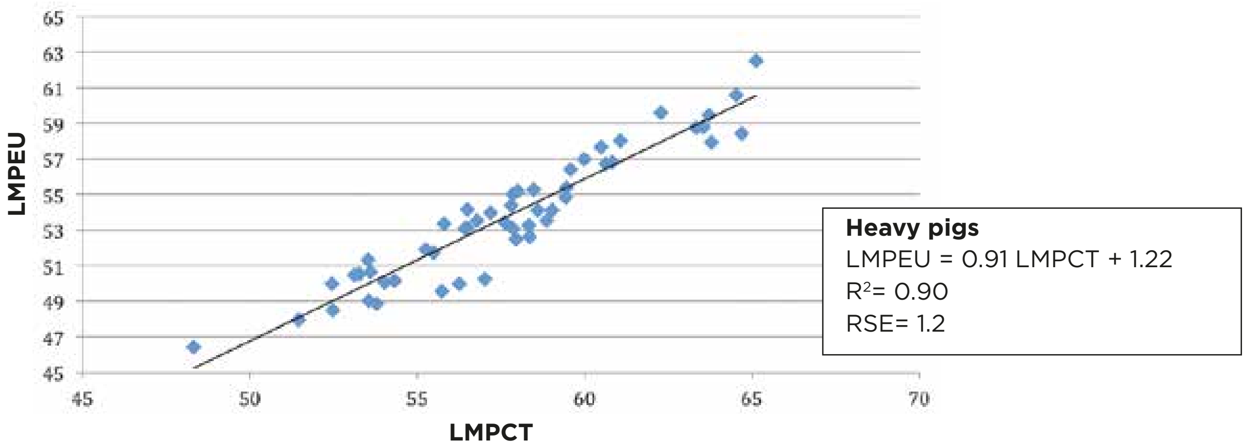


Figure 2. Relationship between LMPCT and LMPEU for light pigs.

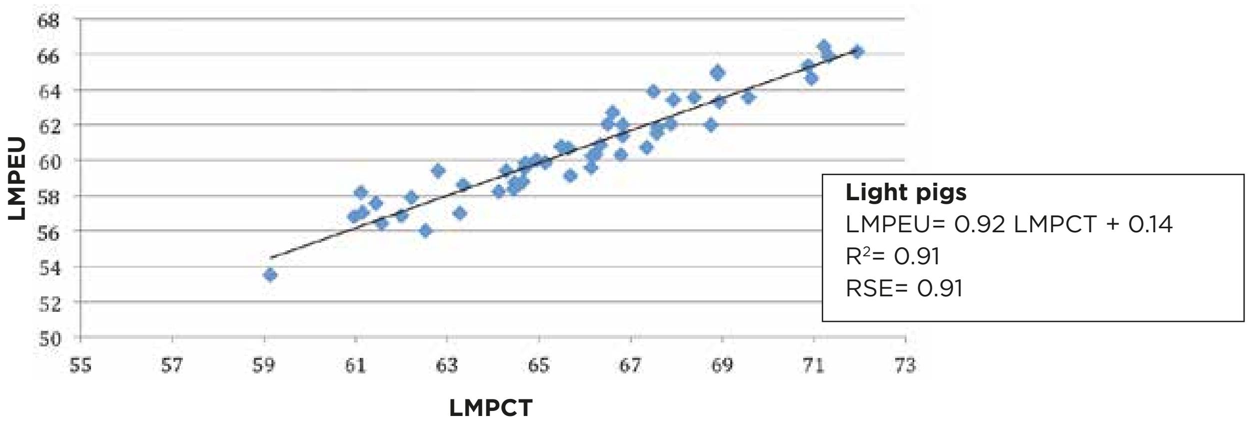
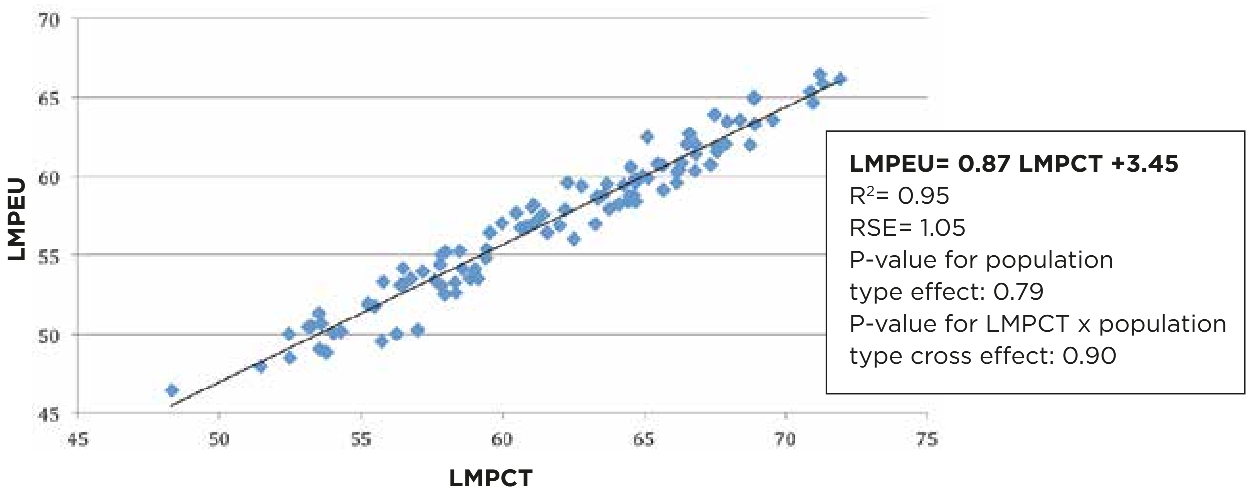


Figure 3. Relationship between LMPCT and LMPEU for heavy and light pigs.



The **figure 3** shows that the relationship between LMPEU and LMPCT is important for the whole population in this study, furthermore the residual standard error is still acceptable (very close to 1). However, the main result is that neither the effect of population type (light or heavy) nor the cross effect between LMPCT and population are significant, with two extremely high (0.79 and 0.90) p-values. This shows that the pig type does not contribute information to the model so the relationship between CT and dissection in this study is independent of the type of carcasses.

Scientific conclusions

The main conclusion of this study is that the relationship between a LMP measured by dissection or by CT in this study is clearly independent of the carcass size. Indeed in this study the two pig populations are considerably different with respect to carcass size. Heavy pigs half carcasses were 20 kg heavier than light pigs ones and their LMPEU was 7 points less than the light pig LMPEU. The Italian PDO pigs are very extreme and the difference between the two populations in this study may be unique in Europe. Nevertheless, the results show that in this study the type of pig has no effect on the relationship between LMPCT and LMPEU. Hence, since the relationship between CT and dissection appears to be similar in two extremely divergent populations of pigs, the results of the study suggest that calibration of a CT methodology does not need to be carried out in more than one population of animal.

The other conclusion of the study is that the relationship between an LMPCT method and the reference dissected LMPEU method is heavily dependent on the entities scanned and dissected. In a previous study (Daumas and Monziols, 2011), we showed a higher correlation (R^2=0.98) and a better RSD (RSD =0.54) than the results obtained in this study (R^2=0.95 and RSD = 1.04). But in the previous study, the same four main joints used in the dissection trial after EU cutting were scanned. In the present study the right side was scanned and the left side was dissected, and the dissection was made on EU joints whereas the CT scan was carried out on an Italian cut. In both studies, the same CT machine with the same image acquisition parameters and the same image analysis method was used. So it may be reasonable to think that the differences between these studies come from the difference of entities scanned and dissected in the present work. This result shows that it is really important for the comparison between CT measurement and dissection to perform both measurements on the same entity: joints or whole half-carcass. For the LMP reference measurement, the EU regulation allows only the use of the CT method on entire half carcass, whereas the measurement by dissection can be done on half carcass or four main joints. In order to achieve parity for countries that want to continue with the current four main joints measurement methodology, and those who wish to use CT methods, it would be beneficial if the EU regulation also allowed LMP measurement by CT on the four main joints.

The next steps

This study is a very important step for the acceptance of CT based methods as a reference body composition measurement method. It clearly shows that the measurement is independent of the animal population studied and that the accuracy of the relationship between CT and dissection measurements is more dependent on the entities compared : four main joints or whole half carcass.

For the use of CT methods for pig grading calibration trials, a change in the EU regulation would be needed to allow the use of CT as a reference method. To achieve this, a comparison trial against dissection is necessary, comprising the comparison of half-carcass or four joints by both methods.

For future steps, this work shows that a body composition measurement by CT method is not dependant of the type of pigs. This is a quality required for a reference method. Indeed, a unique reference CT method for body composition independent of the dissection must appear in a near future.

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References

Christensen LB and Borggaard C (2005). Challenges in the approval of CT as future reference for grading of farmed animals. ICoMST Proc., 51th International Congress of Meat Science and Technology, Baltimore, USA, 2005.

Daumas G and Monziols M (2011). An accurate and simple Computed Tomography approach for measuring the lean meat percentage of pig cuts. ICoMST Proc., 57th International Congress of Meat Science and Technology, Gent, Belgium, 2011, paper 061.

Font-i-Furnols M, Teran MF, Gispert M (2009). Estimation of lean meat content in pig carcasses using X-ray Computed Tomography and PLS regression. Chemometrics and Intelligent Laboratory Systems, 98, 31-37.

ICRU (1989). Tissue substitutes in Radiation dosimetry and measurement. ICRU report 44.

Judas M, Höreth R, Dobrowolski A, Branscheid W (2006). The measurement of pig carcass lean meat percentage with X-Ray with Computed Tomography. ICoMST Proc., 52th International Congress of Meat Science and Technology, Dublin, Ireland, 2006, pp 641-642.

Monziols M, Faixo J, Zahlan E, Daumas G (2013). Software for automatic treatment of large biomedical Images Databases. Workshop on food quality and farm animal imaging proceedings, Espoo, Finland, 2013.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, www.R-project.org.

Romvári R, Dobrowolski A, Repa I, Allen P, Olsen E, Szabó A, Horn P (2006) Development of a CT calibration method for the determination of lean meat content in pig carcass. Acta Veterinaria Hungarica, 54,1-10.

Walstra P, Merkus GSM (1996). Procedure for assessment of the lean meat percentage as a consequence of the new EU reference dissection method in pig carcass classification. Report IDDLO 96.014, March 1996.