Robustness of weight and meat content in pigs determined by CT

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Abstract

An increasing number of European countries are exploring the application of computer tomography (CT) as objective reference technology for determination of lean meat percentage (LMP) in domestic animals. One important requirement for a reference is the reproducibility or quantitative performance. 23 carcasses are CT scanned twice using different settings. The first setting was equal for all carcasses (140kV, 140mA, helical, standard reconstruction) whereas for the second scanning either photon current, reconstruction algorithm, or physical position of carcass was changed.

The weight determination was based on a volumetric method using specific constants for lean meat, fat and bone tissue thus leaving any difference to be a volume issue. The lean meat content was a simple calculation based on the tissue weights. Our results on weight determination showed that the soft reconstruction algorithm overestimated the weight of the carcass by 0.3% compared to the standard reconstruction. The reduction of photon current down to 80 mA or repositioning of the carcass showed no significant influence on the weight.

When calculating LMP no of the introduced changes in CT protocol introduced significant effect on the estimate of LMP, thus leaving CT as a very robust reference method for determination of LMP in pigs.

Introduction

Estimation of the lean meat percentage (LMP) is a central part of determination the value of a pig carcass. It is important to the farmer as he is paid by carcass weight and LMP, it is important to the abattoir as the final production yield is influenced by the LMP and an important sorting procedure based on LMP is often employed to optimize the yield. As carcass payment is under EU-regulation objectivity and transparency of the reference for the estimation process is of major importance. Today the reference is based on a manually dissection of commercially important parts of the carcass and thereby the reference is influenced by operator skills and cutting tradition [G6RD-CT-1999-00127 EUPIGCLASS].

One way of coping with this problem is to apply a virtual dissection to the carcasses using a full-body CT scanning and a software tool to estimate the LMP_{CT} of the individual carcass. Two different strategies to determine the LMP_{CT} has been proposed: A spectral calibration where the distribution of all voxel densities measured on the Hounsfield scale is calibrated to the result of a manual dissection process using multivariate models. This procedure includes the cutting tradition in the calibration [G6RD-CT-1999-00127 EUPIGCLASS]. One other strategy is based on contextual volume grading of all voxels into three different tissue classes: fat, meat or bone [Lyckegaard, A., et al.] The latter has the important advantage of not being influenced by cutting tradition nor operator skills. Therefore we apply this strategy.

Material and methods

23 pig carcasses was CT scanned twice using two different settings of the CT scanner (GE HiSpeed CT/i) The carcasses were 24 hours PM, prepared for a manual dissection according to EU recommendation, i.e. cutting the head and the feet and removing eventually internal fat and spine cord remains. The scanning was performed twice in a chilled laboratory temporarily attached to the cooling room of the abattoir. One first scanning protocol was used for all carcasses and one second protocol was changed with respect to one of three different scanning parameters according to Table 1. The constant protocol parameters are: 140kV voltage, 0.9x0.9x10mm voxel size, 0.7mm spot size and 10mm between slice centers.

The scanned tomograms were analyzed with a contextual based Markow Random Fields type of algorithm called Owen-Hjort-Mohn [Lyckegaard, A., et al.]. The algorithm estimates the volume of lean meat, fat and bone tissue in the scanned volumes, i.e. the half carcasses. The three tissue volumes are then multiplied with specific tissue densities to give an estimated carcass weight (W_{CT}). The estimated weight is compared to a scale weight (W_S) measured just before scanning and the three tissue densities are found by a linear procedure based on posterior probabilities for each tissue type given a specific voxel [Lyckegaard, A., et al.]

From the tissue weights the LMP_{CT} is estimated for all scanning protocols and the difference is tested for significance together with the difference in estimated carcass weight (W_{CT}).

Table 1. An overview of the applied scanning protocols. First protocol (No. 1) is arbitrarily used as reference

Parameter	First protocol	Second protocol					
Protocol No.	1	2	3	4	5	6	7
Reconstruction	Standard	Soft	Detail	Standard	Standard	Standard	Standard
X-ray current	140 mA	140 mA	140 mA	140 mA	140 mA	80 mA	100 mA
Position	1. position	1. position	1. position	2. position	1. position	1. position	1. position
Axial/helix	Helix	Helix	Helix	Helix	Axial	Helix	Helix

The two different scanning sessions are made without changing the position of the carcass, the procedure is controlled completely from an adjacent control room outside the scanning area. However, the scanning in 2. position (No. 4) is made after taking the carcass to the chilling room of the abattoir and back to the scanner laboratory.

Results and discussions

The first scanning protocol (No. 1) used equally for all carcasses is used as reference and the second (No. 2-7) is then tested for difference with respect to estimated carcass weight W_{CT} and LMP_{CT}.

Weight differences

Recently [Christensen, L.B. et al.] the potential of weight estimation has been revealed based on a small test sample and spectral calibration. In the present study we have replaced the spectral calibration with a volume grading and the specific density estimation. We have tested the sensitivity to more scanning parameters according to table 1 above. In Figure 1 a plot of the estimated weights, calculated with scanning protocols No. 2-7, are shown with the first protocol (No. 1) as reference.

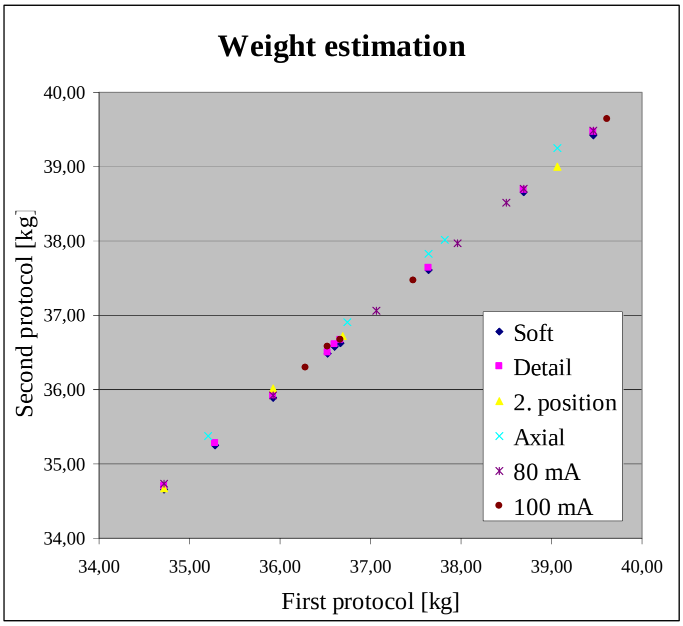

Figure 1. Estimated carcass weight using different scanning protocols. Protocol 1 used as reference.

The average difference between weight estimates from the first protocol to the second protocol is calculated and tested using a standard t-test.

The results show a significant difference in weight estimate of less than 0.5% irrespective of which of the seven different scanning protocols that is applied to the scanning procedure. This is of the same level as estimated for the used scale.

Table 2. Weight estimation

Protocol difference	Soft	Detail	2. position	Axial	80 mA	100 mA
Protocol No.	**2**	**3**	**4**	**5**	**6**	**7**
Difference [kg]	0.041	0.007	0.001	-0.18	-0.009	-0.017
Difference [%]	0.11	0.02	0.00	-0.48	-0.03	-0.05
Significance p	0.0000	0.0570	0.9761	0.0000	0.0209	0.0955
Significance level	***	NS	NS	***	*	NS

LMP_{CT} estimation:
The sensitivity of the LMP_{CT} estimation to the scanning protocol is evaluated and the results shown in Figure 2.

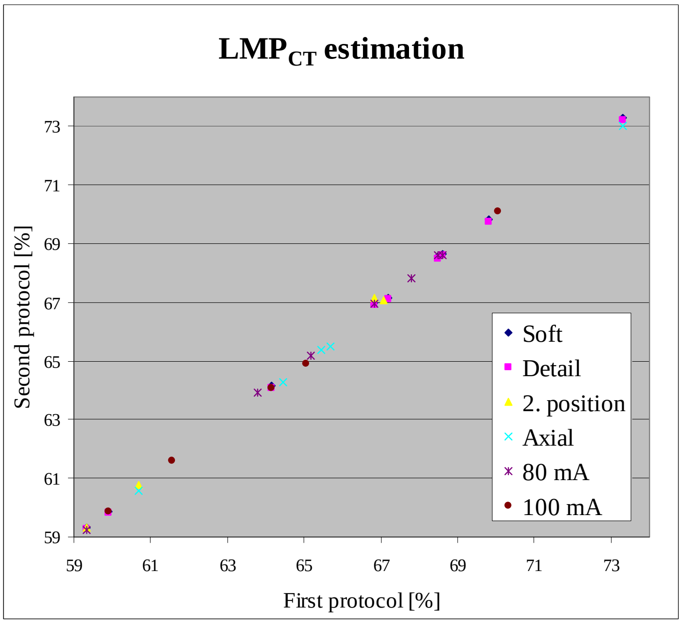

Figure 2. Estimated LMP_{CT} using different scanning protocols. Protocol 1 is used as reference.

The correlation seems even better than the performance for the weight estimation. Again the difference between the LMP_{CT} estimated with the different scanning protocols of table 1 is evaluated and tested for significant difference using a standard t-test.

The results listed in Table 3 show that LMP_{CT} estimation only has a slight dependence (**) of the changes in scanning protocol applied in this experiment. The most significant difference is the change of Helix to Axial scanning where a difference (p=0.0074) is found.

Table 3. LMP_{CT} estimation.

Protocol difference	Soft	Detail	2. position	Axial	80 mA	100 mA
Protocol No.	**2**	**3**	**4**	**5**	**6**	**7**
Difference [LMP_{CT} %]	-0.02	0.03	-0.10	0.17	-0.05	0.04
Significance p	0.3108	0.1285	0.2620	0.0074	0.1990	0.2943
Significance level	NS	NS	NS	**	NS	NS

Conclusions

From this experiment it may be deduced that CT is capable of measuring carcass weight and estimate the lean meat content in a quite robust and objective way. The highest sensitivity of scanning protocol is found in weight estimation where a relative error of less than 0.5% of changing a Helix scanning to an Axial scanning protocol. Minor sensitivity (but still significant) is found by change of reconstruction algorithm from a standard to a soft and no significance influence in repositioning the carcass, reduction of photon current from 140 mA to 100 mA or reconstruction with a high contrast detailed algorithm.

Determination of the lean meat content, expressed as LMP_{CT}, is demonstrated to be even less sensitive to the imposed changes in scanning protocol. For estimation of this very important parameter the experiment reveals that CT may be expected to have only a slight dependence to changing the scanning from Helix to Axial. The remaining changes in reconstruction, positioning and applied x-ray current result in not significant changes in the LMP_{CT} determination. This concludes that CT offers a robust measurement technology with a very small sensitivity to the different settings of the scanning protocol.

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References

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G6RD-CT-1999-00127 EUPIGCLASS, Details to be found at http://www.eupigclass.net/