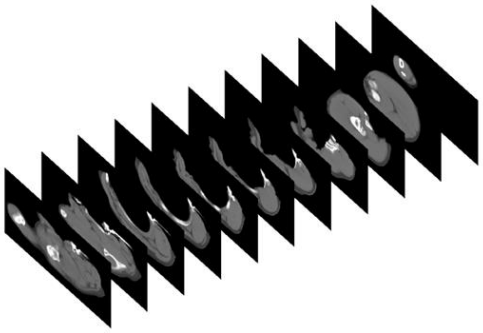
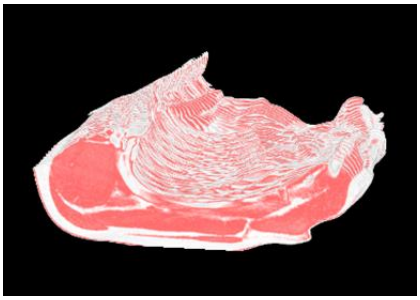
DANISH MEAT
RESEARCH INSTITUTE

25 January 2011

The Danish reference method based on CT aimed at calibration of online methods for classification of pig carcasses





The Danish reference method for Lean Meat Percent (LMP) based on CT

Introduction

The Danish reference method is based on scanning of an entire carcass to obtain an image for each 10 mm. Each image consists of a number of voxels representing 1 x 1 x 10 mm^3 of the carcass. To each voxel a numerical value is linked determined by the amount of meat, fat, membranes, bones etc. in the position in question.
The voxels are grouped into three groups: Fat, meat and bone, see the right image in figure 1, as a parallel to traditional dissection performed by a butcher with a knife.

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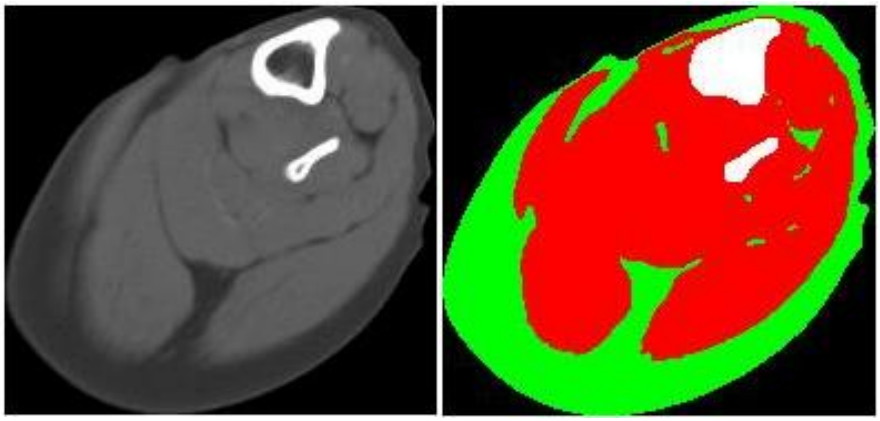
Figure 1

Segmentation
Meat, fat, bone



Definitions

The work behind the images is to estimate the number of the three types of voxels in such a way that the same result is obtained by repeated measurements with the same scanner or with a different scanner. The underlying model is:

(1) $$W = \beta_{fat}V_{fat} + \beta_{meat}V_{meat} + \beta_{bone}V_{bone}$$

W is the total weight of the carcass

$V_{fat}, V_{meat}, V_{bone}$ is the number of fat, meat and bone voxels respectively in all images.

$\beta_{fat}, \beta_{meat}, \beta_{bone}$ is the average density of the three types of tissue. Based on the estimated parameters $\hat{\beta}_{fat}, \hat{\beta}_{meat}, \hat{\beta}_{bone}$ from model (1) the lean meat content can be estimated by

(2) $$LMP_{CT} = \frac{\hat{\beta}_{meat}V_{meat}}{W} \times 100\%$$

Table 1

Average densities of fat, meat and bone based on data from three trials [95% confidence interval]

Average densities	**Fat**	**Meat**	**Bone**
Denmark	0.997 [0.992;1.003]	1.117 [1.111;1.124]	1.433 [1.368;1.497]
Norway	0.976 [0.967;0.985]	1.105 [1.097;1.113]	1.434 [1.348;1.520]
Sweden	0.9904 [0.9830;0.9970]	1.1202 [1.1110;1.1300]	1.4185 [1.3330;1.5040]

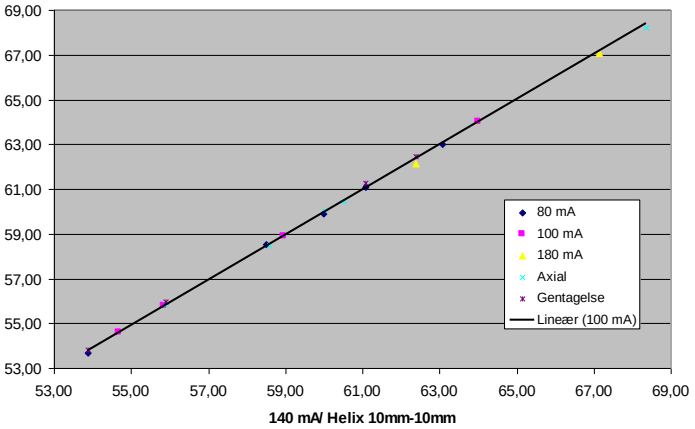
Precision of the method

Preliminary examinations have shown that the repeatability (standard deviation of differences between repeated measurements at the same carcass after handling, but with the same CT protocol) and the reproducibility

(standard deviation of differences between repeated measurements at the same carcass but with different CT protocols, scanners etc.) are expected to be highly accurate. At figure 2 examples are entered of estimated LMP_{CT} based on two measurements at the same carcass on two days in succession or with the use of different scanning protocols.

Figure 2

Repeated measurements (y-axis) under different conditions vs. a reference protocol (x-axis)

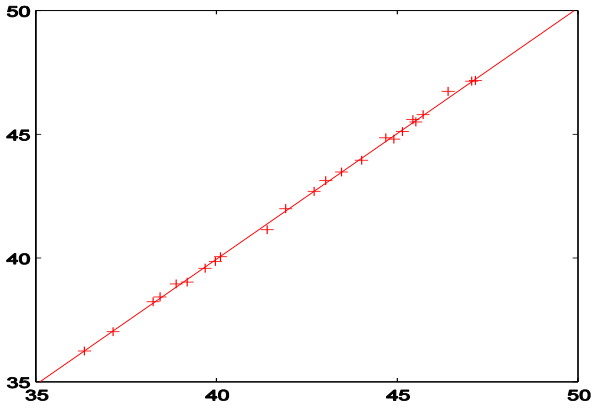


Credibility of the method

A preliminary calculation makes it possible to estimate the weight of the carcass immediately after scanning. A comparison with the weight from an ordinary weigh provides a good control of the measurement as the calculated weight can be determined within 150 g with 70% confidence, see figure 3.

Figure 3

Relation between predicted (y-axis) and weighted total weight (x-axis).
Comparison of the two weights gives an effective control of the scanning quality immediately after scanning



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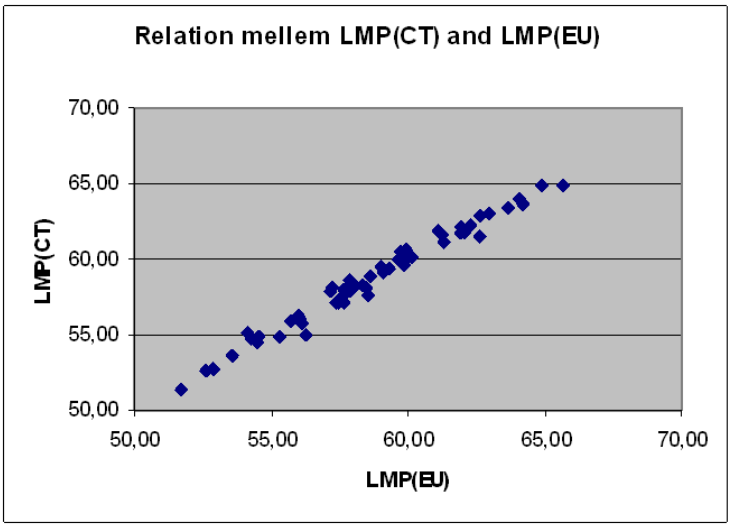
Relation to dissection with knife

Examinations have shown that dissection with knife do not provide the same amounts of meat, fat and bones as with CT. Furthermore, dissection with knife is very dependent on the procedure. It is shown [5] that if all tendons, membranes and glands are removed from the muscles, then the result is one unit of lean meat percent less than for a less time-consuming method.

Figure 4 shows the relationship between LMP_{CT} and LMP estimated by knife according to the EU definition of partial dissection [4]. LMP_{CT} is adjusted to the same scale as LMP. The Danish adjustment is given by $LMP_{CT,}$ adj = LMP_{CT}x0.9281 – 1.54.

Figure 4

Relationship between Virtual $LMP_{CT,}$ adj *and real LMP by knife. Danish trial 2008 RMSEP=0.48 LMP*



Scanning protocol

The following CT scanning protocol is chosen. It provides optimal scanning time and image quality. The time needed for cooling can be used to handle the carcass:

- The carcass is prepared to be a ”CT standard carcass”, see below
- Placing on the rind side
- P2-slice is used as a fixing point (hindmost rib)
- 10 mm slices, single slice
- 140 kV - 80 mA
- 47 cm field of view
- Standard reconstruction
- Owen-Hjort-Mohn classification of meat, fat and bone pixels
- Rind is defined as fat (in spite of different density)

Procedure

Cycle of operation for virtual dissection:

- The carcass is received from cold-storage room (5°C) and is prepared
- The scanner is calibrated
- The carcass is weighed
- The carcass is placed at full length at the couch
- P2 slice is marked by the operator (hindmost rib)
- The entire carcass is scanned
- Data is transferred to the PC
- Data is validated to the weight

- The carcass is returned for cutting

Definitions
- carcass

The left half of the carcass is scanned and possibly dissected. Only carcasses which are split correctly both along the back, head, sternum and stomach are selected. The definition of the hindmost rib is that a rib is a rib irrespective of size. If a carcass is not split correctly, the next carcass which fits the selection table is selected.

- Standard CT carcass

Before CT scanning, parting and dissection, the carcass must be cut up to a CT standard carcass which is:

- The slaughtered animals is bled and eviscerated
- Without tongue, bristles, hoofs and genital organs
- Split in the centre line at the back and ventral side
- Without leaf fat, kidneys, spinal cord, diaphragm and large surface cervical glands
- The jowl is loosened from a point just below the ear, 2 cm past the eye and the junction of the lips down to the natural ending of the jowl
- The head is cut off through the atlas bone and along the cranium edge so no neck meat is left on the cranium. The final cutting off of the head is made by following the incision made when cutting the jowl and continuing the cut past the ear. No auditory canal must be left at the side

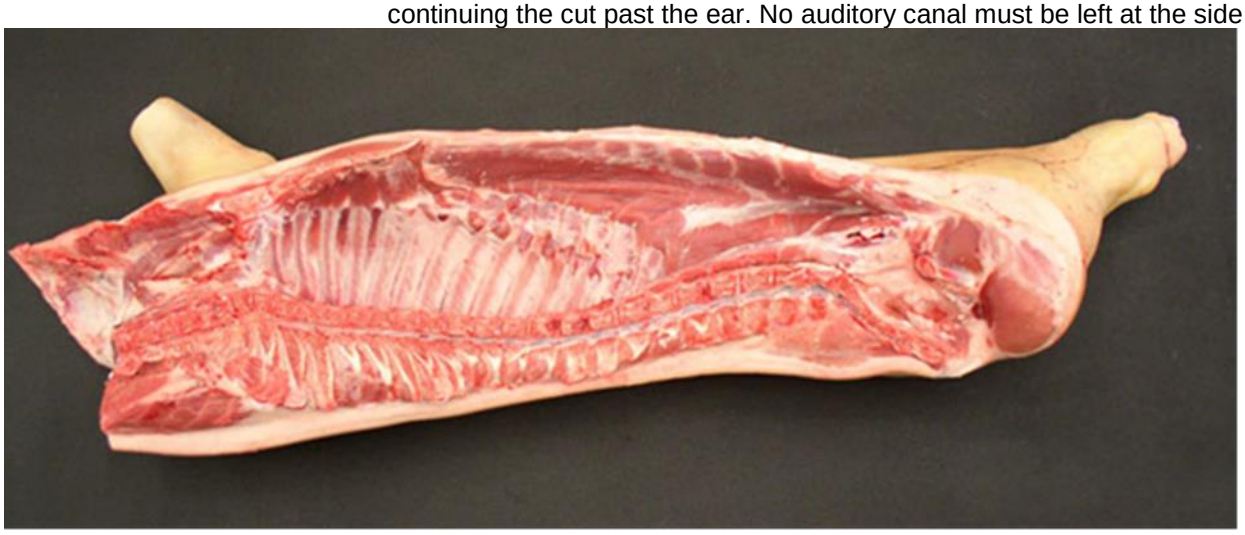


Figure 6

Danish standard carcass for CT scanning. The left half of the carcass is scanned and possibly dissected. Only carcasses which are split correctly both along the back, head, sternum and stomach are selected.

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References

[1] Martin Vester-Christensen, Søren G.H. Erbou, Mads F. Hansen, Eli V. Olsen, Lars B. Christensen, Marchen Hviid, Bjarne K. Ersbøll, Rasmus Larsen: Virtual dissection of pig carcasses. *Meat Science*, *Volume 81, Issue 4*, *April 2009*, *Pages 699-704*

[2] Eli V. Olsen: Classification/grading of carcasses; Pig Carcass classification in Europe. *Encyclopedia of Meat Sciences*.

[3] P.M.Nissen, H.Busk, M.Oksama, M.Seynaeve, M.Gispert, P.Walstra, I.Hansson, E.Olsen: The estimated accuracy of the EU reference dissection method for pig carcass classification. *Meat Science 73 (2006) 22-28.*

[4] COMMISSION REGULATION (EC) No 1249/2008 of 10 December 2008 laying down detailed rules on the implementation of the Community scales for the classification of beef, pig and sheep carcases and the reporting of prices thereof

[5] E. V. Olsen, L. B. Christensen, M.F.Hansen,M. Judas, R. Höreth: Challenges developing an instrumental reference for classification of pigs. ICoMST 2007.