# Density of lean meat tissue in pork - measured by CT

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**Abstract**

A CT-image of a carcass uses the principle of different tissue types absorbing Rontgen-energy differently. The metric used for monitoring the attenuation is the Hounsfield unit (HU), and the level will mainly depend upon the density of the tissue. Density of tissue is usually defined as the ratio of its mass (gram) to its volume ($cm^3$). When measured with CT, the density will be modelled by the HU and can be used to quantify density at any point in a carcass. The Hounsfield spectrum of the total lean meat content in a carcass will show some variation in the distribution of meat density, and the distribution will also differ between carcasses. This study shows that some of these variations are caused by differences in density between muscles (different fibre types etc.). Twenty-four carcasses which differ in weight and lean meat percentage were analyzed. Hounsfield spectra for the total lean meat content and in 4x4x4 $cm^3$ meat cubes in Longissimus Dorsi and Biceps Femoris were calculated and compared. Difference in HU was found between meat cubes from the two muscles. However the difference between carcasses was found not to be explained by the lean meat content or the carcass weight.

## Introduction

A Computed Tomography (CT) scan of a carcass is a non-invasive measurement of the absorption of Rontgen-energy anywhere in the body. Absorption of different tissue type differs mainly according to the tissue density. Density of tissue is usually defined as the ratio of its mass (gram) to its volume ($cm^3$). When measured with CT, the density will be expressed in Hounsfield units HU and is available at any point in a carcass, Kalender (2005). Thus, the output of a CT scan is a volume consisting of voxels. To each voxel a numerical value is linked and determined by the amount of meat, fat, membranes, bones etc. in the position in question. Earlier work exploits this to group all voxels in a carcass into three groups: Fat, meat and bones (Lyckegaard et al., 2006).

The Hounsfield spectrum of the total lean meat content shows some variation in the distribution of meat density (Figure 2, left). The distribution also differs between carcasses (Figure 2, middle). These differences can be caused by differences in density between muscles (different fibre types etc.) and by biological differences between the carcasses. Furthermore some difference is also caused by partial volume effects, which is inherent in the CT technology. A 1x1x10 $mm^3$ voxel can contain data from more than one tissue type.

The aim of this study is to investigate differences in meat density between Longissimus Dorsi (LD) and Biceps Femoris(BF), two pig muscles which differ in fibre types and protein content (Lawrie, 2002).

## Material and methods

24 carcasses from the Danish pig population was selected based on the fat depth between the 2nd and 3rd thoracic vertebra and slaughter weight covering the entire variation in the population. The pigs were slaughter at a commercial Danish slaughterhouse. The day after slaughtering the left side of the carcass was prepared for CT-scanning and dissection. The scanning was based on the 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. All voxels are grouped into three groups: fat, meat and bones, as a parallel to a traditional dissection made by a butcher. A 4x4x4 $cm^3$ cube from the centre in LD and BF is extracted from the CT data. The meat density is then modelled as the mean voxel value measured in HU.

To obtain consistency, a technique known as image registration is applied (Hajnal et al. 2001). In short it is the process of transforming a CT-volume of one carcass into a coordinate system of a reference. Thus making the anatomy of the registered carcasses as similar as possible in a least squares sense. The knowledge of the transformations of all carcasses onto the reference is valuable. It enables the propagation of measurement points from the reference onto the rest of the test population. Figure 1 shows a transverse CT-slice of the LD with an inserted square illustrating the extension of the extracted cube. The same method was used to obtain a cube in both LD and BF.

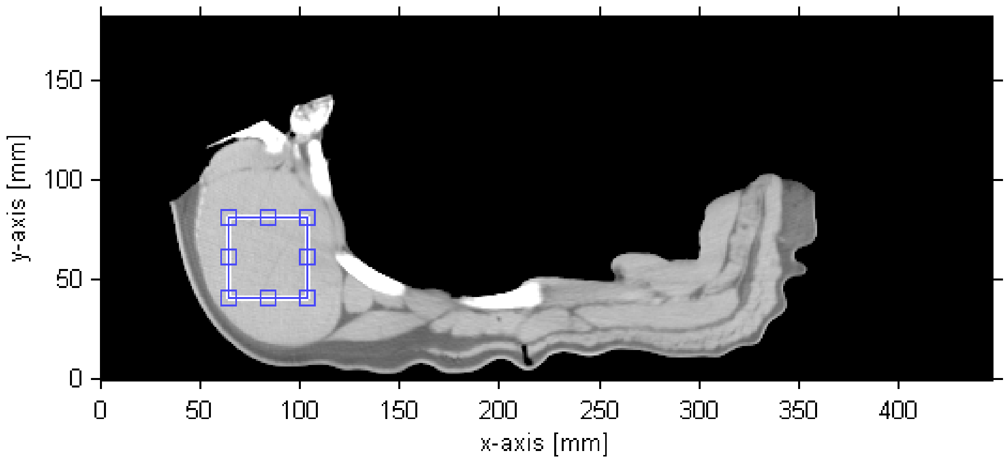



**Figure 1.**. Slice from the CT-volume depicting LD. The inserted square illustrates the extension of the extracted cube.

After scanning a traditional total dissection was made on the same carcass side to calculate the lean meat content. The two muscles Longissimus Dorsi and Biceps Femoris was minced after dissection. Protein content was analyzed in a sample of 200 g from each muscle/carcass by using the Kjeltec-Tecator system (ISO/IEC 17025).

**Results and discussions**

The mean value and standard deviation for lean meat content in the left side carcass, the total meat density, the meat density from LD and BF and protein content in LD and BF are shown in Table 1. A t-test shows that the densities in LD and BF are significantly different, as is the protein content.

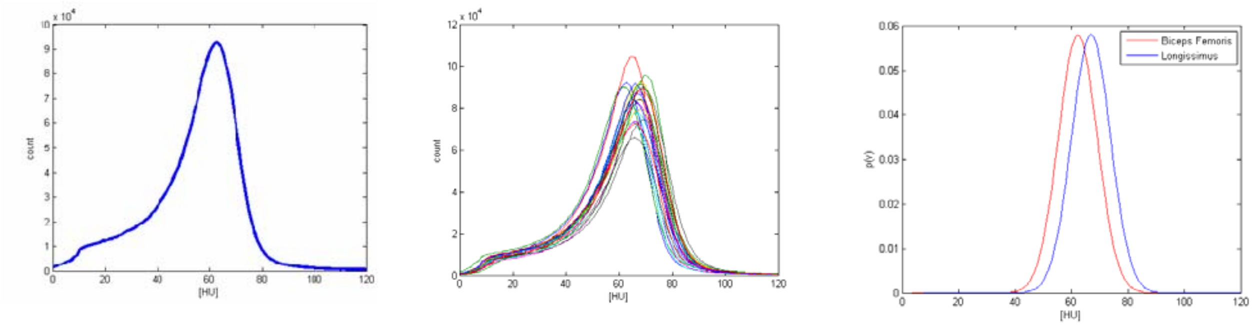
**Table 1.** Mean and std. for the analyzed traits in 24 carcasses

| | Carcass lean meat percent | Total carcass meat HU | LD, Meat density HU | BF, Meat density HU | LD, Protein percent | BF, Protein Percent |
|---|---|---|---|---|---|---|
| Mean* | 63.5 | 57.5 | 69.6[a] | 65.4[a] | 22.8[b] | 21.3[b] |
| STD | 3.0 | 1.7 | 2.1 | 2.4 | 0.3 | 0.3 |

* Different letter indicate that the mean is significant different at 0.1 % level $p<0.001$

The figures in Table 1 and Figure 2 shown that the total meat density measured with CT is lower and with a bigger variance than the meat density from the two muscles. The LD muscle has a significant higher density than BF and in figure 3 plots of values of the density and protein content show a clear distinction between LD and BF.

Nevertheless the correlation between meat density and protein content per muscle is not significant, and one explanation could be that the variation in protein content in the muscle is very low. The difference in muscle density across carcasses cannot be explained by either lean meat content or weight. Neither correlations are found to be significant, only between




Carcass All Carcasses BF+LD estimated distribution

**Figure 2.** Distribution of meat density, HU in carcass, LD and BF.

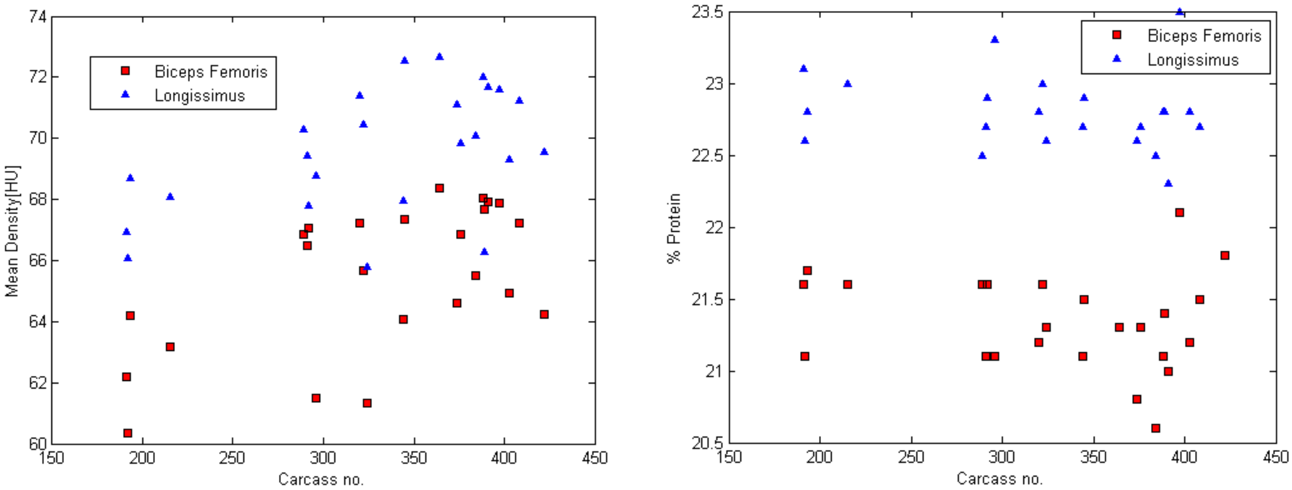



**Figure 3.** Plot of meat density and protein content in LD and BF.

**Conclusions**

LD and BF has different meat density measured with CT. The different level of meat density in the two muscles could be explained by different level of protein, but the correlation between meat density and protein content within a muscle was not significant. However as indicated in figure 3 there is a clear distinction between the two muscles both in the CT density measurements and in protein level.

In summary, some of the variation in total meat density for a carcass is caused by difference in density of the muscles, and not only because of partial volume effects.

**Reference**

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