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Comparative analysis of meat and fat tissue of Mangalica and meat-type hybrid pigs by means of Computerised Tomography

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ABSTRACT

The tissue composition of 6-6 Mangalica and meat-type pigs was determined by serial in vivo CT scanning. X-ray density frequency curves were developed from the whole body to determine the different tissue volumes. The calculated meat to fat ratio values were 3.4, 3.2 and 1.9 (meat-type pigs), while those of fat-type pigs were 1.0, 0.6 and 0.5, respectively, in the average weight of 30, 60 and 90 kg. In these weights, the meat percentage values were 35.5, 30.9 and 28.5 of the Mangalicas and 61.5, 57.7 and 53.2 % of meat-type pigs. The investigation of the tissue development in the body was carried out by means of 3D histograms. In the cross-sectional images the surface of the m. longissimus dorsi and also the m. semitendinosus was determined and the fat thickness at the back and the rump were measured. The intramuscular fat content was characterised by the average X-ray density value.
(Keywords: Pig, meat-type, Mangalica, tissue composition, computerized tomography)

INTRODUCTION

Pigs can be regarded as a highly variable species with as many as 500 breeds known worldwide. Its biological diversity is demonstrated by the differences found in the tissue and body composition of the meat- and fat-type pigs. Carcass traits have been extensively studied concerning meat-type pigs, however Mangalicas are much less known from this aspect. The growing intensity of the two genotypes is considerably different and among other factors it is detectable through the feed conversion ratio and tissue composition. The fattening period of the Mangalica is double than that of the meat-type pigs until reaching the same final weight.

Based on test slaughters of different genotypes comparative studies were already accomplished (*Adilovic et al*., 1985; *Rede et al*., 1986; *Rühl*, 1971). The specific characteristics of Mangalica meat and fat were also investigated (*Ender et al*., 2002). Having the same carcass weight Mangalica pigs attain substantially less skeletal muscle and more fat. They also show significantly higher fat thickness and lower loin depth compared to the meat-type pigs. According to *Straadt et al*. (2013), when crossing Duroc and the crossbreed Landrace/Yorkshire with the alternative breeds Iberian and Mangalica the pork loins of the offspring did not differ generally in odour, appearance or flavour/taste when compared with the traditional DLY crossbreed (*Straadt et al*., 2013).

Computed tomography scanning has the ability to describe and follow the changes in the whole body composition across time in live animals, in a non-invasive and nondestructive manner (*Bunger et al*., 2011). Having the advantage of an *in vivo* application, multiple measurements can be taken on the same individuals. Tissue volumes can then be transformed into very accurate tissue weights by multiplying them by the tissue density values (*Lambe et al*., 2013). This procedure was applied by numerous investigators for body composition determination and for making selection decisions in pig research (*Horn et al*., 1997; *Szabó et al*., 1999; *Thompson and Kinghorn*, 1992; *Vangen*, 1992).

Parallel with the current study, cine MRI examinations were performed to characterise the heart performance of the two pig genotypes (*Petrási et al*., 2003). Acceording to the authors Mangalicas possess considerably higher circulatory reserves than the meat-type pigs.

The objective of the present *in vivo* analysis by means of computerised tomography was to conduct a comparative study of tissue composition of meat-type and Mangalica pigs weighing 30, 60 and 90 kg, respectively.

MATERIALS AND METHODS

During the course of our investigation six castrated meat-type (Hungarian Large White × Belgian Landrace × Pietrain × Norwegian Landrace) and six castrated 'dirty' white Mangalica pigs were measured at different weight categories (30, 60 and 90 kg). Meat-type pigs were set into small groups of 25–30 individuals applying intensive housing, meanwhile Mangalicas were individually penned in outdoor system. All animals were fed according to their genotype and age.

The CT scanning of the pigs was performed using a Siemens Somatom S40 equipment at the Institute of Diagnostic Imaging and Radiation Oncology of the Kaposvár University. The details of the applied premedication and inhalation anaesthesia were already published (*Petrási et al*., 2001). The data collection was performed in spiral mode. Consecutive cross-sectional scans of 10 mm slice thickness were reconstructed from the raw data covering the whole body. The picture-forming pixels of the scans are in fact small prisms (voxel) with definite volume (10 mm^3). It is possible, therefore, to determine the part of the total volume of the examined scan that falls into the Hounsfield unit (HU) interval of interest. This enabled us to estimate the volume of different tissues of the body from serial scans (*Romvári et al*., 1996). By the image evaluation from the total Hounsfield scale only 400 density values, ranging from –200 to +200, were taken into account, belonging to fat, and muscle tissue (water = 0). From these values all 10 neighbouring ones were summarised, resulting in altogether 40 Hounsfield variables (HUv) (*Romvári et al*., 1998).

The tissue composition and its changes were demonstrated by means of histograms. Using volumetric estimation, the total muscle percentage (sum HUv22- HUv40 / HUv1- HUv40 x 100), and the muscle to fat ratio (HUv22- HUv40 / HUv1- HUv18) was determined (without intestines). Moreover, on the cross-sectional images the cross-sectional area and the average X-ray density of *m. longissimus dorsi* and *m. semitendinosus* were calculated at the kidneys and at the knee joint, respectively. Furthermore, the fat thickness was also measured. Finally, twenty-five scans representing identical anatomic points (from the neck (atlas) to the hock) were used for the graphical demonstration of the body composition. Based on the 40 HUv, 3D histograms were developed with the method of the negative exponential interpolation to characterise the amount of fat and muscle tissue of the body at the live weight of 30 and 90 kg.

RESULTS AND DISCUSSION

In order to determine the tissue composition of the meat-type and Mangalica pigs, X-ray density distributions are depicted (*Figures 1-2*), where the frequency of voxels are illustrated on the Y-axis and the HU variables (ranging from –200 to +200) on the X-axis. Concerning meat-type pigs, clear peaks can seen at the section of the X-axes corresponding to muscle (HU22-HU40) , while less pronounced peaks were found at the density values related to fat (HU1-HU18) (*Figure 1*). Muscle content was substantial at all times of investigation showing intensive deposition. Fat ratio between the weight range of 30–90 kg was smaller. This tendency was the same for all weight categories. Based on the volumetric data, the calculated muscle and fat volumes were 15.5, 24.8, 35.2 and 4.6, 7.8, 17.6 dm^3, respectively in the average weight of 30, 60 and 90 kg. Similarly measured values of the Mangalica pigs can be viewed at *Figure 2*.

Figure 1

Histograms of meat-type pigs in the -200 to +200 Hounsfield interval (1–40 HU variables)

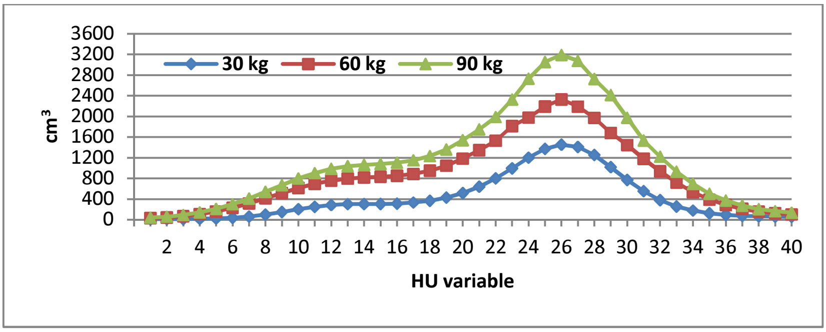
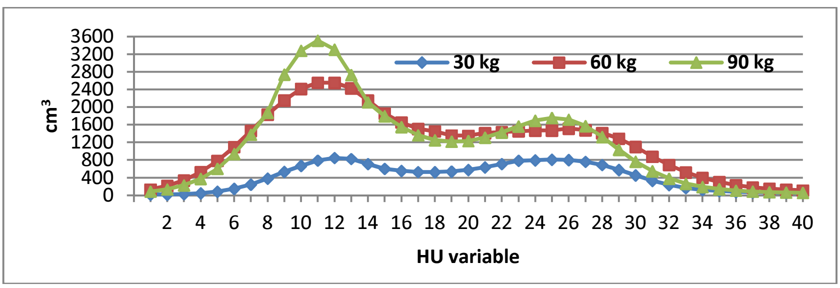


Figure 2

Histograms of mangalica pigs in the -200 to +200 Hounsfield interval (1–40 HU variable)



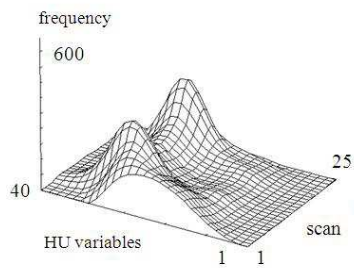
Mangalica pigs weighing 30 kg showed approximately identical peaks related to muscle and fat, respectively. At the second time of investigation of these animals weighing 60 kg, an intensive fat deposition was observed coupled with a less intensive lean gain. At the body weight of 90 kg no lean tissue gain could be found, however further substantial increase of the fat ratio was detected. The concerning muscle and fat volume data were 8.6, 15.1, 17.9 and 8.9, 27.3, 37.4 dm^3, respectively, in the three weight categories.

On the 3D histograms the serial number of the pictures was illustrated on the X-axis, the HU variables on the Y-axis (numbering from 40 to l after reducing by 10 from + 200 to - 200) and the frequency of the density values on the Z-axis. For the comparability of the histograms prepared from the different genotypes identical scaling was used. In the case of the 30 kg animals, two characteristic peaks can be clearly recognized in the muscle tissue interval (HUv 21–40). The first from the head is the periphery of the scapular arch (2–8). The next, something lower part is the spine, after which the highest "peak", formed by the ham can be seen (18–25). In the fat interval (HUv 2–18) remarkable differences can be seen within the two genotypes, especially in the abdominal region (*Figure 3*). According to the 3D surface and volumetric data the Mangalica can be characterized with equal volume of fat and muscle tissue in the examined liveweight.

The tissue distribution in 90 kg are very similar to that of the animals weighing 30 kg. The earlier described differences of the two genotypes became stronger as the meat-type and the Mangalica pigs showed an intensive muscle and fat tissue deposition (*Figure 4*).

Figure 3

3D histograms of meat-type (left) and Mangalica pig (right) at 30 kg



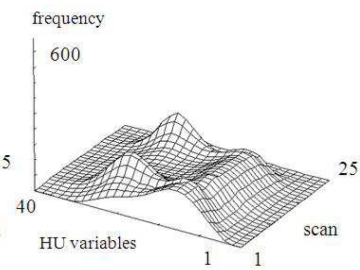
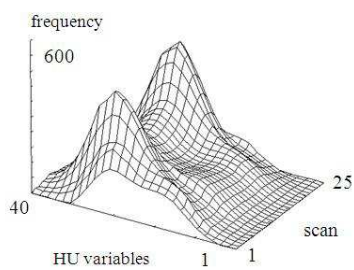
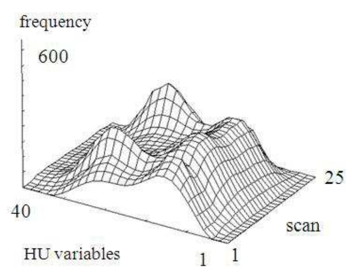


Figure 4

3D histograms of meat-type (left) and Mangalica pig (right) at 90 kg





Examining the tissue composition of the analysed meat- and fat-type pigs opposite muscle to fat ratio was found. Having the same body weight, the muscle content of the meat-type pigs was almost identical with the fat content of the Mangalicas. At 30 kg, being the first stage of our investigation, the lean meat percentages of 61.5% and 35.5% were recorded on the meat-type and on the Mangalica pigs, respectively, showing 3.4 and 1.0 muscle to fat ratios. Based on the CT scanning a dominant lean gain and fat deposition was found on the meat-type and Mangalica pigs, coupled with an increasing body weight. At 60 kg body weight the lean meat percentage of the former group showed 57.7% lean meat and 3.2 muscle to fat ratio, while the related values of the latter group were 30.9% and 0.6, respectively. At the final stage of investigation (90 kg), practically no muscle deposition was found in the Mangalica pigs while an increase in the fat tissue volume could be detected, compared to the preceding time of investigation. At this specific time their lean meat percentage and muscle to fat ratio decreased to 28.5% and 0.5, respectively. Compared to the data measured at the live weight of 60 kg, further intensive growth was found by the meat-type pigs, resulting in a lean meat percentage and muscle to fat ratio of 53.2% and 1.9, respectively.

Figure 5

CT images at the level of the kidney of meat- (left) and fat-type (right) pig at 90 kg

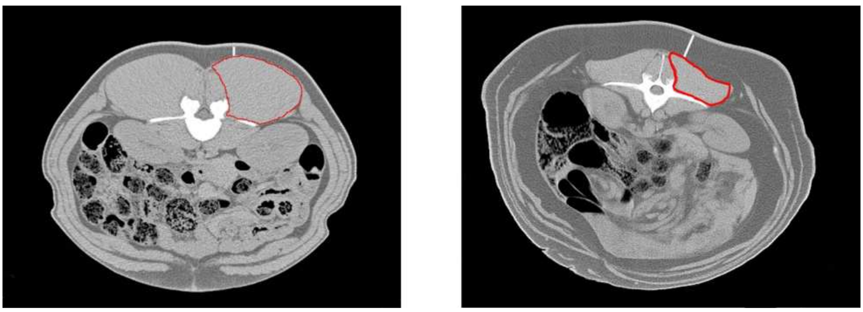
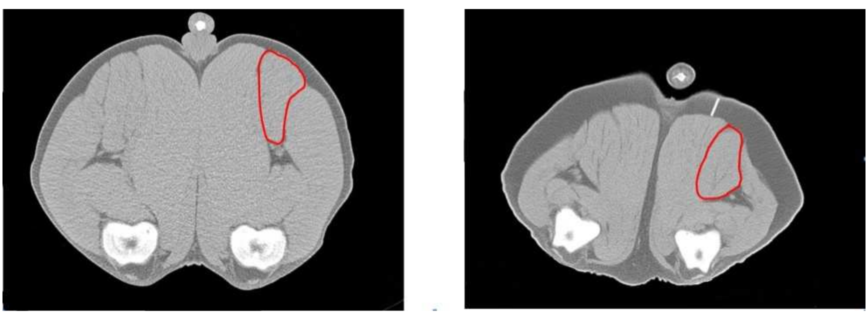


Figure 6

CT images at the level of the knee joint of meat- (left) and fat-type (right) pig at 90 kg



At the live weight of 90 kg basic anatomical differences of the two examined genotypes can be seen on *Figures 5*. and *6*. showing cross-sectional images at the level of the kidney, and ham (and knee joint, resulted from the stretched hind limbs). Extreme differences between the meat- and fat-type pigs are clearly visible in the images. The average cross sectional surface values of the right *m. longissimus dorsi* were determined, which showed 45 and 23 cm^2 in the case of the meat- and fat-type pigs, respectively, verifying the reported results (38.4 and 20.9 cm^2) (12). The concerning values of *m. semitendinosus* were 31 and 24 cm^2 at the liveweight of 90 kg, respectively.

Besides the loin area, fat depth values were also provided by the CT images measured 8 cm laterally from the spine. At the areas of kidney and rump the recorded fat thickness values were 53, 38 and 18, 16 mm on average on the Mangalica and meat-type pigs, respectively. The previously mentioned authors recorded fat depth values of 48, 58 mm on Mangalicas and 28, 38 mm on meat-type pigs. The former values were rather similar to those found in the present investigation but the latter values differed significantly as a result of changes took place during the past approximately 20 years. Using the same CT images as before, frequency curves of the loin and ham were depicted in order to quantitatively analyse IMF content on pigs weighing 30 and 90 kg, using average X-ray density values. Concerning meat-type pigs 53 and 58 HU were found on the loin meanwhile 52 HU were recorded on the ham at both (consecutive) times of investigation. Average density values of 46, 47 and 32, 34 were obtained on the loin and ham of Mangalica pigs. The latter results of both muscles demonstrate that intramuscaular fat of the Mangalica pigs – especially on the ham – exceeds that of the meat-type pigs causing lower HU variables. Similar findings were described about the IMF content comparing four genotypes including F2 Mangalica pigs (*Kipfmuller et al*., 2000).

CONCLUSIONS

The phenomenon that potential daily lean tissue growth of meat-type pigs can be almost constant for most of the fattening period was justified by the received results (*Whittemore*, 1986). The growing intensity and capacity of lean tissue of the Mangalica pigs was low, while the fat deposition was significant during the whole period of the investigation. At the body weight of 60 kg, the lean gain was practically stopped, while the fat deposition continued on considerably. The applied negative exponential interpolation presented through 3D histograms is a clearly suitable method for describing growth characteristics and tissue deposition differences of different genotypes as demonstrated on rabbits (*Romvári et al*., 1998), turkey (*Andrássy-Baka et al*., 2003), and fish (*Hancz et al*., 2003). Regarding Mangalica pigs (contrary to meat-type conspecies), our results clearly demonstrated the gain of substantial amount of IMF during the growing period also showing significantly higher fat thickness values than that of the meat-type pigs, verifying the results based on test slaughters (*Adilovic et al*., 1985; *Rede et al*., 1986). In our opinion the *in vivo* CT scanning is an appropriate method to study the IMF content with certain limitation, namely the sensitivity of the process is increasing with the increasing IMF content.

The applied non invasive procedures are appropriate to monitor the changes of body composition of extremely different pig genotypes during the growing period and also the selection-induced alterations are clearly demonstrated within the species. The *in vivo* determination of body composition, particularly lean and fat content, can provide an effective tool to be used in the selection.

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