FEMUR STRENGTH OF PIGS

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Introduction

Bones provide the main structural support for the body. Bony tissue is classified as either compact bone on the bone surface or spongy bone in the deeper layers. The main structural elements of bones are the epiphysis at both ends, with a joint surface, and the diaphysis in the middle. In the core of the diaphysis is the medulla containing soft material. Bones contain both inorganic mineral and organic components. The inorganic components, mostly calcium and phosphorous, constitute 65-70 percent of bone weight (Ross *et al.*, 1995). The inorganic salts form a solid porous material able to resist pressure. The other constituents, connective tissue, bone cells, nerves, arteries and veins etc. are embedded in bone matrix. The organic part, mostly collagen, increases the tensile properties, especially resistance to bending. There is, however, a need for better understanding of bone strength of pigs because their bones break easily during transport to the abattoir and during the slaughter process, resulting in loss of carcass weight. The joint defects, e.g. osteochondrosis, are also rather common. Bone and joint defects have also been linked to high growth rate of pigs. Bone weakness and other bone problems also constitute significant animal welfare issues.

This study investigated the effect of femur dimensions, mineral content and mineral density on femur strength in pigs slaughtered at the same age.

Materials and Methods

The study consisted of 18 pigs from nine litters (9 gilts and 9 barrows): 7 Landrace, 7 Yorkshire and 4 crossbreed. The pigs were housed individually in pens. A barley-soybean based diet was used. The pigs were slaughtered at the age of 165 ± 2 d at the experimental abattoir of University of Helsinki, Department of Food Technology. One day after slaughter the bones were dissected from the carcasses and weighed. The femur was weighed separately.

Four rings (thickness 7 mm) were cut from the diaphysis of femur. The bone area and wall thickness of the ring were measured with an image analysis system using Zeiss stereo microscope (Stemi DV4, Carl Zeiss, Germany), AxioCam camera (Carl Zeiss AxioCamera MRc, Germany) and KS300 image analysis computer program (KS300, Carl Zeiss Vision GmbH, Germany). Bone mineral content (BMC) and bone mineral density (BMD) were measured from the femur rings by scanning all femur rings at the same time with dual-energy X-ray absorptiometry (DXA) and using a Lunar PIXImus 2 densitometer (software version 1.42.006.010; Lunar Corporation, Madison, WI). After measuring the femur ring dimensions, the rings were broken with Instron compressometer (Instron TM-M, Instron Ltd., UK). The maximum force required to break the ring of bone was recorded.

The statistical analysis was performed with SAS Program version 8.02 (SAS, 1999). Linear regression analysis (REG procedure) was used to explain the variation in femur ring strength.

Results and Discussion

The weight of pigs at slaughter was on average 108 kg and the carcass weight was on average 83.9 kg. The bone content in the carcass was on average 14.9% (Table 1).

Table 1: The live and carcass weights of the pigs and the measured parameters of femur.

N	18
Live weight, kg	108.0 ± 7.0
Carcass weight, kg	83.9 ± 5.6
% bone in the carcass	14.9 ± 1.1
Femur weight, g	325 ± 44
Femur ring area, cm^2	3.2 ± 0.40
Femur wall thickness, mm	4.7 ± 0.5
Femur ring strength, kg	38.0 ± 10.2
Bone mineral content per femur ring, g (BMC)	2.45 ± 0.31
Bone mineral density, g/cm^2 (BMD)	0.76 ± 0.06

The femur ring area was on average 3.2 cm^2, but the variation was large ranging from 2.5 to 4.1 cm^2, although the pigs were slaughtered at the same age. Femur wall thickness was on average 4.7 mm ranging from 3.9 to 5.4 mm. Bone mineral content (BMC) and density (BMD) measurements were made from the femur rings. The correlation between

BMC values and femur weight was weakly positive (r=0.458, P=0.0558). The reason for this was the larger femur ring area in heavier femurs (r=0.808, P<0.0001).
Femur ring strength was on average 38 kg varying from 27.6 to 71.4 kg. Keller (1994) reported high positive correlations between bone mineral mass and bone strength. In this study, however, several measured traits explained femur ring strength. Live weight, carcass weight, femur ring area, femur wall thickness and BMC accounted for 84% of the variation in femur ring strength while femur ring area, femur wall thickness and BMC accounted for 73% of the variation in femur ring strength (Table 2). The results showed that the bone mass in pigs must be large enough with high mineral content to guarantee strong bones. Thick femur wall strengthens the bone.

Table 2: Coefficients of determination (R^2) for simple linear regressions of measured traits on femur strength.

	R^2
Live weight, carcass weight, femur weight, femur ring area, femur wall thickness, BMD, BMC	0.85
Live weight (P<0.013), carcass weight (0.021), femur ring area (P<0.0001), femur wall thickness (P<0.0004), BMC (P<0.0001)	0.84
Femur ring area (P<0.0003), femur wall thickness (P<0.0059), BMC (P<0.0001)	0.73

Conclusions

For strong bones in pigs it is required that the bone mass is large with a high mineral content.

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References

Keller, T.S. (1994). Predicting the compressive mechanical behaviour of bone. Journal.of Biomechanics 27: 1159-1168.
Ross, M.H., Romrell, L.J. and Kaye, G.I. (1995). Histology: a text and atlas. Williams & Wilkins.
SAS. (1999). SAS, Version 8.2, SAS Institute Inc., Cary, NC.