MORPHOMETRIC CHARACTERISTICS OF PIG CARCASSES: EFFECTS OF GENETIC AND REARING BACKGROUND AND CONSEQUENCES FOR POST-MORTEM METABOLISM

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Background

Pig selection companies aim to improve simultaneously carcass morphology, especially muscularity, defined as muscle thickness relative to skeleton dimensions (Purchas, 1991), and meat leanness. It is likely that post-mortem metabolism and muscle morphology are related. Post-mortem metabolism is strongly influenced by metabolism during the pre-slaughter period (Lawrie, 1966). During this period, muscle morphology, which influences the way muscles are used, probably affects post-mortem metabolism and consequently technological meat qualities. Improvement of muscularity may influence post-mortem metabolism in relation to changes in contractile and metabolic fibre type (Klont et al. 1998, Laville et al., 2002). As alternative pork production (outdoor production, different genetic types) gains an increasingly important place on the market, it is further relevant to evaluate effects of rearing environment and genetic background on carcass composition and meat quality. This study is part of a larger study (see Astruc et al, 2004, for more details).

Objectives

To study 1) effects of rearing environment and genetic background on carcass morphology and on technological meat quality and 2) possible relationships between shape and size of body parts and post-mortem metabolism.

Materials and methods

Twenty-five Large White (LW) and 52 Duroc (D) crosses (pure bred LW and D sires, LW x French Landrace dams) were reared indoors (slatted floor, 6.3 m^2) or in fields (850 m^2) with huts over two consecutive years (April-October), in an unequally balanced design. Pigs were slaughtered at 150 kg body weight; half of each treatment group after mixing and overnight lairage, the other half immediately upon arrival at the abattoir. Various morphometric measurements were taken on carcass images (Fig. 1). Glycogen and lactate content, temperature and pH, at 45 min and 24 h after bleeding, were evaluated in the *Longissimus lumborum* (LL) and the *Semimembranosis* (SM). Treatment effects have been assessed with analyses of variance. For the study of correlations, simple and multiple regression analyses have been associated analyses of covariance to correct for treatment effects and with pooled Pearson correlations, which take into account the means of each treatment group, rather than the overall means.

Results and discussion

The second year, summer temperatures were exceptionally high, repeatedly reaching 35 to 40 °C. Carcass weight was not influenced by genetic background or type of housing, but tended to be lower the second year (128.8 ± 2.5 *vs* 123.1 ± 1.5; p=0.08). Carcass weight was positively correlated with leg and body lengths for the both crosses (Table 1). Due to these combined effect, leg and body lengths were lower the second year. LW crosses or indoor reared pigs had longer legs ($p<0.05$) and this was not caused by differences in carcass weight. The D cross had a larger external angle of the ham ($p<0.05$) while outdoor bred pigs had greater thoracic depth ($p<0.00001$). Compared to the first year, the second year, length of the iliac bone and thoracic depth were reduced and pelvis width, and posterior and internal angles of the ham were increased (p between 0.03 and 0.00001), but these variables were unrelated to carcass weight. For the LW cross, body length was negatively and for the D cross, positively correlated with posterior angle of the ham (Table 2). Internal angle of the ham was correlated with iliac bone length, pelvis width and posterior angle of the ham for the D cross (Table 2). Similar tendencies existed for the LW cross, but Pearson correlations, pooled over the two years did not reach significance, possibly to insufficient animal numbers. For example, unpooled Pearson

correlations found a positive correlation between internal and posterior angle of the ham ($r=0.43$; $p<0.05$) for the LW cross.

Thus, data show only a few direct effects of genetic and rearing background on morphometric characteristics. Year of rearing had more pronounced effects on all parameters. Data on the D cross show that shapes and sizes of different body parts are related to each other: pigs with a rounder interior angle of the ham have a rounder posterior angle of the ham and a larger pelvis with a shorter iliac bone. The different fused bones of the pelvis receive attachments from various muscles of the thigh and from the *Psoas major*, allowing posture maintenance and flexing of the thigh upon the pelvis (Barone, 1980). Muscles and bones act together in growth and movement (Barone, 1980) and the observed relationships show that size and length of the pelvis and shape of the ham are connected. More data are needed to determine exact relationships between shape of the pelvis and of ham muscles in the LW cross. The two genetic types showed opposite correlations between body length and posterior angle of the ham indicating that differences between breeds exist also.

Glycogen content was higher in LW than D crosses at both times in both muscles (p between 0.08 and 0.001) and higher in outdoors than indoors reared pigs ($p<0.001$). Lactate content was higher the first year for both sampling times in both muscles ($p<0.01$). For the LL, lactate content (24 h) was lower and ultimate pH was higher in pigs slaughtered after mixing and lairage ($p<0.01$).

For the D cross, SM glycogen content (both times), and lactate content (24 h), were negatively correlated with external angle of the ham (Table 3; Fig. 2). These correlations were probably due to negative correlations between this angle of the ham and pre-slaughter glycogen of the SM muscle: glycolytic potential (GP; [lactate]+2x[glycogen]) at 45 minutes, reflecting muscle glycogen content at the moment of slaughter (Monin and Sellier, 1985), was also negatively correlated with external angle of the ham. GP was further positively correlated with glycogen content of the SM at both times ($p<0.0001$) and lactate content at 24 h ($p<0.0001$). SM lactate content (24 h) was simultaneously, negatively correlated with iliac bone length (Table 3). For the LW cross, the external angle of the ham was negatively correlated with SM lactate content (24 h) and positively with SM and LL temperature (45 min; Table 3). Lactate content of the LL (24 h) was negatively correlated with the iliac bone length and positively with pelvis width for D and LW crosses, respectively (Table 3). Temperature (both times) of the LL was positively correlated with iliac bone length for the D cross (Table 3).

For both genetic types and for both muscles, at 45 min, pH was positively correlated with glycogen content (e.g. D, SM: $r=0.45$; $p<0.01$) and negatively with lactate content (e.g. D, SM: $r=-0.73$; $p<0.001$). Ultimate pH was negatively correlated with GP (e.g. D, SM: $r=-0.31$; $p<0.05$) and with lactate content at 24 h (e.g. D, SM: $r=-0.28$; $p<0.05$). Despite these correlations, initial and ultimate pH's of the 2 muscles were not correlated with morphometric measurements.

Thus, morphometric characteristics are related to post-mortem metabolism, with similarities and differences between the two genetic types. LL post-mortem metabolism was related to pelvis shape and size, differently according to genetic cross. Pigs of both genetic types with rounder posterior angles of the ham had lower SM lactate content. Data on the D cross suggest that lower pre-mortem glycogen levels explain at least part of this effect. Data show further that D crossbreds with a longer iliac bone produce less post-mortem lactate. Lower pre-mortem glycogen content may be simultaneously related to lower resting glycogen levels (i.e. before mixing/transport) and higher energy expenditure of the muscle during the pre-slaughter period. However, generally, the larger a given muscle is, the more glycolytic fibres it contains (Laville et al., 2002), it is therefore expected that pigs with rounder external angles of the ham had higher muscle glycogen content. Shape of the external angle measures predominantly the thickness of the *Biceps femoris* and may be a poor estimate of SM size, more closely related to the posterior angle of the ham. Possibly, pigs with a rounder external angle or longer iliac bone had higher energy expenditure during the pre-slaughter period, indicating that efficiency of certain muscles in terms of energy use depends on shape or other characteristics of surrounding muscle and bone structures.

Conclusions

Shape and size of bones and muscles influence post-mortem metabolism. While data on the D cross show clearly relationships between the shape of pelvis and ham and post-mortem glycogen metabolism, more data on LW crosses are needed to confirm that at least part of these relationships exists in this breed. The observed variations between genetic types and years suggest that other factors (possibly related to pre-slaughter stress reactions) may intervene and modify or cancel some of the relationships between conformation and post-mortem metabolism.

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Figures and Tables

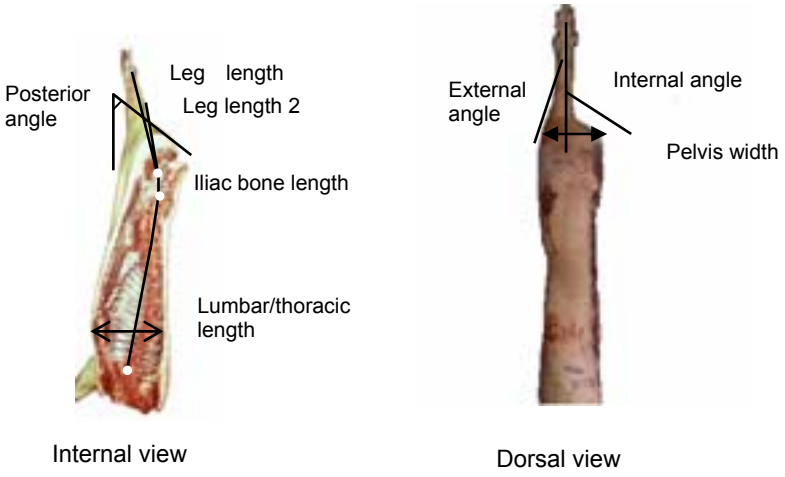

Fig. 1. Morphometric measurements on the carcass images. Iliac bone length showed large variations in sheep in an earlier study (Laville pers. obs.). Measurements of angles reflect muscle plumpness.

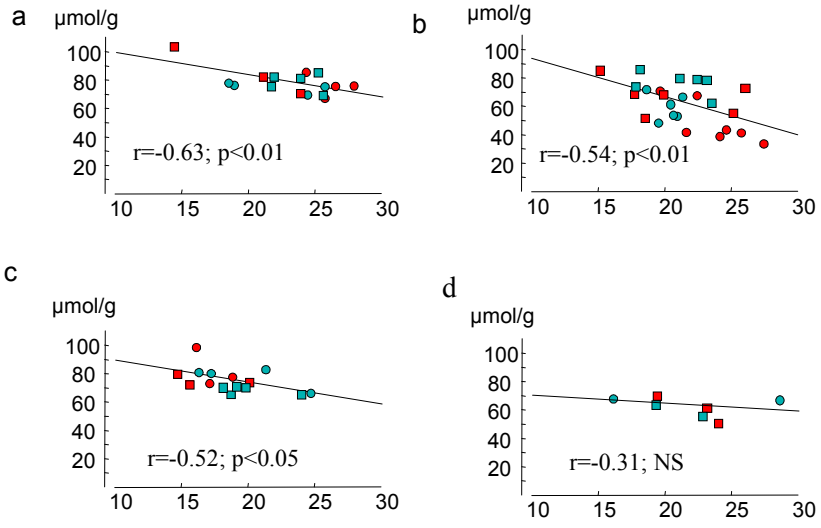

Fig. 2. Negative correlations between external angle of the ham and lactate content at 24 h for the D cross, during the first (a) and second year (b) and LW cross, in the first (c) and second year (d). Circles and square represent indoor and outdoor rearing, respectively. Red and green colours represent slaughter after mixing and lairage, and without mixing and lairage, respectively.

Table 1. Pearson correlations (pooled over the two years) between carcass weight and leg and body length, for the two genetic types separately.

	Large White cross		Duroc cross	
	r	p	r	p
Carcass weight, with				
Leg length 1	0.55	0.005	0.46	0.001
Leg length 2	0.47	0.02	0.33	0.02
Lumbar/thoracic length	0.50	0.01	0.54	0.0001

Table 2. Morphometric characteristics described by r-values for simple (pooled over the two years) and multiple regression analyses for the two genetic types separately.

	Large White cross		Duroc cross	
	Simple regression			
	Pooled r	p	Pooled r	p
Lumbar/thoracic length, with				
Posterior angle of the ham	-0.63	0.001	0.32	0.02
			Multiple regression	
			Semi-partial r	p
Internal angle of the ham, with				
Pelvis width			0.41	0.001
Iliac bone length			-0.42	0.001
Posterior angle of the ham			0.33	0.01

Table 3. Pearson correlations (pooled over the two years) between morphometric characteristics and post-mortem metabolism-related parameters, for the two genetic types separately.

	Large White cross		Duroc cross	
	r	p	r	p
External angle of the ham, with				
SM glycolytic potential, 45 min			-0.41	0.01
SM glycogen content, 45 min			-0.45	0.01
SM glycogen content, 24 h			-0.39	0.01
SM lactate content, 24 h	-0.44	0.05	-0.54	0.001
SM temperature, 45 min	0.53	0.02		
LL temperature 45 min	0.63	0.01		
Iliac bone length, with				
SM lactate content, 24 h			-0.48	0.01
LL lactate content, 24 h			-0.56	0.0001
LL temperature, 45 min			0.30	0.04
LL temperature, 24 h			0.44	0.01
Pelvis width, with				
LL lactate content, 24 h	0.69	0.001		