MUSCLE TRAITS, PRESLAUGHTER STRESS AND MEAT QUALITY INDICATORS AS INFLUENCED BY PIG REARING SYSTEM

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Introduction

Consumers often associate alternative pig rearing systems like outdoor housing or straw bedding with better animal welfare and meat quality, and lower environmental impact (Ngapo *et al.*, 2003). However, effects of alternative rearing systems on pork quality often differ between studies, possibly due to differences in housing conditions, pig genotype, and behavioural and physiological responses of pigs to preslaughter handling. An additional advantage of alternative systems may be the larger group sizes, due to increased space allowance, that reduces the need for mixing pigs before slaughter, thus avoiding fights between animals and therefore reduces variability in pork quality. This study aimed to evaluate the effects of different alternative rearing systems and preslaughter handling procedures on muscle metabolism, preslaughter stress and meat quality indicators, compared to the conventional system.

Materials and Methods

On 3 different rearing sites, 3 alternative pig rearing systems, free range (**FR**, 150 m²/pig, 1 group of 40 pigs), outdoor courtyard with a shed (**OUT**, 1.3 m²/pig, 4 groups of 10 pigs), and indoor housing on straw bedding (**ST**, 1.3 m²/pig, 2 groups of 25 pigs) were each compared with the conventional or control system (1 per site) (**CONT**, 0.65 m²/pig, fully slatted floor, 4 pens of 10 pigs). FR and ST pigs and their controls were (Large White X Pietrain) X (Large White X Landrace) crossbreeds, and OUT pigs and their controls were synthetic line X (Large White X Landrace) crossbreeds. Pigs were reared during the winter and fed *ad libitum* with conventional diets. Pigs from the same rearing site were slaughtered on the same day in a commercial slaughterhouse 80-km away. With the exception of FR pigs, animals within comparisons and systems were mixed to form a single group during lairage. Blood and urine samples were taken at evisceration to determine levels of plasma glucose, lactate, creatine kinase (**CK**) and cortisol, as well as of urine cortisol, adrenaline and noradrenaline (Foury *et al.*, 2005). Thirty min after slaughter, **pH1** of *Semimembranosus* muscle (**SM**) was measured and an SM sample was taken to determine lactate dehydrogenase (**LDH**) and citrate synthase (**CS**) activities and glycolytic potential (**GP**) (Lebret *et al.*, 2006). The next day, the number of skin lesions (>3 cm) on the right carcass side and SM ultimate pH (**pHu**) were recorded. Within comparisons, the effect of rearing system was tested using analysis of variance (proc GLM, SAS). Halothane genotype effect (NN or Nn) was added for FR-CONT and ST-CONT comparisons. Urine and plasma hormones and CK levels were analysed after logarithmic transformation to fit a normal distribution. Correlations between biological parameters were calculated using the "Pooled Pearson" method to correct for treatment effects.

Results and Discussion

The rearing system influenced muscle metabolism and quality traits (Table 1). Compared to their controls, FR and ST pigs had a higher CS activity and FR pigs had a lower LDH activity, whereas the OUT system had no effect on muscle metabolism. The increased SM oxidative capacity with alternative rearing is in agreement with the findings of Gentry *et al.*, (2004). However, the present study shows that effects depend on rearing system, and possibly genotype. Muscle pH1 and lactate levels (not shown) were not influenced by rearing conditions, in accordance with Lebret *et al.*, (2006). The OUT system did not affect GP or pHu of SM, but FR and ST pigs had higher GP and lower pHu, suggesting higher resting muscle glycogen stores and/or lower glycogen consumption during preslaughter for these pigs. A similar but lower effect of alternative (straw bedding + outdoor access) or free range rearing was previously found on SM GP and pHu (Terlouw *et al.*, 2004; Lebret *et al.*, 2006). FR pigs had fewer skin lesions, lower plasma CK (indicator of cell suffering consecutively to high muscle activity) and lower urine adrenaline and noradrenaline, and higher plasma glucose, than their controls. However plasma lactate (not shown), and cortisol and urine cortisol levels were unaffected. OUT pigs had fewer skin lesions and lower CK activity than controls, but similar levels of other plasma and urine components. The ST system did not have a significant effect on skin lesions, plasma and urine metabolites, or hormone levels.

Strong correlations were found between biological parameters (Table 2). Plasma CK activity was positively correlated with urine catecholamines and the number of skin lesions. Skin lesions were correlated with urine adrenaline levels. GP was negatively correlated with plasma CK and urine cortisol and catecholamines, whereas strong correlations were found between pHu and plasma CK, urine catecholamines, and skin lesions ($r=0.38$, $P<0.001$). These correlations, the lesser skin damage and lower levels of plasma CK and urine catecholamines indicate that the higher GP and lower pHu of the FR pigs are at least in part explained by their lower physical exercise and/or stress during the preslaughter period (no mixing) (Foury *et al.*, 2005). In accordance, we observed fewer aggressive events (> 5 s) during the first hour in

lairage for the pigs reared in alternative systems than for controls, independently to mixing in lairage (13 vs 25 aggressive events for FR and CONT pigs; 32 vs 70 for OUT and CONT pigs; 71 vs 180 for ST and CONT pigs, respectively). In agreement with present results, Terlouw *et al.* (2004) reported less aggressive behaviour of outdoor pigs during mixing and higher muscle glycogen content at slaughter compared with conventionally reared pigs.

Conclusions

The largest differences between alternative and conventional pig rearing systems were found in the free-range system. However, outdoor courtyard or straw bedding showed similar, albeit less strong effects. Alternative rearing systems increased muscle oxidative capacity and glycolytic potential at slaughter, resulting in lower meat pHu in 2 of the 3 systems investigated. This is partly explained by reduced physical activity including less aggressive behaviour of pigs during the preslaughter period.

Table 1: Influence of rearing systems on muscle traits, skin lesions, and plasma and urine components.

	FR *vs* conventional			OUT *vs* conventional			ST *vs* conventional		
	FR	CONT	Sign.	OUT	CONT	Sign.	ST	CONT	Sign.
No. of pigs	39	39		30	36		50	39	
Semimembranosus traits									
LDH, µmol substrate/min/g	2294	2478	***	2456	2476	ns	2408	2389	ns
CS, µmol substrate/min/g	12.4	10.0	***	8.9	9.0	ns	11.4	8.5	***
Glycolytic pot., µmol/g	151	131	***	150	148	ns	138	126	*
pH1	6.28	6.30	ns	6.30	6.22	ns	6.29	6.35	ns
pHu	5.58	5.85	***	5.63	5.69	ns	5.69	5.90	***
No skin lesions	5.8	22.6	***	9.4	19.0	*	12.1	9.4	ns
Plasma components									
Glucose, µmol/ml	11.1	8.8	***	7.1	6.1	ns	9.4	8.2	ns
Creatine kinase, UI/ml	9.1	28.3	***	2.8	7.1	***	26.7	25.0	ns
Cortisol, ng/ml	33.6	31.2	ns	42.5	35.0	ns	55.8	49.9	ns
Urine hormones									
Cortisol, ng/mg creatinine	29.7	32.2	ns	8.0	11.1	ns	36.0	25.7	ns
Adrenaline, ng/mg creatinine	8.4	17.8	***	3.8	5.1	ns	16.8	17.3	ns
Noradrenaline, ng/mg creat.	17.1	26.7	**	13.1	17.4	ns	22.0	33.7	ns

Table 2: Correlation coefficients between physiological and meat quality traits, and skin lesions.

	Plasma CK	Nb skin lesions	GP SM	pHu SM
Plasma CK		0.37 ***	-0.28 ***	0.32 ***
Urine cortisol	0.16 ns	0.17 ns	-0.25 *	0.22 *
Urine adrenaline	0.42 ***	0.37 ***	-0.31 **	0.55 ***
Urine noradrenaline	0.31 ***	0.18 ns	-0.32 **	0.49 ***

* : P<0.05; ** : P<0.01; *** : P<0.001.

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