EFFECT OF BREED AND STRATEGIC FEEDING ON PORK TENDERNESS EVALUATED WITH INSTRUMENTAL AND SENSORY ANALYSES

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Background

Consumers have high expectations to outdoor produced pig meat, especially from organic outdoor pigs. However, these expectations are seldom achieved. Recent studies have shown that strategic feeding of pigs can change many pork quality characteristics in a consumer-wise positive direction. Accelerated growth rates occur in pigs with free access to feed following a period of restricted feeding (Oksbjerg *et al*., 2002), and feeding intensity is directly related to muscle growth rate and in turn to meat tenderness (Kristensen *et al*., 2002). Muscle growth rate is principally determined by the ratio between the rates of protein synthesis and protein degradation. A high rate of protein degradation at slaughter accelerates meat tenderness development post mortem. Pigs produced outdoors on a restrictive feeding regime and with free access to roughage, have reduced muscle growth rate and lower tenderness score (Danielsen *et al*., 2000). Contradictory results concerning the influence of the intramuscular fat content (IMF) on pork tenderness are reported (Göransson *et al*., 1992; Fernandez *et al*., 1999; van Oeckel *et al*., 1999).

Objectives

The aim of the present study was to evaluate the effect of various rearing systems including strategic feeding on pork tenderness using both instrumental and sensory analyses, as well as to evaluate the relationship between (IMF) and pork tenderness.

Materials and methods

During two years, 280 growing/finishing pigs were raised to approximately 107 kg live weight in four different production systems. Pigs were equally distributed within litter and breed to housing systems (outdoors/indoors), crossbreed (Duroc*LargeWhite/Landrace*LW) and gender (castrates/females). Outdoor pigs were fed *ad libitum*, with either an organic diet diluted with 20% alfalfa roughage throughout (org.dil; decreased energy density) or with first this diet and thereafter the undiluted organic diet (org.dil./org.; strategic feeding for compensatory growth). In two indoor treatments, pigs were fed restrictively with either an undiluted organic diet or a conventional diet. A random part of the material, 135 pigs (67 D*LW and 68 L*LW) was used in the present study.

Sensory profiling was performed on *M. longissimus dorsi* (LD) using a trained sensory panel of 9 assessors. The loins were sliced in 20 mm thick chops and fried on a frying plate at 155°C to a core temperature of 65°C. No salt or spices were used. Sensory attributes related to meat structure, ie., tenderness, hardness at first bite, stringiness and crumbliness, are reported in this paper. The intensity of each attribute was evaluated on an unstructured scale from 0 to 15 (0 for low intensity and 15 for high intensity).

300 g pieces of LD were cooked in a water bath at 70°C for 90 min for determination of Warner-Bratzler (WB) shear force. Maximal WB peak force (WBPF) and total WB-work (WBwork) were measured on 8 strips (10x10x50 mm), sheared across the fibre direction (speed: 55 mm/min, TA-HDI texture Analyser; Stable Micro Systems, Surrey, UK). The intramuscular fat content (IMF) was analysed from some samples (48 D*LW loins and 50 L*LW loins) by the SBR-method after hydrolysis with HCl using diethyl ether and petroleum ether for extraction.

Statistical analyses of meat quality traits were performed with the MIXED procedure in SAS (SAS Institute Inc., Cary, N.C., USA, version 8.2). The model included treatment, crossbreed (D*LW or L*LW) and gender (female or castrate) as fixed effects. Two-way interactions between the fixed factors were included in the model, when significant ($p \leq 0.05$). Sire within crossbreed, as well as dam within crossbreed and sire, were treated as random. Each assessor, as well as the interaction between assessor and sensory session, was also included as random in the model of sensory traits. In the tables, data are expressed as least square means with pooled standard errors. The Unscrambler version 8.0 (Camo Process AS, Oslo, Norway) was used for partial least squares regression (PLS) using standardised variables and full cross validation. Means of the sensory scores from all the assessors were used in the PLS. Martens' uncertainty test was used for significance testing of variables in PLS.

Results and discussion

The rearing system, crossbreed and rearing year affected the sensory attributes of tenderness, hardness at first bite, stringiness and crumbliness (Table 1). Organic outdoor rearing resulted in more tender pork than conventional indoor rearing for both crossbreeds (year 2). Organic outdoor D*LW pork was also more tender than indoor organic D*LW pork (year 2). Pork from strategic organically fed outdoor L*LW pigs was more tender than pork from indoor organic L*LW pigs both years. Strategic outdoor organic feeding improved tenderness of L*LW pork (year 2), whereas no such effect was found in D*LW pork. Strategic outdoor feeding increased hardness at first bite and stringiness and decreased crumbliness in D*LW pork, whereas the opposite was seen in L*LW pork (year 2). Indoor rearing of the pigs produced pork with the highest hardness at first bite, especially with conventional feeding. The most stringy and least crumbly D*LW pork was produced by organic indoor rearing (year 2).

Contrary to sensory tenderness, no interaction between crossbreed and rearing was found on WB shear force. Rearing effect was only seen on WBPF (year 2). WBPF was highest in pork from indoor organic pigs and lowest in pork from strategic fed organic outdoor pigs. The improving effect of strategic outdoor feeding (compensatory growth) on pork sensory tenderness was not seen on WB shear force. However both tenderness and WB shear force were improved when compared to indoor organic restricted feeding. The effect of strategic feeding was not as pronounced in the present study as in the study of Kristensen *et al.*, 2002. The reason might be that the pigs were not slaughtered at an optimal compensatory growth period in the present study.

There were significant relationships between most of the measured traits (Table 2). WBPF and WBwork were, as expected, highly correlated, and both were correlated to sensory tenderness at almost the same level within both crossbreeds. The correlations were generally higher for D*LW pork except for crumbliness with higher correlations for L*LW pork. The most marked breed difference was for the correlations with IMF. Significant correlations were found for all traits, except WBwork, within D*LW pork, whereas IMF only was significantly correlated to stringiness within L*LW pork. Van Oeckel *et al.* (1999) found correlations between WBPF and sensory tenderness of pork loin between -0.39 and -0.69 depending on different modifications of the WB-method, which is in agreement with the present study.

All sensory traits were to some degree correlated to WB shear force (Table 2) and thus it was interesting to evaluate the total influence of the investigated sensory traits on shear force. It has been discussed whether IMF has an impact on pork tenderness or not. Göransson *et al.* (1992) found some negative influence of IMF on tenderness in pork of Hampshire crossbreeds, whereas van Laak *et al.* (2001) found a linear relationship accounting for 47% of the variation in WB shear force in Duroc pork loin, but no relationship in Hampshire or Berkshire pork loins. Fernandez *et al.* (1999) found a tendency to improved tenderness with higher IMF in one experiment, but no effect in another experiment. Therefore IMF was included in the PLS in the present study. The rearing system did not affect IMF (Table 1), but IMF was higher in D*LW compared with L*LW loin (2.0% vs 1.4%, $P=0.029$). IMF varied between 1.1-3.8% in D*LW loin and between 0.7-3.1% in L*LW loin. PLS on WBPF showed significance for IMF only in D*LW loin, not in L*LW loin (Figures 1 and 2), which was in agreement with the single correlation coefficients (Table 2). Tenderness, hardness at first bite and stringiness were significant for loin of both crossbreeds, but crumbliness only for L*LW loin.

Conclusions

Outdoor strategic feeding for compensatory growth improved the sensory attributes of tenderness and hardness at first bite on L*LW pork loin, but this effect was not seen in D*LW pork loin. The outdoor rearing systems resulted in more tender pork, evaluated both with instrumental and sensory analyses, compared with the indoor restricted rearing systems. IMF influenced WBPF in D*LW pork loin, but not in L*LW pork loin.

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Table 1. Intramuscular fat, sensory scores and Warner-Bratzler shear force on *M. longissimus dorsi*[1]

Trait	Breed	Year	Rearing (R)				SE	P-value	
			Outdoor		Indoor				
	(B)		Org. dil.	Org.dil./Org.	Org.	Conv.		R	B*R
IMF, %		1	1.9	1.9	1.9	–	0.2	0.900	NS
		2	1.6	1.7	1.6	1.6	0.1	0.579	NS
Sensory quality									
Tenderness	D*LW	1	8.4	8.4	8.8	–	0.7	0.222	0.004
	D*LW	2	10.4^{a}	9.7^{a}	8.7^{b}	8.6^{b}	0.7	0.001	0.015
	L*LW	1	8.3^{ab}	9.0^{a}	7.6^{b}	–	0.7	0.222	0.004
	L*LW	2	9.1^{a}	9.9^{b}	9.1^{a}	8.2^{c}	0.7	0.001	0.015
Hardness at 1st bite	D*LW	1	5.4	5.3	5.1	–	0.6	0.098	0.006
	D*LW	2	4.8^{a}	5.3^{b}	5.9^{bc}	6.2^{c}	0.6	0.001	0.044
	L*LW	1	5.3^{a}	5.1^{a}	6.3^{b}	–	0.6	0.098	0.006
	L*LW	2	5.6^{a}	4.8^{b}	6.0^{ac}	6.6^{c}	0.6	0.001	0.044
Stringiness		1	3.9^{a}	3.1^{b}	4.0^{a}	–	0.8	0.005	NS
	D*LW	2	3.5^{a}	4.4^{b}	5.3^{c}	4.8^{bc}	0.8	0.001	0.008
	L*LW	2	4.5^{a}	3.3^{b}	4.9^{a}	5.0^{a}	0.7	0.001	0.008
Crumbliness		1	2.3^{a}	3.2^{b}	2.3^{a}	–	0.8	0.001	NS
	D*LW	2	6.2^{a}	5.3^{b}	5.0^{b}	5.5^{b}	0.9	0.001	0.017
	L*LW	2	6.0^{a}	6.9^{b}	5.3^{a}	6.0^{a}	0.9	0.001	0.017
Warner Bratzler									
WBPF, N		1	30.5	28.9	30.6	–	1.4	0.506	NS
		2	28.1^{ac}	27.6^{a}	33.8^{b}	31.7^{bc}	1.8	0.007	NS
Wbwork, Nmm		1	175	162	168	–	5.6	0.243	NS
		2	151	145	163	156	6.0	0.143	NS

[1] Significant differences between LSM with different letters in the same row, P≤0.05; NS = not significant.

Table 2. Pearson's correlation coefficients for relationships between the measured traits within crossbreed[1] D*LW correlations are shown in the upper diagonal and L*LW correlations in the lower diagonal.

L*LW \ D*LW	WBPF	WBwork	Tenderness	Hardness 1st bite	Crumbl.	String.	IMF
WBPF		0.850	-0.635	0.641	-0.236	0.647	-0.488
Wbwork	0.845		-0.622	0.557	-0.404	0.536	-0.257
Tenderness	-0.564	-0.492		-0.917	0.423	-0.729	0.333
Hardness at 1st bite	0.552	0.363	-0.919		-0.189	0.818	-0.474
Crumbliness	-0.337	-0.532	0.614	-0.422		-0.200	-0.286
Stringiness	0.523	0.355	-0.810	0.853	-0.528		-0.531
IMF	-0.193	-0.135	0.145	-0.178	0.017	-0.302	

[1] Bold coefficients are significant (P≤0.05).

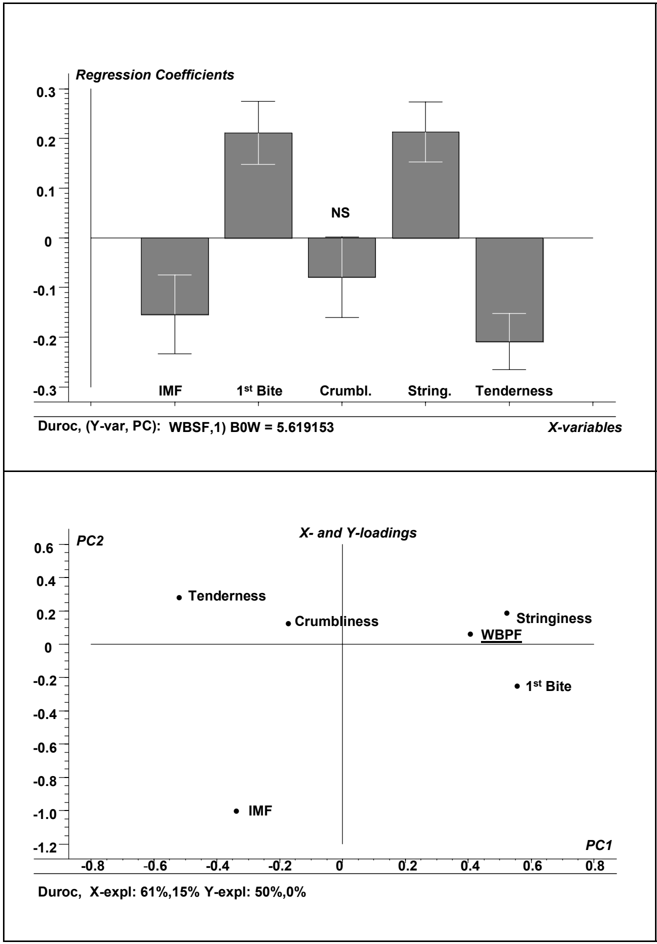

Figure 1. PLS regression coefficients and loadings plot on WBPF related to sensory traits and IMF on D*LW loins. NS = not significant

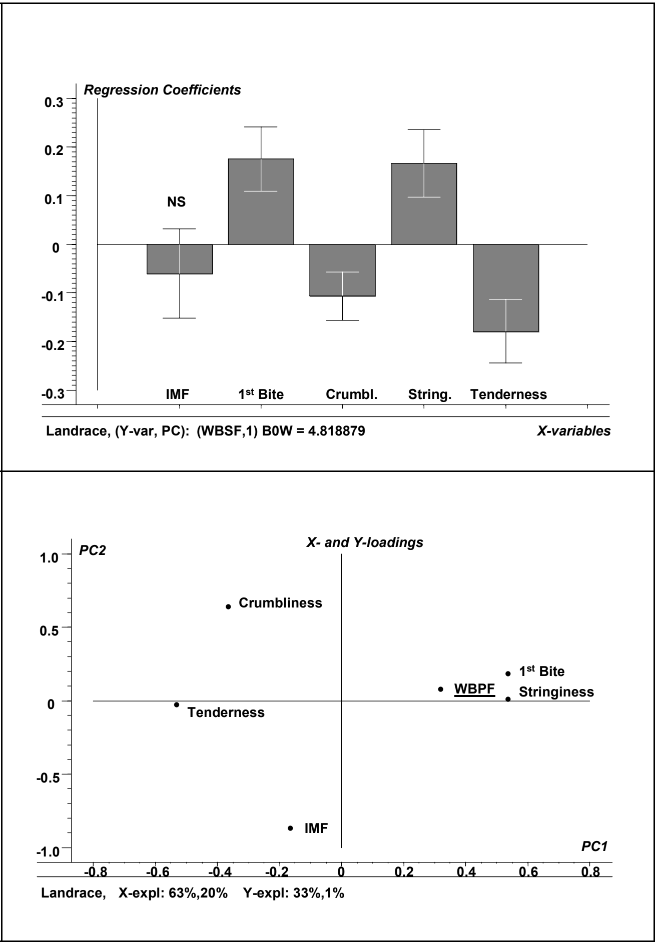

Figure 2. PLS regression coefficients and loadings plot on WBPF related to sensory traits and IMF on L*LW loins. NS = not significant

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