Effect of chilling process and lairage time on meat quality in heavy slaughter pigs

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Background

Ultra fast chilling processes ensure that pH fall immediately *post mortem* is retarded, whereby protein denaturation is reduced, colour is improved and drip losses minimised. However, too fast a chilling rate increases the risk of cold contracture, especially when muscle pH levels are high (Barton Gade *et al.,* 1987, Møller & Vestergaard, 1987). An optimised process is thus one which leads to the least possible degree of protein denaturation, while at the same time avoiding cold contracture and tough meat. Process conditions are well known for pigs of normal Danish carcass weight (70-75 kg) but not for heavy pigs (carcass weight about 90 kg). Preliminary work indicated, however, that batch chilling was not an option at this weight due to an increased PSE frequency especially in leg muscles, although this was modified by lairage time. Slow chilling did not lead to PSE to the same extent after overnight lairage compared to slaughter on the day of arrival. In addition, time in lairage has been shown to improve colour, reduce the incidence of PSE meat but increase the amount of skin damage and DFD meat (Nielsen, 1981; Lundstrom *et al.,* 1987). However, relatively little has been published on the effect of lairage time on sensory characteristics. Milligan *et al.* (1998) showed that lairage times from 0 to 3 hours had no significant effect on sensory characteristics in pork loin chops.

Objectives

The aim of this work was to investigate the effect of two different chilling regimes and two different lairage times on meat quality and sensory characteristics of Danish heavy pigs.

Materials and methods

The experimental material consisted of 120 LYDH (Landrace- Large White × Duroc-Hampshire) crosses from one producer. 60 pigs were delivered at the factory at 10:00 am and a further 60 at 3:00 pm on the same day. Transport was carried out by the same haulier in the same truck and transport distance was 70 km. Half of the pigs delivered in the morning were slaughtered after a lairage time of 45 mins and chilled at an air temperature of about -12°C. The remaining pigs were lairaged for 2 hrs longer, slaughtered and chilled at about -16°C. Pigs arriving in the afternoon were offered 1 kg feed each with continuous access to water and held overnight. Half were then slaughtered after a lairage time of 15 hrs and chilled at about -16°C and the remaining were slaughtered 2 hrs later and chilled at about -12°C. The differences in lairage time for groups slaughtered respectively on the day of arrival and after an overnight stay were due to the time needed to change air tunnel temperatures to constant levels. After passing through the chilling tunnel all carcasses were equalised at 3-4°C, air velocity about 1 m/s until 18 to 24 hrs post mortem, when muscle temperatures were 3-4°C in the leg, 2-3°C in the loin and 4-5°C in the shoulder. Carcass weight and meat content as assessed by the classification centre as well as sex (castrate or gilt) was noted for all pigs.

pH was measured in *M. longissimus dorsi* (LD) between the 2nd and 3rd lumbar vertebrae and *M. semimembranosus* (SM) 35 mins, 3 hrs and 21-25 hrs after slaughter using a Knick pH meter and Ingold electrode (No. 1046006-3123). pH was also measured in *M. biceps femoris* (BF) the day after slaughter. Temperature was measured in LD and SM at the same positions and times as above using a Testotherm thermometer with a Ni-Cr-Ni probe (type 06000-2694). The day after slaughter internal reflection was measured in LD and BF using the MQM-equipment (Borggaard *et al.,* 1989) and samples were taken from LD for the evaluation of % IMF (Soxtec method), shear force value to 80% penetration (Volodkevich, 1938), sarcomere length (Voyle, 1971) and sensoric analysis, where 2 cm thick cutlets were heated on a frying pan to a centre temperature of 65°C and assessed by a 9 member trained sensory panel using an unstructured intensity scale (0 = no and 15 = high intensity). Samples for IMF were minced and the minced samples frozen to -20°C until analysis. Samples for shear force, sarcomere length and sensory analysis were vacuum packed, held at 4°C until 3 days after slaughter before freezing as before. Finally, samples were taken from LD at the 2nd and 3rd lumbar vertebra on the other side of the carcass for evaluation of drip loss in whole slices (Barton Gade *et al.*, 1994). The results were investigated using an analysis of variance SAS (1990) with chilling group, lairage time and sex as variables. For discontinuous variables a χ^2-test was used.

Results and discussion

Meat content and slaughter weight were similar for the two chilling groups (respectively for -12 and -16°C, 57.5 and 57.4 % and 90.2 and 90.3 kg) but different for the two lairage times, where pigs held overnight were lighter than pigs slaughtered on the day of arrival (91.4 v 89.1 kg). Meat content was the same for castrates irrespective of lairage time, whereas gilts held overnight had a 2.1 % higher meat content than gilts slaughtered on the day of arrival. Table 1 shows the results for meat and sensory quality.

The chilling process had relatively little effect on pH and temperature changes after slaughter. LD pH 24 hrs *post mortem* and SM temperature at 3 hrs *post mortem* was highest in pigs chilled at -16 °C. Lairage time on the other hand affected pH values 24 hrs *post mortem* in all muscles (highest with overnight lairage), thus confirming the previously mentioned work in the literature. pH in SM at 3hrs *post mortem* was also highest with overnight lairage, probably as a result of a lower temperature at that time. A similar tendency was found for LD but the difference was only significant for temperature 3 hrs *post mortem*. Contrary to the preliminary experiment only castrates showed a significantly higher $pH_{35\ mins}$ on overnight lairage (6.61 v 6.39 for LD and 6.65 v 6.40 for SM). Chilling at -16°C gave significantly lower temperatures in LD and SM at 35 mins *post mortem* and for LD also at 3 hours *post mortem* on overnight lairage compared to slaughter on the day of arrival and this affected pH values which were significantly higher in LD 3 hours *post mortem* (6.24 v 6.03) and in SM 35 mins *post mortem* (6.75 v 6.47).

Chilling method and lairage time had relatively little effect on LD quality. MQM values were slightly lower with chilling at -16°C compared to -12°C but no muscles showed values higher than 80 corresponding to PSE meat. BF on the other hand, although average MQM values were not different, showed a strong tendency (p= 0.078) towards more PSE and more doubtful cases, (MQM respectively ≥100 and 95-99), with chilling at -12°C, especially when pigs were slaughtered on the day of arrival (23% as against 7, 3 and 3% for the other experimental groups). % IMF and sarcomere lengths were not affected by chilling method but unexpectedly

shear force values were higher with chilling at -12°C than at -16°C and the percentage of LD muscles with tough and slightly tough meat (≥120N and 100-119N respectively) was higher. Again there was a strong tendency (p=0.084) towards a greater percentage with shear force values of 100 and higher when pigs chilled at -12° C were slaughtered on the day of arrival (30 as against 4, 14 and 3% for the other experimental groups). None of these differences however affected tenderness as assessed by the sensory panel. In fact only scores for juiciness and piggy flavour were affected by respectively chilling method and lairage time. The differences were however small and not of practical significance. % IMF was lower in the group held overnight than with slaughter on the day of arrival, possibly as a result of the higher meat content in gilts in this group.

Conclusions

Of the two chilling methods investigated, chilling at -16°C is to be preferred for heavy Danish pigs. There was less PSE in BF and at the same time eating quality in LD was not compromised. Overnight lairage had a number of advantages compared to slaughter on the day of arrival: slightly higher pH values and less PSE in BF and there were certain tendencies to interaction with chilling method. However, these interactions need further research.

Literature

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Table 1: Results of the analysis of variance for slaughter line measurements and meat quality the day after slaughter

LS means with different superscripts are significantly different: *** p <0.001, ** p <0.01, * p <0.05

Characteristic		Chilling method		Lairage time		Significance				Standard error: means
		-12°C	-16°C	1-3 hrs	Overnight	CM	L	CMxL	LxSex	
LD	pH - 35 mins	6.55	6.55	6.47	6.62				*	0.03
	pH - 3 hrs	6.08	6.14	6.06	6.16			*		0.03
	pH - 24 hrs	5.53[a]	5.58[b]	5.53[a]	5.59[b]	*	**			0.01
SM	pH - 35 mins	6.47	6.61	6.48	6.61			***	*	0.03
	pH - 3 hrs	6.01	6.05	5.97[b]	6.09[a]		*			0.03
	pH - 24 hrs	5.58	5.59	5.54[b]	5.63[a]		***			0.02
BF	pH - 24 hrs	5.62	5.63	5.56[b]	5.69[a]		***			0.02
LD	°C - 35 mins	39.9	39.0	39.6	39.3			***		0.08-0.09
	°C - 3 hrs	12.7	12.6	13.5[b]	11.9[a]		***			0.20-0.30
SM	°C - 35 mins	40.6	40.4	40.5	40.5			***		0.05
	°C - 3 hrs	30.9[a]	31.6[b]	32.0[b]	30.6[a]	*	***			0.22
LD	MQM-value	59[b]	52[a]	55	56	**				1.5
BF	MQM-value	81	78	84[b]	75[a]		***			1.3
LD	drip loss - 24 hrs	1.15	1.02	1.09	1.07					0.06
	drip loss - 48 hrs	2.28	2.18	2.20	2.26					0.11
	% IMF	2.08	2.10	2.20[a]	1.98[b]		*			0.08
	shear force (N)	85[b]	76[a]	84	78	**				2.4-2.5
	sarcomere length	1.82	1.82	1.82	1.82					0.008
	meat flavour	10.2	10.1	10.3	10.0				**	0.06
	piggy flavour	1.0	1.1	0.8[a]	1.4[b]		***			0.07
	acidic flavour	0.9	0.9	1.0	0.7				***	0.05
	tenderness	9.6	9.6	9.5	9.6					0.08
	juiciness	9.7	9.9	9.9	9.7					0.08