The Effects of Blast Chilling on Carcass Weight Changes and Pork Muscle Quality

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SUMMARY

Blast chilling pork carcasses for different periods of time post-mortem was compared to conventional chilling combined with a spray chill system for carcass shrinkage and pork muscle quality in two experiments. In experiment 1, pork carcass sides were allocated to one of four treatments. Treatment 1 was chilling sides at 1°C combined with 40 spray cycles (every 15 min) each lasting 60 sec and followed by a 14 h drying/chilling period. Treatments 2, 3 and 4 consisted of 1, 2 and 3 hours of chilling sides at -20°C, followed by the remainder of the spray chill and 14 hour drying/chilling period at 1°C. Experiment 2 followed the same procedures except that -40°C was used as a blast chill temperature. Carcass shrinkage was similar for all treaments in experiment 1 at 24 h and ranged from 0.5-0.7 g $100g^{-1}$. No consistent differences were found among treatments in muscle colour, drip loss, shear or sarcomere length. In experiment 2, treatment 4 sides gained in weight (0.4 g $100g^{-1}$), but all other treatments recorded a similar weight loss (0.2-0.4 g $100g^{-1}$) at 24 h post-mortem. Sides chilled for 3 h at -40°C had darker muscles than sides that were only spray chilled. It was concluded in most cases that spray chilling controlled carcass shrinkage with a similar effectiveness to blast chilling. Blast chilling had few significant effects on muscle quality.

INTRODUCTION

Blast chilling has been adopted by several pork processing plants in Canada over the last 5 years, and has been used in several European countries for a longer period of time. The general procedure has been to chill carcasses for a period of about 1 h at temperatures between -20 and -30°C, followed by an equilibration period in a conventional chiller. Scientific studies indicate under laboratory (Dransfield and Lockyer 1985) and plant (Barton-Gade et al. 1987; Moller and Vestergard 1987) conditions that blast chilling can induce shortening of the muscle fibres and result in tough meat. While blast chilling has been shown to reduce carcass shrinkage during chilling (James et al. 1983), no comparisons have been made between spray chill and blast chill systems for overall effects on carcass shrinkage and muscle quality. The present study was conducted to compare various blast chilling regimes with a spray chill system in relation to carcass shrinkage and muscle quality.

MATERIAL AND METHODS

Experiment 1. A total of 45 pork carcasses with an average weight close to 100 kg and backfat thickness at the last rib of 21 mm were used. pH and muscle temperature were recorded at approximately 45 min post-slaughter in the centre of the longissimus thoracis between the 12th and 13th ribs and the semimembranosus muscle. These measurements were repeated at 3, 6 and 24 h post-slaughter. Carcass sides were allocated randomly to a control treatment (1°C, air speed 1 m s^{-1}) or to chilling for 1, 2 or 3 h at -20°C (air speed 5 m s^{-1}). Paired sides were used so that each of the blast chill treatments had 15 carcass sides and the control group 45 sides. Control sides were spray chilled every 15 min for 60 sec for 10 h (total of 40 cycles). Blast chilled sides all received the remaining portion of the spray chilling regime. Thus sides having 1 h at -20°C had 9 h of spray chilling, whereas sides having 3 h at -20°C had 7 h of spray chilling. Sides were weighed immediately before chilling commenced and at 24 h. A boneless portion of the longissimus thoracis between the 5-13th ribs and the semimembranosus was removed from all carcass sides at 24 h post-slaughter and used for evaluating muscle quality. Steaks (25mm thick) were removed from both muscles and placed in a bag for 48 h to determine drip loss. Further steaks were removed from both muscles and allowed to bloom for 30 min before recording muscle colour using a Minolta Chroma Meter (L* a* b* colour system)and then cooked. Two 19 mm cores were removed from each cooked steak and sheared using an Ottawa Texture Measuring System equipped

with a Warner-Bratzler cell. Sarcomere length was determined using a phase contrast microscope and recording the length of 10 sarcomeres for each of 20 muscle fibres.

Experiment 2. The same procedures were followed as for experiment 1 in every respect, except that the carcasses were blast chilled at -40°C. The data was analysed using a least squares analysis of variance with chilling treatment as the main effect. Means were compared using linear contrasts.

RESULTS AND DISCUSSION

Carcass Shrinkage. Weight changes over 24 h were all negative in experiment 1 and no significant differences were found between the control or treatments (Table I). In experiment 2, only the 3 h blast chill shrinkage was different to the other chilling treatments. A period of 3 h of blast chilling followed by 7 h of spray chilling resulted in a gain in carcass weight.

Table 1. The effect of chilling treatment on carcass weight changes to 24 h post-mortem

	Control		1 h Blast-Chill		2 h Blast Chill		3 h Blast Chill	
Weight change	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Experiment 1 g 100 g^{-1}	-0.50	0.05	-0.59	0.11	-0.67	0.11	-0.74	0.11
Experiment 2 g $100g^{-1}$	-0.40^{a}	0.04	-0.19^{a}	0.09	-0.21^{a}	0.09	$+0.40^{b}$	0.10

ab Means with different superscript are significantly diffferent at $P<0.05$.

While other authors have demonstrated that both blast and spray chilling systems reduce carcass shrinkage compared to conventional chilling (James et al. 1983; Swatland 1983; Jones et al. 1988) there have been no direct comparisons of spray and blast/spray chilling regimes. The results of the present study indicate that apart from the extreme blast chill treatment (3 h at -40°C), spray chilling is equally effective in the control of carcass shrinkage as a combined blast/spray chill regime at 24 h post mortem.

Table II. Least squares means and standard errors of muscle quality in the longissimus thoracis (LT) and semimembranosus (SM) muscles in response to chilling at 1°C or -20°C.

Trait	Control		1h Blast chill		2h Blast chill		3h Blast chill	
LT:								
Colour, L*	52.4	0.27	51.1	0.61	52.0	0.61	50.2	0.61
Drip loss, g $100g^{-1}$	3.3	0.11	3.2	0.25	2.8	0.25	2.8	0.25
Shear, kg	7.4	0.12	7.4	0.26	7.2	0.26	8.4	0.26
Sarcomere length, m	1.70^{ab}	0.01	1.76^{a}	0.02	1.70^{ab}	0.02	1.62^{b}	0.02
SM:								
Colour, L*	47.4	0.28	47.7	0.62	47.1	0.62	46.7	0.62
Drip loss, g $100g^{-1}$	2.5	0.12	2.3	0.26	2.3	0.26	2.1	0.20
Shear, kg	8.9	0.22	9.6	0.49	8.9	0.49	10.0	0.03
Sarcomere length, m	1.60	0.01	1.66	0.03	1.60	0.03	1.66	0.03

ab Means with different superscript are significantly different at $P<0.05$.

Muscle Temperature and pH. Chilling treatment influenced muscle temperature and pH in both experiments. pH decline with time was reduced at 3 and 6 h post-mortem in the longissimus thoracis by 0.2-0.3 pH units in the blast chill compared to the control treatment, but final pH was not affected by chilling treatment. Muscle temperature in both the loin and the ham were also lower at 3 and 6 h post-mortem in the blast chill treatments compared to the control in both experiments. For example, in experiment 1 temperature in the loin after 3 h of chilling for the control was 17.1°C compared to 9.2°C in the 3 h blast chill treatment. The combined effects of rapid cooling and reduced pH fall would be expected to improve the pH dependent aspects of meat quality.

Meat Quality. The meat quality characteristics measured in this study in experiment 1 are shown in Table II. Muscle color, drip loss, and shear in both muscles were not influenced by chilling treatment. Sarcomere length was shorter for the 3 h blast chill treatment compared to the 1 h blast chill treatment with the other treatments having intermediate values for the loin muscle. However, sarcomere lengths were not influenced by chilling treatment in the semimembranosus muscle (Table II).

Muscle quality results for experiment 2 are shown in Table 3. Color became increasingly darker as the length of the blast chill period increased in both the loin and the ham muscles. Chilling treatment had no effect on drip loss, shear or sarcomere length (Table III). There was a trend for the 3 hour blast chill treatment to have the highest shear values in both muscles evaluated whether the blast chill temperature was -20 or -40°C.

Other reports have shown that blast chilling can result in pork of darker colour compared to conventional chilling (James et al. 1983; Crenwelge et al. 1984), although these differences on their own are not great enough to justify the installation of a blast chill system. There were only trends observed between shear value and length of the blast chilling period. The average initial pH in pork carcasses for this study was 6.2 and it may be that the majority of the carcasses were protected from cold induced toughness by the onset of the rigor process. Barton-Gade et al. (1987) found evidence of cold shortening in pork carcasses with a high initial pH and a low intramuscular fat content that were chilled at -25.5°C for 47 minutes.

Drip loss was not significantly influenced by chilling treatment although for experiment 1 there was a trend for drip loss to be reduced as the length of the blast chilling treatment increased. Dransfield et al. (1991) showed that muscle drip increased when cooling was

Table III. Least squares means and standard errors of muscle quality in the longissimus thoracis (LT) and semimembranosus (SM) muscles in response to chilling at 1°C or -40°C.

	Control		1h Blast chill		2h Blast chill		3h Blast chill	
LT								
Colour, L*	51.7[a]	0.22	52.1[ab]	0.50	50.1[ab]	0.50	49.7[b]	0.50
Drip loss, g 100g-1	3.0	0.11	2.2	0.25	3.3	0.24	3.2	0.24
Shear, kg	7.3	0.12	7.1	0.28	7.4	0.28	7.6	0.28
Sarcomere length, m	1.65	0.01	1.71	0.03	1.65	0.03	1.67	0.03
SM:								
Colour	47.0[a]	0.28	47.6[a]	0.63	44.6[ab]	0.63	43.8[b]	0.63
Drip loss, g 100g-1	2.4	0.12	2.4	0.22	1.9	0.22	2.0	0.22
Shear, kg	10.9	0.27	10.8	0.61	11.5	0.61	12.0	0.61
Sarcomere length, m	1.56	0.01	1.54	0.02	1.64	0.02	1.54	0 .02

Means with different superscripts are significantly different at $P < 0.05$.

sufficiently fast to produce cold shortening. There was no evidence for increased drip loss to be related to chilling rate in the present study, except in the loin for the 3 h blast chill treatment in experiment 2.

CONCLUSIONS

Blast chilling as applied resulted in a similar shrinkage to a spray chill conventional system of chilling pork carcasses. Blast chilling gave carcasses with darker muscles, but there were no consistent effects on shear, drip loss, or sarcomere length.

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