Chilling rate and pork quality - an orientation

H.L.J.M. VAN LAACK and F.J.M. SMULDERS

Department of the Science of Food of Animal Origin, Faculty of Veterinary Medicine, University of Utrecht, P.O. Box 80175, 3508 TD Utrecht, The Netherlands

INTRODUCTION: In fresh meat technology there is a continuing need for improved economy and efficiency. An important means to achieve this, is reducing chilling time and costs. Carcasses must be chilled using the most effective system to ensure minimum weight losses and a high throughput. Hence, carcasses are chilled at lower temperatures for shorter times.

Chilling, more specificly temperature decline post mortem, impacts on meat quality. It is well documented that a fast drop in muscle temperature may result in cold shortening (CS) and toughening. The risk for occurrence of CS is dependent on the rate of glycolysis. Bendall (1972) assessed that when the temperature is below 10°C and the pH is still >6.2, CS will result. Thus, one would not expect CS to occur in fast glycolysing porcine muscle. Yet, it has been reported that, when meat or carcasses are cooled extremely fast, even pig meat toughens (Bendall, 1976; Marsh et al., 1972).These reports have received relatively little attention; in commercial practice, such fast chilling rates were unlikely to occur. However, as a result of developments in chilling technology, the effect of rapid chilling on pig meat quality has recently become the subject of some concern, after some investigators published reports that the introduction of rapid chilling systems had resulted in tougher pig meat (Barton-Gade et al., 1987; Taylor, 1989).

The temperature decline in the muscle is not only an important determinant of meat tenderness, it may also affect waterholding capacity (WHC) and colour. A fast rate of glycolysis at high muscle temperatures promotes the denaturation of sarcoplasmic proteins and the tendency of actomyosin to contract as it forms (Bendall, 1960). This results in a loss of WHC. If, on the other hand, the temperature of pre-rigor meat is reduced too quickly, loss of WHC will ensue due to sarcomere shortening (Honikel et al., 1986).

The pig population in The Netherlands is relatively stress-resistant; only 1-2% of the pigs are halothane-positive (Eikelenboom, 1988). This implies that, in general, post mortem glycolysis will be relatively slow. Therefore, it is not expected that rapid chilling will result in significant improvements of WHC and colour in the Dutch pig population. On the other hand, the relatively slow glycolysing muscles are more prone to CS and toughening.

In the present study the effects of chilling rate on the quality of Dutch pig meat was investigated. As pork is generally marketed several days post mortem, quality was assessed after different periods of storage.

MATERIALS and METHODS: Based on the loin pH at 45 min post mortem being >6.2, 20 pig carcasses (Large White/Dutch Landrace cross-bred) were selected. "Bone-in" loins of all 40 carcasses sides, excised within 1.5 h post mortem, were put in a bag which was sealed without drawing vacuum. Of each carcass one loin was rapidly chilled (RC) and one loin moderately chilled (MC). Rapid chilling was achieved by immersing the loins for 2 h in water of 10°C, followed by 21 h immersion in ice-water (0°C). Moderate chilling was effected by 2 h immersion in water of 15°C, followed by 21 h storage in air of 2±2°C.

During the first 24 h, temperature in the center of two RC and two MC loins was monitored. Temperatures were recorded

at every 5 min. These loins were not included in the rest of the experiment.

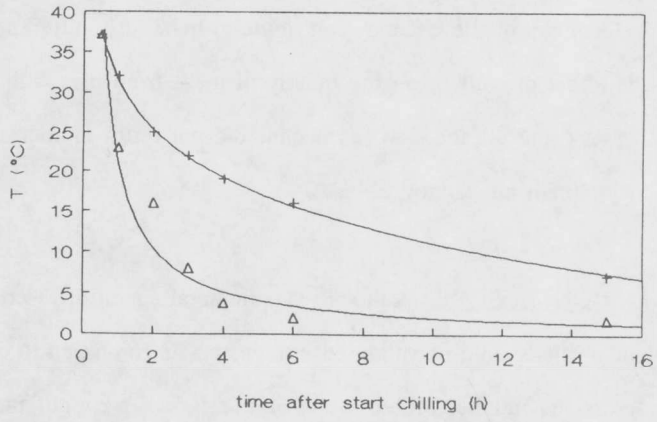
At approximately 24 h post mortem, pH was measured. Subsequently the loins were deboned, divided in three parts of similar size, vacuum packaged, and stored at 1±1°C. At 1, 3, and 8 days post mortem, one part of each loin was unpacked and quality characteristics were assessed.

pH, colour- (L^*, a^*, b^*-value), WHC- (filter paper method, drip loss and cooking loss), transmission value-, shear force-, and sarcomere length measurements were performed as described by Van Laack (1989).

Significance of differences between RC and MC group was assessed with Student t-test.

RESULTS: The average pH of the loins at 45 min post mortem was 6.47±0.15. Temperature decline in the RC loin was considerably faster than in the MC loin (Fig. 1). Within 3 h of chilling temperature in the RC loin was below 10°C. In the MC loin it took ±15 h before the temperature was that low.

Fig. 1 Temperature of the centre of the loin as influenced by chilling rate; x=moderate chilling; Δ=rapid chilling



Chilling rate did not affect ultimate pH, neither did it affect most of the physical chemical quality traits (Table 1). Only a^*-value at 3 days post mortem and the b^*-value at 8 days post mortem of MC and RC loins differed significantly.

Table 1 The effect of chilling rate (RC=rapid chilling, MC=moderate chilling) on some physical-chemical quality traits of pork loins at 1, 3 and 8 days post mortem) (mean values, n=20)

	Days post mortem					
	1		3		8	
Chilling rate	RC	MC	RC	MC	RC	MC
Ultimate pH	5.53	5.51	ND**	ND	ND	ND
Drip loss (%)	-	-	1.1	1.4	3.1	3.6
WHC-filterpaper method (mg)	41	41	ND	ND	ND	ND
WHC-Honikel's method (%)	3.4	3.6	3.6	3.2	1.1	1.2
Cooking loss (%)	22.1	21.6	19.7	17.4	21.4	21.0
Transmission value (%)	41	41	38	39	43	45
Colour						
L^*-value	55.3	56.1	55.0	55.0	56.1	56.5
a^*-value	14.4	14.0	13.9^{b*}	15.2^{a}	16.0	15.9
b^*-value	8.0	8.2	9.5	9.7	9.8^{b}	10.6^{a}
Shear force (kg/cm^2)	3.91	3.23	2.92	2.47	3.00	2.80
Sarcomere length (μm)	1.65	1.64	1.66	1.67	1.68	1.69

*, In rows, within sampling day, figures with different superscripts differ significantly (Student t-test, $p<0.05$).
ND = not determined.

Drip losses were slightly, though not significantly, higher in MC than in RC loins. Also, differences in shear force were negligible. Time of storage did hardly affect the influence of chilling procedure. During storage drip losses increased and shear forces decreased in both MC and RC loins.

DISCUSSION: In the present experiment we studied the effect of rapid vs. moderate chilling under laboratory conditions. The temperature decline found in the MC loin is comparable with a chilling rate induced by cooling at 1°C with low air speed, i.e. the conventional way of chilling pig carcasses. With the available rapid chilling systems temperature in the deep loin can be reduced to 10°C within 3 h (Moerman, pers. comm.). This situation was simulated by the RC treatment.

According to Dransfield and Lockyer (1985) rapid chilling is likely to induce toughening. Especially carcasses with a slow pH fall are prone to cold-induced toughening (Møller and Vestergaard, 1987). Although the muscle pH before chilling was 6.47 and toughening in the RC loins was expected, this was not observed. Maybe the temperature decline achieved (10°C at 4.5 h p.m., i.e. after 3 h of chilling) was not fast enough. In the experiments of Dransfield and Lockyer (1985) and Møller and Vestergaard (1987) temperature fell below 10°C at 3 h post mortem. Under current Dutch industry conditions loin temperatures are generally not below 10°C within 3 h. The fact that in The Netherlands pigs are slaughtered at a higher live weight than in Denmark or the UK may contribute to that. Also, differences in genetic make-up may interfere. Presently we are investigating the effect of chilling on the quality of meat from pigs with a different genetic background.

As expected, the slow pH decline did not result in aberrant WHC. Under such conditions an effect of rapid chilling is likely to be small and unnoticable.

CONCLUSIONS: Although experimental conditions were very similar to those observed in commercial practice, we believe our results should be validated in industry. As compared to chilling in air, chilling in water effects another temperature gradient across the muscle. Moreover, after excision of pre-rigor muscles, we left the muscles on the bone to prevent extreme rigor shortening. Nevertheless, some shortening of the MC loins may have occurred. Before reassuring the pig meat industry there is no risk for toughening, additional studies under industry conditions have to be performed.

REFERENCES:

BARTON-GADE, P., BEJERHOLM, C. and BORRUP, U. (1987): Influence of different chilling procedures on the eating quality of pork chops. Proc. 32nd ICOMST, Helsinki. pp. 181-184.

BENDALL, J.R. (1960): In: "The structure and function of muscle". Vol. 3 (G.H. BOURNE, ed.). Academic Press, New York. pp. 227.

BENDALL, J.R. (1976): Cold-contracture and ATP-turnover in the red and white musculature of the pig post-mortem. J. Sci. Fd. Agric. 26: 55-71.

DRANSFIELD, E. and TOCKYER. D.K. (1985): Cold-shortening toughness in excised pork. Meat Sci. 13: 19-32.

EIKELENBOOM, G. (1988): Effects of preslaughter treatments on meat quality: Proc. Int. Meat Pig Carcass and Meat Quality. June 2-3, Reggio Emilia, Italy.

HONIKEL, K.O., KIM, C.J., RONCALÉS, P. and HAMM, R. (1986): Sarcomere shortening of presigor muscles and its influence on drip loss. Meat Sci. 16: 267-282.

LAACK, H.L.J.M. VAN (1989): "The quality of accelerated processed meats - An integrated approach". PhD Thesis, University of Utrecht. 221 pages.

MARSH, B.B., CASSENS, R.G., KAUFFMAN, R.G. and BRISKEY, E.J. (1972): Hot boning and pork tenderness. J. Food Sci. 37: 179-180.

MØLLER, A.J. and VESTERGAARD, T. (1987): Effect of delay time before chilling on toughness in pork with high or low initial pH. Meat Sci. 19: 27-37.

TAYLOR, A.A. (1989): Electrical stimulation and rapid chilling of pig carcasses. Proc. 35th ICOMST, Copenhagen pp. 1157-1162.