TENDER PORK THROUGH STEPWISE CHILLING

K. Rosenvold[1]*, U. Borup[1] and M. Therkildsen[2]

[1.] Danish Meat Research Institute, 4000 Roskilde, Denmark, [2.] Department of Food Science, Danish Institute of Agricultural Sciences, Post box 50, 8830 Tjele, Denmark. Email: kro@danishmeat.dk

Keywords: chilling, *longissimus dorsi*, pork, tenderness, WHC

Introduction
Implementation of groupwise treatment of slaugther pigs during transport, lairage and stunning has resulted in a reduced temperature in the carcass at the time of sticking as well as an improved water-holding capacity (WHC) (Støier *et al.*, 2001). However, the chilling process has not been optimised to the lower carcass temperature, and trials have indicated that pork is less tender today than before.

It is assumed that, the chilling process can be optimised to improve pork tenderness without compromising WHC. The assumption is based on the following:

1. Carcass temperature at 1min pm ($T_{1\ min}$) is essential for WHC as shown in a study where $T_{1\ min}$ and $pH_{2\ h}$ explained 89% of the variation in drip loss (range: 2 to 13%) (Schaëfer *et al.*, 2002). Implementation of groupwise transport, lairage and stunning reduce $T_{1\ min}$ (Køltoft, 2005).
2. Pre-rigor carcass temperature is crucial for tenderness in beef, lamb and pork (Tornberg, 1996; Rees *et al.*, 2003). In beef, pre-rigor temperatures in the interval of 10 to 15°C results in more tender beef compared to temperatures above and below this interval (Tornberg, 1996).
3. The *post mortem* pH-fall is a result of lactic acid formation from glycogen breakdown. Glycogen is broken down by glycogen phosphorylase and glycogen debranching enzyme (GDE) (Brown and Brown, 1996). Kylä-Puhju *et al.*, (2005) has shown that the activity of GDE is temperature dependent and that its activity at 15°C is identical to that at 4°C. *Post mortem* pH-fall may therefore be identical in the temperature interval of 4°C to 15°C.

Thus, combining the facts that 1) $T_{1\ min}$ is reduced because of groupwise transport, lairage and stunning, 2) the temperature interval 10 to 15°C results in maximal tenderness and 3) glycogen breakdown at 15°C is identical to that at 4°C, we hypothesised that a stepwise chilling method, composed of a rapid temperature reduction to 10 or 15°C (in chilling tunnel), a 6 h holding period at 10 or 15°C followed by rapid post chilling (in chilling tunnel) and finally equalization, would improve tenderness without compromising the waterholding capacity of the meat. This hypothesis was tested in the present study.

Materials and Methods
A total of 42 pigs, 21 female and 21 castrate crossbreed pigs (D(LY)) were slaughtered at the research facility at The Danish Institute of Agricultural Sciences. The pigs were exposed to 2 stepwise chilling methods. One half of the carcasses was chilled stepwise (F10 and F15), while the other half was the control (C10 and C15). The chilling methods were imposed 40 minutes post mortem: F10 was placed in the chilling tunnel (-22°C/3 ms^{-1}) for 69 minutes, and then placed in a chilling room at 10°C for 6 h, returned to the chilling tunnel for 12 minutes and finally placed in a chilling room at 4°C for equilization until the next day. F15 was placed in the chilling tunnel for 47 minutes, and then placed in a chilling room at 15°C for 6 h, returned to the chilling tunnel for 24 minutes and finally placed in a chilling room at 4°C until the next day. C10 and C15 were placed in the chilling tunnel for 75 minutes and then placed in a chilling room at 4°C until the next day. The temperature was measured continuously and pH was measured in *Longissimus dorsi* (LD) after 1 minute, 35 minutes, when the carcasses were moved to and from the chilling tunnel, 4 h, 6 h and 24 h *post mortem*. WHC was determined as drip loss in LD using the EZ-drip method. Sensory tenderness was determined in LD 3 days post mortem without prior freezing. Cooking and sensory method were as described by Hansen *et al.* (2004).

Results and Discussion
The mean $T_{1\ min}$ measured in LD in the 84 half carcasses was 39.5 ± 0.4°C. The maximal $T_{1\ min}$ was measured to 40.6°C. $T_{1\ min}$ was low – one of the arguments that the hypothesis tested was based upon. The temperature profiles in LD are shown in Figure 1. Clear temperature differences were obtained between the treated and the control carcasses. Furthermore, at the end of the 6 h holding period the temperatures were 10.4°C and 13.7°C in F15, hence close to the desired pre-rigor temperatures of 10°C and 15°C, respectively. $pH_{6\ h}$, $pH_{8\ h}$ and $pH_{24\ h}$ was sligthly (< 0.15 pH unit) yet significantly lower in F10 as well as F15 compared to C10 and C15 (data not shown). But this pH difference did not influence WHC, which was found to be low and identical in the four groups (Table 1). Chilling loss was increased in F15 compared to C15, but identical in F10 and C10.

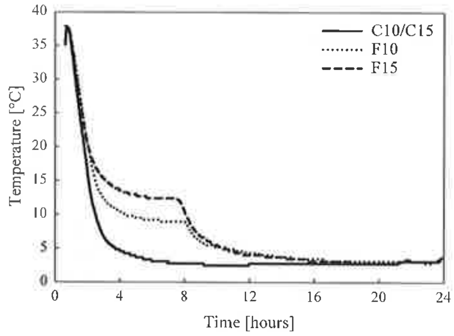

Figure 1: Temperature measured in the LD from 35 mins. to 24 h post mortem in **F10**, **F15** and **C10/C15.**

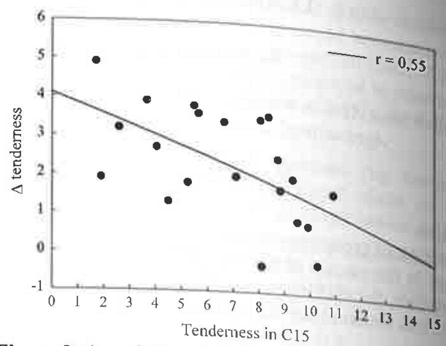

Figure 2: Δ tenderness between **F15** and **C15** plotted against tenderness in **C15**.

Table 1: Waterholding capacity (WHC) and sensory tenderness in LD from F10, C10, F15 and C15.

	F10	C10	p-value	F15	C15	p-value
WHC [%]	1.5	1.9	0.023	1.4	1.7	0.79
Tenderness[1]	8.4	6.4	< 0.0001	9.0	6.7	< 0.0001

[1]sensory scale from 0 (not tender) to 15 (very tender).

Three days *post mortem*, sensory tenderness of LD was evaluated. Both F10 and F15 had improved the sensory tenderness of the meat by 2 sensoric units (on at 15 point scale) compared to C10 and C15 (Table 1).

The pig functioned as its own control, one carcass side being the control and the other being either F10 or F15. Hence, the specific effect of the stepwise chilling method could be found for each pig. In Figure 2, the difference in tenderness between F15 and C15 is plotted against tenderness in C15, indicating that the effect of stepwise chilling on tenderness was greater in pigs with tough meat whereas the effect is small in pigs with per se tender meat despite the rapid chilling process.

Conclusions

This study shows that stepwise chilling of carcasses can improve pork tenderness significantly without compromising WHC. The effect was greatest in meat that potentially would have been tough.

References

Brown, D.H. and Brown. B.I. (1966). In S.P. Colowic, and No.O. Kaplan (Eds.). Methods in enzymology (Vol. 8, pp. 525-524). New York: Academic Press.

Hansen, S., Hansen, T. Aaslyng, M.D. and Byrne, D.V. (2004). Sensory and instrumental analysis of longitudinal and transverse textural variation in pork. *Meat Science*, 68: 661-629.

Kylä-Puhju M., Ruusunen, M. and Puolanne, E. (2005). Activity of porcine muscle glycogen debranching enzyme in relation to pH and temperature. *Meat Science*, 69, 143-149.

Køltoft, P. (2005). Undersøgelse af kølemetodens betydning for kødkvaliteten. Meat trainee report, KVL, pp 1-12.

Rees, M. P., G. R. Trout, and R. D. Warner. (2003). The influence of the rate of pH decline on the rate of ageing for pork. II: Interaction with chilling temperature. *Meat Science*, 65:805-818.

Schäfer, A., Rosenvold, K., Purslow, P. P., Andersen, H. J. and Henckel, P. (2002). Physiological and structural events post mortem of importance for drip loss in pork. *Meat Science*, 61(4), 355-366.

Støier, S., Aaslyng, M. D., Olsen, E. V. and Henckel, P. (2001). The effect of stress during lairage and stunning on muscle metabolism and drip loss in Danish pork. *Meat Science*, 59, 127-131.

Tornberg, E. 1996. Biophysical Aspects of Meat Tenderness. *Meat Science*, 43(S), S175-S191.