Influence of the chilling process on the quality of fresh pork

Susanne Støier, Marchen Andersson & Marjatta Oksama
Danish Meat Research Institute, Maglegaardsvej 2, DK-4000 Roskilde, Denmark

Background

The use of chilling tunnels at Danish pig abattoirs ensures rapid and uniform chilling of carcasses. This impedes growth of microorganisms, reduces losses due to evaporation and limits the risk of PSE. The development of PSE is primarily related to the Halothane-gene. The Halothane-gene has been eliminated from Danish breeding pigs, and the need for very fast chilling is therefore not so acute. Even though a pig does not carry the Halothane-gene and has normal glycolysis it may very well develop PSE if the chilling process is too slow (Offer, 1991). On the other hand, too rapid chilling may provoke cold shortening resulting in tougher meat (Feldhusen & Kühne, 1992). Therefore a too fast as well as a too slow chilling processes should be avoided.
The effect of the chilling process on the quality of fresh pork has been investigated. Preliminary investigations showed that compared to tunnel chilling, batch chilling resulted in a higher frequency of PSE particularly in legs of pigs slaughtered on the day of delivery. In pigs lairaged overnight only insignificant differences were found with respect to PSE-frequency when comparing the two chilling processes (Barton Gade, 1994). This indicates that when the chilling process is slow, the energy level of the muscles at the time of slaughter may influence a possible development of PSE.

Objective

The objective of this investigation was to find which influence the chilling process has on the development of PSE, drip loss, meat colour and eating quality and to clarify whether the energy level of the carcass at the time of slaughter had any effect on meat quality after chilling.

Methods

The following Danish crosses were used in this experiment: D(LY), HD(LY) and YD(LY). The pigs were slaughtered on the day after delivery.
Carcasses were chilled according to the following three programmes:
- Batch chilling at 0°C with air circulation
- Pre-chilling in tunnel at -8°C, aftercooling in equalising chill room with air circulation
- Tunnel chilling at -15°C, chilling finalised in equalising chill room

The experiment was repeated 3 times with 20-27 pig carcasses per chilling process.
Carcass temperatures were registered continuously for each chilling process. pH was measured in the longissimus dorsi muscle (LD) 40 mins., 3 hours and minimum 22 hours post mortem (pm). For the pH-measurements a Knick pH-meter with Ingold glass electrode was used.

On the day after slaughter the level of reflection was measured in LD and in the semimembranosus muscle (SM) with the MQM equipment (Borggaard et al., 1989). From the left loin samples were cut for analysis of drip loss (Rasmussen and Andersson, 1996) glycolytic potential (Monin & Sellier, 1985) and intramuscular fat (Soxhlet method). Slices of loin were wrapped in oxygen permeable film and left for blooming for 1 hour at a temperature of 4°C. Thereafter colour measurement was made with the Minolta equipment.

Cuts of loin for sensoric assessment were vacuum packed and stored at a temperature of 4°C until 4 days after slaughter followed by storage at -20°C. The loin cuts were thawed and sensoric assessment was performed on fried pork chops. A sensoric profile analysis was performed by an experienced panel of 9 members utilising a scale of intensity for the individual sensoric traits ranging from 0 to 15.

Results and Discussion

Chilling process. Registration of carcass temperatures showed that the chilling process was the slowest when using batch chilling. There was no big difference between the chilling rates of the two tunnel processes. The temperature drop in the loin was fastest in the -15°C process whereas the temperature drop in ham was the fastest in the -8°C process. The chill room was able to accommodate the need for more aftercooling when using the -8°C chilling process. Air velocity round the carcasses during chilling and equalisation was therefore locally rather high which increased the evaporation from the surface and consequently the rate of chilling. This may explain why the -8°C process did not deviate that much from the -15°C process.
For all chilling processes the equalised ultimate temperature in the carcasses was 4-5°C 22 hours after slaughter.
Meat quality. In the statistical analysis the groups were first checked for differences in glycolytic potential, amount of intramuscular fat in loin, carcass weight and meat percent.
No differences were found between the groups with respect to glycolytic potential (2 x (glycogen + glucose + glucose-6-p) + lactate) the average being in the area 176 - 190. This indicates that the energy level of the slaughter pigs at time of slaughter was the same in all three groups. The glycolytic potential in individual carcasses showed a big variation - from 89 to 350 - which may be attributed to the use of Hampshire crosses. Compared to other breeds Hampshire pigs have in general a higher energy level in the musculature (Monin & Sellier, 1985).
Experiments have shown that intramuscular fat has a positive effect on sensoric characteristics (Bejerholm & Barton, 1986). The analysis for intramuscular fat was included in this experiment to ensure that differences between the groups - if any - with respect to eating quality do not relate to variation of fat content. The intramuscular fat content of the loin was in the range 1.6 - 1.7% for all three groups and there were no significant differences between the groups.
The rate of temperature fall in the carcass relates to carcass weight and meat percentage. Therefore, the temperature drop is slower in heavier and fatter pigs. The pigs in this experiment had an average carcass weight of 87 kg and a lean meat content of 60.1%. No differences were found between the groups with respect to these parameters.
$pH_{40\ min\ pm}$ indicates the rate of glycolysis which again has an influence on the meat quality. Meat quality data were analysed based on following model:

$$\text{Meat quality} = \text{constant} + \text{group} + \text{date} + pH_{40\ min.\ pm} + \text{random error}$$

SAS-General Linear Models Procedure was utilised for the statistical analysis.
There were no significant differences between the groups with respect to pH measured 40 min., 3 hours and 22 hours pm.
The rate of pH fall was determined by the difference between pH measured in the loin 40 min. and 3 hours pm. There was a tendency towards a faster pH-fall with batch chilling compared to the two tunnel chilling processes. This was anticipated as the rate of the glycolytic processes and thus the pH-fall is related to temperature and will become higher at higher temperatures.

Reflection level measured with the MQM equipment gives an indication of the water holding capacity of the meat. The figures for reflection were highest in LD from batch chilling indicating a higher risk of PSE with this chilling process.

Table 1 – pH, reflection level and drip loss of LD (average and standard deviation – Sd.)

	Batch		–8°C		–15°C	
	Ave.	Sd.	Ave.	Sd.	Ave.	Sd.
$pH_{22\ hrs\ pm}$	5.6	0.1	5.6	0.2	5.6	0.2
Reflection	65[a]	10	59[b]	10	58[b]	11
Drip loss (%)	6.0	2.9	4.8	2.4	4.8	2.2

Average figures with different letters attached indicate significant differences, $p<0.001$.

As indicated by the reflection levels, drip loss in the loin was biggest with batch chilling. The difference between the groups was, however, not significant which may be attributed to the rather high standard deviation for drip loss in the individual groups.
A visual evaluation of MQM–profiles of the SM showed that the frequency of SM–muscles with PSE spots was approx. 50% with batch chilling compared to the –8°C and –15°C processes which had a frequency of approx. 25%.
No differences were found between the groups for meat colour measured on slices of loin on the day after slaughter.

Table 2 – L–value and sensory characteristics (average and standard deviation)

	Batch		–8°C		–15°C	
	Ave.	Sd.	Ave.	Sd.	Ave.	Sd.
L–value (hue)	61.8	2.6	51.6	2.8	52.0	2.8
Tenderness	10.3	0.8	10.2	1.0	10.2	0.9
Juiciness	9.8	0.8	9.9	0.7	9.8	0.7

Results of the sensoric assessments showed that the chilling process did not influence the eating quality. It has to be noted, however, that all loins for sensoric assessment were frozen on the 4th day after slaughter. Ageing has a positive effect on tenderness and experiments have shown that ageing reduces the negative influence that cold shortening has on tenderness (Feldhusen and Kühne, 1992). Cold shortening may hardly apply in this experiment since it took 5 to 10 hours in all chilling processes before the temperature of the LD was below 10°C.

As expected, the level of intramuscular fat affected the eating quality. An increasing amount of intramuscular fat in LD resulted in a better tenderness and a more distinct meat flavour. The effect was significant on the 1%–level.
Energy level: Differences in energy level within groups in this experiment relate primarily to the crosses used and only to a limited extent to difference in pre–slaughter stress as treatment before slaughter was standardised.
No interaction was found between the chilling processes and the glycolytic potential with respect to the measured meat quality characteristics. The influence of the chilling process on meat quality does thus not relate to the energy level of the musculature at time of slaughter.
According to the analysis of variance made on the raw material used in this experiment, the glycolytic potential has a significant effect on meat quality. An increasing glycolytic potential thus results in a lower ultimate pH, a higher level of reflection, a bigger drip loss plus higher a–, b– and L–values.

Conclusion

Summing up, the chilling processes used in this experiment where pigs were lairaged overnight did not result in large quality differences. However, batch chilling had a negative effect on the level of reflection in LD and the frequency of PSE–spots in SM. The experiment could not confirm the presumption that batch chilling results in a better eating quality.

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