A note on the influence of ambient temperature at slaughter on pig meat quality

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SUMMARY: Ten batches of pigs were killed on different days after careful preslaughter handling. Ambient temperature ranged from 12.3 to 23.9 °C. Batches killed at higher temperatures had muscles with higher initial temperature, lower ultimate pH and poorer water holding capacity. They tended to be paler and had less acceptable eating quality when assessed by a taste panel.

INTRODUCTION: Much of the value of good ventilation in transport rests with its effect on the temperature of the pigs' immediate environment. Transport at an ambient temperature of 19°C was less stressful, based on elevation of the heart rate, than at either 2°C or 29°C (Augustini and Fischer, 1982). Higher ambient temperatures (25°C) have been shown to be associated with poorer meat quality than normal temperatures (15°C) in Dutch slaughter pigs (Lendfers, 1968) and a significant effect of season was seen in Danish studies (Barton, 1971). In the latter, the poorer meat quality in summer and autumn was largely due, not to more pigs having meat quality deviating from normal, but to an increase in the extent of the deviation. Conversely, Scheper (1971) observed higher incidences of PSE and dark, firm, dry (DFD) meat in autumn and winter, than in spring and summer, in Germany. We have examined the relationships between ambient temperature on the day of slaughter and aspects of pig meat quality using information collected from an experiment in which pigs were subjected to transport and lairage under ideal conditions and over a moderate range of ambient temperatures.

MATERIALS AND METHODS: The experiment used 320 LW x (LW x LR) pigs (89 ± 7 (SD) kg) slaughtered at the University of Bristol Slaughterhouse. Half were entire males and half were females. They were obtained in ten batches of thirty-two and were held at the University farm for 7 to 14 days prior to the experimental handling. During this time, and during preslaughter handling, they were not allowed to mix with unfamiliar animals. The pigs were fed *ad libitum* a commercial pelleted compound diet. Food was removed 1h before loading on the day of transport. The pigs were transported for 2h (including loading and unloading), a distance of about 80km. They were carried only on the lower deck of the transporter and loading and unloading were carried out without the use of sticks or goads. Stocking density during transport was $0.52m^2$ per 100kg live weight. On arrival at the slaughterhouse the pigs were killed after various times in lairage ranging up to 21h. These times were balanced within batches and for the present purpose the data for all thirty-two pigs in a batch have been pooled. The pigs were slaughtered using normal commercial practices.

Ambient temperatures were measured at the entrance to the lairage at 12.00h and 17.00h on the day of transport to slaughter and at 0900h the following morning when the pigs which had been kept in lairage for 21h were killed. The mean of the three readings was used in the subsequent analyses. At 45 minutes post mortem a small sample of *m.longissimus dorsi* (LD) was taken in the region of the last rib for measurement of pH (pH_{45}) and about 1h post mortem, just before entering the chiller, the temperature in the LD was recorded. After overnight chilling samples of LD were used for measurement of ultimate pH (pH_u), colour, drip loss, instrumental texture (shear force) and taste panel assessment. Griddled chops were assessed by ten panellists using eight-point category scales (a score of 8 = extremely juicy, extremely tender, extremely strongly flavoured and extremely liked overall). For analysis, the mean values for measurements on all 32 pigs in one batch were used in order to remove treatment effects due to differences in preslaughter handling. Differences between means were tested using t-tests and simple correlations were calculated.

RESULTS: Ambient temperature ranged from 12.3°C to 23.9°C when the ten batches were slaughtered. Initially the data were divided into two sets, one from the five batches killed at lower (<18.3°C, mean = 14.4 ± 1.02°C) temperatures, the other from those killed at higher (≥18.3°C, mean = 20.6 ± 1.10°C) temperatures (Table 1). Compared with those slaughtered at lower temperature, pigs killed when the temperature was higher produced carcasses in which the initial LD temperature was higher (P<0.001), pH_u was lower (P<0.05), drip loss was higher (P<0.01) and the muscle was paler (P<0.05), although the pH_{45} was not significantly different between the two groups. Although also not significant, pigs killed when it was hotter had LD muscles which had higher instrumental shear force values and tended to receive lower taste panel scores for juiciness, flavour and overall acceptability, but not for tenderness.

Table 1. Meat quality in pigs killed at low or high ambient temperature (means ± SE)

	Low ambient temperature	High ambient temperature	t-value and significance
Ambient temperature (°C)	14.4 ± 1.02	20.6 ± 1.11	
LD temperature (°C)	32.6 ± 0.24	34.4 ± 0.15	6.3***
pH_{45} LD	6.04 ± 0.02	6.05 ± 0.01	0.4^{ns}
pH_u LD	5.43 ± 0.01	5.39 ± 0.01	2.8*
Drip loss (%)	6.3 ± 0.21	7.5 ± 0.27	3.5**
Lightness (L*)	54.7 ± 0.16	55.5 ± 0.19	3.2*
Hue	37.6 ± 0.37	38.8 ± 0.87	1.2^{ns}
Saturation	6.8 ± 0.14	6.4 ± 0.15	2.0^{ns}
Instrumental texture (shear force, kg)	4.9 ± 0.23	5.2 ± 0.20	0.9^{ns}
Taste panel: tenderness	3.9 ± 0.06	4.0 ± 0.05	1.1^{ns}
juiciness	4.0 ± 0.10	3.8 ± 0.09	1.6^{ns}
flavour	4.0 ± 0.04	3.8 ± 0.07	2.0^{ns}
overall acceptability	4.0 ± 0.06	3.7 ± 0.09	2.2^{ns}

Each mean is the average of five batch means and represents information from 160 pigs. n.s. not significant, * P < 0.05, ** P < 0.01, *** P < 0.001.

The relationships between ambient temperature and meat quality were further investigated by calculating simple correlations (Table 2).

Table 2
Correlations of ambient temperature with meat quality characteristics

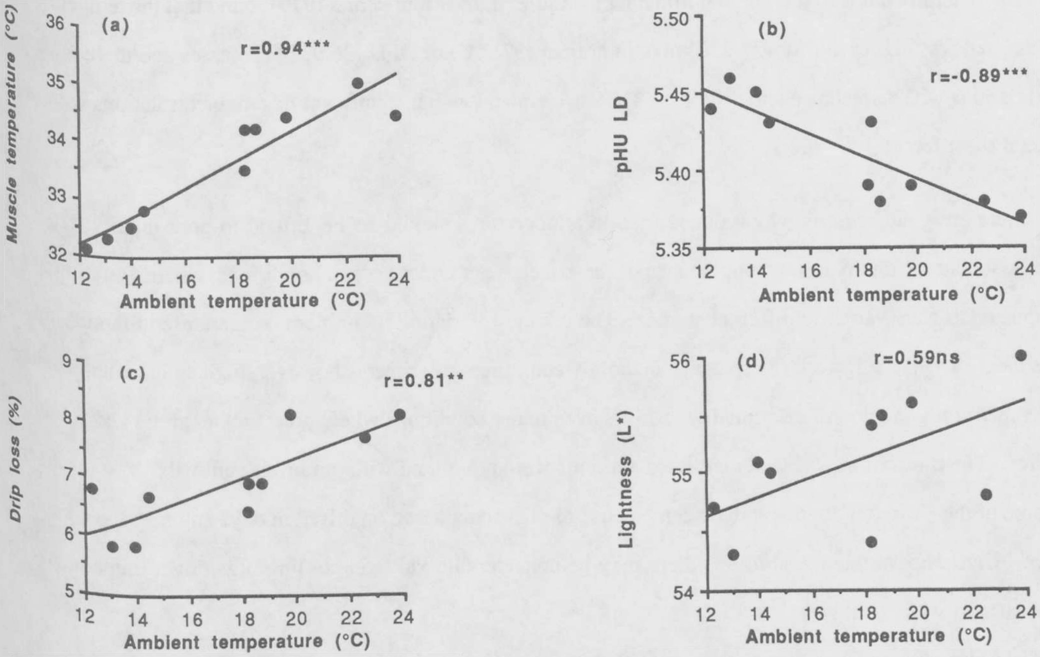
	r
LD temperature (°C)	0.94 ***
pH_{45}LD	0.12
pH_uLD	-0.89 ***
drip loss (%)	0.81 **
Lightness (L*)	0.59
Hue	0.64*
Saturation	-0.32
Instrumental texture (shear force, kg)	0.47
Taste panel: tenderness	0.35
juiciness	-0.48
flavour	-0.58
overall acceptability	-0.76 *

Correlations were calculated using batch means (n=10).

Ambient temperature was significantly negatively correlated with pH_u (r= -0.89, P<0.001), and taste panel overall acceptability score (r= -0.76, p<0.05), and significantly positively correlated with drip loss (r= 0.81, p<0.01) and hue (r= 0.64, p<0.05). There was also a tendency for lightness (L*) to be higher at higher temperatures and the meat to be tougher when measured instrumentally, and to be rated less juicy and less strongly flavoured. There was no relationship between ambient temperature and pH_{45}. Some of these relationships are illustrated in Figures 1 and 2.

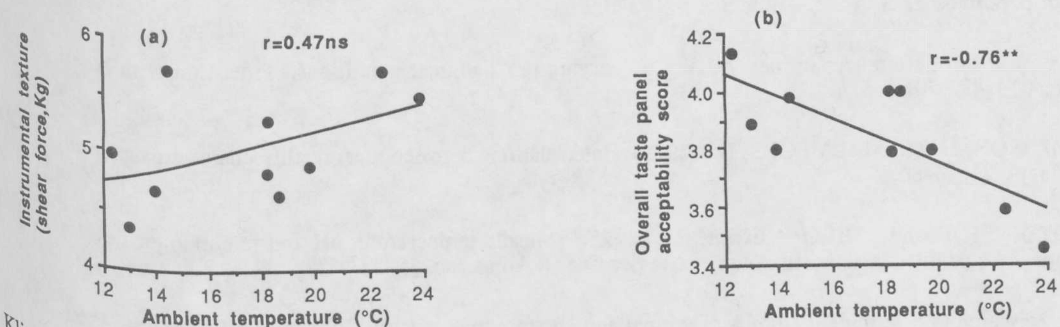
DISCUSSION: The indication from the present results was that as ambient temperature increased, the meat became paler and had poorer water holding capacity. This change in quality was associated with a lower pH_u, rather than lower pH_{45} values, and a higher initial muscle temperature. After cooking the meat tended to be slightly less juicy and have poorer flavour, and its eating quality was judged less acceptable overall. It is not clear whether the close relationship of initial muscle temperature to ambient temperature (r = 0.94, P < 0.001) is due to antemortem or postmortem factors or a combination of both. With higher ambient temperature the rate at which carcasses cooled before entering the chiller would have been slightly slower and muscle temperatures would consequently have been higher.

Fig 1. Relationships between ambient temperature and (a) muscle temperature, (b) pHu LD, (c) drip loss, (d) lightness (L*). Each point is the mean of 32 values.



However, higher ambient temperatures before slaughter would also probably have led to slightly increased body temperature of the pigs, particularly during periods of physical exertion such as unloading after transport and being moved to the point of stunning. This raised body temperature would have been reflected in elevated muscle temperatures immediately postmortem. Tarrant (1989) suggested that the temperatures which pigs experience during transport may often approach their upper limit of thermal tolerance and that spraying pigs with cold water in lairage was effective in improving pork quality mainly because it accelerated cooling of the animals. The exact importance of initial muscle temperature in determining subsequent meat quality nevertheless remains unclear.

Fig 2. Relationship between ambient temperature and (a) instrumental texture, (b) taste panel overall acceptability score. Each point is the mean of 32 values.



Klingbiel *et al*. (1976) found that delayed evisceration of carcasses, which significantly raised muscle temperatures, did not affect meat quality except for the colour of the *m.semimembranosus* (SM) which was slightly paler. Martin *et al* .(1975) in an extensive study of factors affecting pork quality found no evidence that muscle temperature was influenced by differences in cooling rates associated with variation in fatness, nor was temperature closely related to meat quality traits. However, there were low (r < 0.3) but significant positive correlations of temperature measured 45 minutes postmortem in the SM with rate of rigor development and shear value, and low negative correlations with pH_{45} and taste-panel assessed tenderness. In contrast, De Vol *et al* .(1988) found that meat from carcasses which were warmer at 4h postmortem was more tender and darker, but the correlations were very low (r < 0.25). However, meat which subsequently becomes PSE generally has a slightly higher initial temperature. Lundstrom *et al* .(1979) found that the temperature in the LD at 45 minutes postmortem was higher in PSE (38.2°C) than in normal (37.5°C) or DFD (36.9°C) carcasses and there were low but significant positive correlations with reflectance and drip loss. There were also low but significant negative correlations with pH_u and, anomalously, instrumental shear force.

In summary therefore, there are good reasons why reduced muscle temperatures should be beneficial to pork quality, especially in reducing characteristics associated with PSE meat, but the size of the effects seen under normal conditions, where variation in muscle temperature is small, appears to have varied in different studies. The effect of variation in ambient temperature in modifying muscle temperature is even less clear. The present work suggests that in closely controlled experiments however, high ambient temperatures can lead to higher muscle temperatures and poorer meat quality. This is even under conditions where preslaughter stress was minimised by good handling procedures. The transporter was well ventilated and pigs were not mixed with unfamiliar animals. The results may go some way to explain some of the variation often seen between batches of pigs slaughtered on different days and may have implications for commercial practice. Under hot ambient conditions there may be considerable value in cooling pigs down immediately before slaughter using methods such as water mist sprays.

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