CRITICAL POST MORTEM PH AND TEMPERATURE VALUES IN RELATION TO DRIP LOSS IN PORK

Annette Schäfer[a], Katja Rosenvold[b], Peter P. Purslow[a], Henrik J. Andersen[b] and Poul Henckel[b].

[a]Institute of Dairy and Food Science, The Royal Veterinary and Agricultural University, 1958 Frederiksberg
[b]Dept. of Animal Product Quality, Danish Institute of Agricultural Sciences, 8830 Tjele, DENMARK.

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Background

The ability of meat to retain inherent water, also designated water-holding capacity (WHC), is an essential meat quality parameter for economic, technological and sensory reasons. WHC determines the potential weight loss of fresh meat resulting in economic losses. Consequently, the pork industry has a strong interest in prediction, as well as in optimisation, of this property.

pH and temperature in the muscle *post mortem* are generally accepted to be essential factors in relation to the formation of drip. A combination of high temperature and low pH early post mortem is known to lead to marked protein denaturation, resulting in PSE meat. Consequently, pH_{45min} was implemented in certain countries to classify carcasses for further use. Moreover, pH_{24h} has been suggested as a potential predictor of drip loss in carcasses, which especially applies when the variation in drip loss is high. This variation may be assigned to pre-slaughter stress, but is also influenced by genotype. Excluding genetic effects in the pig population, (especially the Halothane gene, which causes a rapid pH fall early *post mortem*) has slowly eliminated the use of pH in slaughter pig classification in most countries. However, the remaining high variation in drip loss made the interest in classification of carcasses with regard to potential drip loss more relevant than ever. Different approaches (including sophisticated techniques such as NMR and NIR spectroscopy) to predict drip loss in pork have been demonstrated in the scientific literature. However, the use of simple methods, e.g. pH or temperature measurement, still seems attractive. The present study shows results from using combinations of pH and temperature explaining variation in drip loss in pork from animals, which were non-carriers of both the Halothane and RN gene.

Objectives

The objective was to find critical *post mortem* pH and temperature values which provide the best explanation for variation in drip loss in pork.

Methods

Female and castrated male pigs (N = 37) Danish Duroc x Danish Landrace x Large White (all non-carriers of the Halothane gene) were used in the experiment. All pigs were reared at the experimental farm at Foulum Research Centre and were given a standard diet *ad libitum*. The slaughter weights were between 74 and 106 kg. Two models were applied to obtain high variation in drip loss. Group A (N = 20), control group, was stunned by 80% CO_2 for 3 min. Group B (N = 17) was exercised immediately prior to stunning on a treadmill till exhaustion (breathing and stride frequency are becoming uncoordinated) and then electrically stunned (220 V, 1.5 A, 15 sec). Immediately after stunning pigs were exsanguinated, scalded at 62°C for 3 min, cleaned and eviscerated within 30 min. After 60 min, the carcasses were placed at 4 °C in a chill room. All measurements were made on the *M. longissimus dorsi*. pH was measured in duplicate at the last rib with a pH-meter (Radiometer, Denmark) equipped with an insertion glass electrode (Metrohm, Switzerland) at fixed intervals *post mortem*: 1 min, 15 min, 30 min, 1 h, 2 h, 3 h, 6 h, 9 h and 24 h. Temperature was also measured at the last rib 1min, 15 min, 30 min, 1 h, 2 h and 24 h with a Testo 110 insertion thermo-element (Testo, Germany). Partial least squares (PLS) regressions (Martens & Næs, 1989) were applied in the data analysis and carried out with the software "The Unscrambler" version 7.6 (Camo AS, Oslo, Norway). Models included either pH, temperature or a combination of both (**X**) to explain drip loss (**Y**). Full cross validation (leave one out) and Martens' uncertainty test was applied. Multivariate validation correlation coefficient (R) and the root mean squares error of prediction (Sep) were applied for the evaluation of the models.

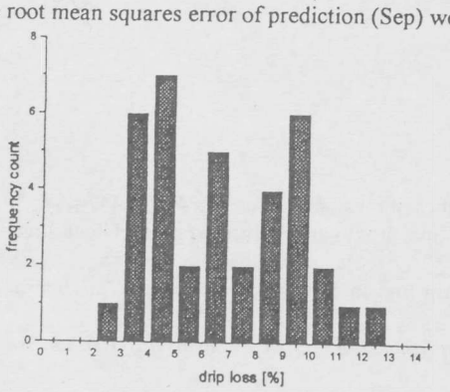

Figure 1 Distribution of drip loss.

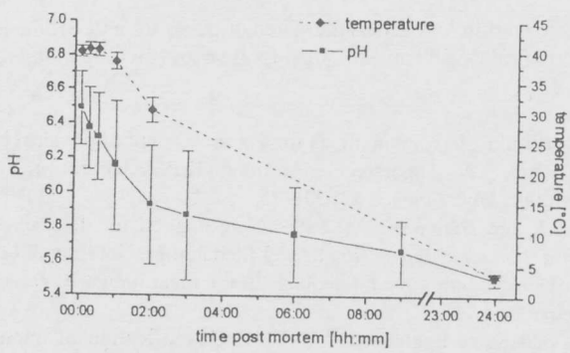

Figure 2 pH and temperature development *post mortem* (mean and standard deviation)

Results and discussions

Figure 1 represents the distribution in drip loss from chops of 37 slaughter pigs. Figure 2 shows the pH and temperature development post mortem and the variation at the different time points in *M. Longissimus dorsi* from the same 37 slaughter pigs.

The analysis of pH and temperature alone shows that each of the parameters on its own can explain a high amount of the variation in drip loss with the range normally found in a Halothane and RN gene free population (Table 1). Looking at single time points, $pH_{2\,h}$ explains most of the variance in drip loss. This is in contrast to the general acceptance of $pH_{45\,min}$ as an indicator of drip in pork from populations containing the Halothane gene, which is consistent with the fact that Halothane carriers induce a very fast pH drop early *post mortem* while the critical point in non-carriers first appears 2 h *post mortem*. Measurements 24 h post mortem did not explain the variance in drip loss in a population free of Halothane and RN gene carriers not exposed to long time stress, e.g. long transportation.

In a similar model including pH at all time points in the prediction of drip, the variation in pH_{24h} is found in the second principal component. This indicates that differences in pH_{24h} are a result of a different mechanism compared to variation in pH earlier *post mortem*.

$T_{1\,min}$ on its own explains 81% of the variation in drip loss. The degree of explanation is reduced at later time points. Analysing a series of pH measurements in multivariate data analysis gives the possibility to take into account the whole pH development *post mortem* (Table 2) and increases the explained variance in drip. The same effect is seen for serial temperature data but it is surprising that the explained variance in drip loss explained by temperature may be slightly higher then explained by pH. Combining pH and temperature in the prediction model only increased the explained variance slightly (Table 3), as these properties are highly interrelated. Animals having high muscle temperatures upon being physically stressed also had faster pH decline. Reducing the time points included in the model at which pH and temperature were measured showed that the explained variance in drip remained the same as in the full model and the correlation coefficient increased. In a model including only pH_{2h} and T_{1min}, the error of prediction is further decreased. This shows that initial differences in body temperature and differences in pH decline are the most important factors for the mechanism responsible for formation of drip.

Conclusions

The results show that a few, critical, pH and temperature measurements early post mortem are sufficient to explain variation in drip loss in pork chops.

References

Martens, H., & Næs, T. (1989). *Multivariate Calibration*. Chichester: John Wileys & Sons.

Table 1 Explained variance for drip loss (Y), the multivariate validation correlation coefficients (R), the standard error of prediction (Sep) are shown for PLS1 models which included pH or temperature variables at a single time point in X.

Variable in X	Y-var	R	Sep
pH_{1m}	66%	0.79	1.66
pH15m	63%	0.77	1.73
pH30m	73%	0.83	1.47
pH1h	72%	0.83	1.52
pH2h	82%	0.90	1.19
pH3h	62%	0.76	1.72
pH6h	59%	0.74	1.79
pH9h	54%	0.71	1.89
pH24h	4%	-0.02	2.74
T1m	81%	0.89	1.21
T15m	78%	0.87	1.34
T30m	71%	0.82	1.52
T1h	35%	0.55	2.27
T2h	10%	0.22	2.62
T24h	4%	0.06	2.71

Table 2 Explained variance for **X** and **Y**, the multivariate validation correlation coefficients (r), the standard error of prediction (Sep), and the number of PC included in the models are shown for PLS1 models which included pH and temperature variables in **X** and drip loss in **Y**. Non-significant time points ($p < 0.05$) were excluded from the models.

Variable in X	X-var	Y-var	R	Sep	#PC
$pH_{1m+15m+30m+1h+2h+24h}$	92%	85%	0.90	1.14	2
$T_{1m+15m+1h+2h}$	99%	87%	0.91	1.12	3

Table 3 Explained variance for **X** and **Y**, the multivariate validation correlation coefficients (r), the standard error of prediction (Sep), and the number of PC included in the models are shown for PLS1 models which include pH and temperature in **X** and drip loss in **Y**. (1) all pH and temperatures variables are included (2) significant time points for pH and temperature and (3) $pH_{2\,h}$ and $T_{1\,m}$.

Significant time points	X-var	Y-var	R	Sep	#PC
$pH_{1m+15m+30m+1h+2h+3h+6h+9h+24h}$, $T_{1m+15m+30m+1h+2h+24h}$	74%	89%	0.92	1.06	2
$pH_{1m+15m+30m+1h+2h+24h}$, $T_{1m+15m+30m}$	88%	89%	0.93	0.97	2
pH_{2h}, T_{1m}	92%	89%	0.94	0.94	1