THE EFFECT OF ACCELERATED CHILLING OF CARCASSES ON PORK SEMIMEMBRANOSUS MUSCLE COLOUR

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Introduction

Accelerated chilling of carcasses, e.g. rapid reducing intramuscular temperature as soon as possible after exsanguination can be an effective method to reduce the incidence of PSE pork (Savell *et al.*, 2001, review; Petrović *et al.*, 1996). Grandin (1994) believes that chilling process accounts for 20 to 40% of the variation in PSE meat. Kerth et al. (2001) reported a reduced incidence of PSE meat in loins and hams from stress sensitive pigs after accelerated chilling, however, not in stress resistent pigs. Some studies have shown, however, that rapid chilling, compared to conventional process, can affect the colour of pork (Jones et al., 1993; Milligan *et al.*, 1998).
Unlike those studies, Eilert (1997) and Hambrecht et al. (2004) stated that more rapid chilling procedures will not prevent PSE, e.g. have no effect on colour (Crenwelge et al., 1984a), since the changes in meat occured before the chilling process. The aim of this work was to determine the effects of two different rapid chilling regimes on colour of *M. semimembranosus*, in the scope of a broader program of decreasing the PSE meat incidence in Serbia.

Materials and Methods

Commercial pigs, slaughtered according to the standard procedure used in abattoirs in Serbia were investigated. At the end of the slaughterline, pH (pH_{30min}) in the medial part of *M. semimembranosus* (MS) and temperature (T_{30min}) at the center of the ham near to *femur* were measured. 40 carcasses with normal flow of glycolysis ($pH_{30min} \geq 5.8$) were chosen (n = 20 – Experiment 1; n = 20 – Experiment 2). Left sides (LS) were air chilled at –31 °C (AC) for 150 min. (Experiment 1) e.g. for 180 min. (Experiment 2), than placed in the conventional chiller at 2 – 4 °C until 24 h *post mortem*. The right sides (RS) were also chilled according to the conventional chilling (CC) regime at 2 – 4 °C until 24 h *post mortem*. Colour of MS was determined after measurement of pH_{24h} and T_{24h}. The procedure described by Honikel (1988) was used for colour measurements, in the CIE$L^*a^*b^*$ system using a Minolta Chroma Meter CR-400 device. On every MS sample, the colour was measured four times. On the basis of total number of instrumental colour measurements (L^*) (n = 160 – Experiment 1; n = 160 – Experiment 2) and according to criteria given by Joo et al. (1999) for colour, e.g. quality of pork (Pale: $L^* > 50$; Reddish-pink: $L^* = 43 – 50$; Dark: $L^* < 43$) the incidence of pale, reddish-pink and dark colour was determined. A five member panel assessed the MS colour according to the following criteria: 1 – Pale-pinkish-gray, 2 – Grayish-pink, 3 – Reddish-pink, 4 – Purplish-red, 5 – Dark-purplish-red.

Table 1: The effect of accelerated chilling on temperature and pH decline and colour of MS.

Trait	Experiment 1		Experiment 2		*P*–value (paired *t*-test) Experiment	
	LS – AC	RS – CC	LS – AC	RS – CC		
	Mean ± SD	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	1	2
T_{30min}	41.36 ± 0.42	41.47 ± 0.30	41.73 ± 0.50	41.73 ± 0.54	0.533	1.000
T_{24h}	4.14 ± 0.39	5.52 ± 0.36	3.80 ± 0.53	5.16 ± 0.26	<<0.001	<<0.001
pH_{30min}	6.23 ± 0.22	6.25 ± 0.23	6.24 ± 0.26	6.19 ± 0.22	0.798	0.386
pH_{24h}	5.71 ± 0.16	5.66 ± 0.16	5.77 ± 0.22	5.65 ± 0.23	0.013	0.010
CIEL^* (lightness)	47.92 ± 2.65	48.15 ± 3.15	45.74 ± 4.50	48.24 ± 4.69	0.757	0.006
CIEa^* (redness)	8.79 ± 1.38	9.22 ± 1.60	9.32 ± 1.37	9.25 ± 1.60	0.401	0.883
CIEb^* (yellowness)	4.21 ± 0.76	4.47 ± 0.98	4.62 ± 1.27	4.81 ± 1.10	0.103	0.339
Colour – Sensory	2.90 ± 0.21	2.75 ± 0.42	2.90 ± 0.52	2.60 ± 0.64	0.343	0.132

Results and Discussion

At the beginning of chilling, 30 min. *post mortem* (Table 1), no significant difference ($P > 0.05$, Experiment 1, 2), was estimated between the average temperatures measured in the ham of left and right sides. However, at the end of the chilling process, 24 h *post mortem*, in accelerated chilled sides (LS – AC) a statistically significantly lower average temperature in the middle of the ham was found ($P << 0.001$; Experiment 1, 2), compared to conventionally chilled sides (RS – CC). The accelerated chilling e.g. the rapid decrease of intermuscular temperature, resulted in slower biochemical processes in MS. In rapid chilled sides (LS – AC) statistically significantly higher ($P = 0.013$; $P = 0.010$; Experiment 1, 2) average pH_{24h} values were found. The obtained results, which point to slower decrease of pH, are in accordance with the results obtained at similar conditions of rapid air chilling, but no significant difference between the ultimate pH values. In the first experiment the average lightness (L^*) of MS was not significantly affected ($P = 0.575$) by accelerated air chilling. However, in the second experiment significantly ($P = 0.006$) darker colour of MS was found

bottom of the chamber collects condensate and drains it to the back of the unit, preventing hot water falling onto experimenters as the system is loaded.

Results and Discussion

The effects of various atmospheric steam treatments on the appearance, shelf-life and microbiological quality of chicken have been investigated. Initial experiments (James *et al.*, 2000a) showed that a 10s steam treatment on naturally-contaminated chicken breast portions resulted in a 1.65 $\log_{10}$ CFU (colony-forming units)/cm^2 reduction in aerobic plate count (APC). However, in comparison with untreated controls, this treatment did not extend the shelf-life. Overall, results indicated that significant reductions in microbial counts could be achieved for chicken meat using steam. Further work has looked at the effectiveness of steam against *Campylobacter* spp., under laboratory and commercial conditions (James *et al.*, 2005). In experimental studies whole chicken carcasses, inoculated with ca. 6 $\log_{10}$ CFU/cm^2 *Campylobacter jejuni* and *Escherichia coli* K12, were treated with steam at atmospheric pressure for up to 20s. Numbers of *C. jejuni* were reduced by ca. 1.8 $\log_{10}$ CFU/cm^2 in 10s and 3.3 $\log_{10}$ CFU/cm^2 in 20s. Corresponding reductions in numbers of *E. coli* K12 were 1.7 and 2.8 $\log_{10}$ CFU/cm^2. However, the 20s treatments caused the skin to shrink and change colour. The optimum steam treatment for maximum effect on *C. jejuni* and *E. coli*, least skin shrinkage and change of colour was concluded to be 10-12s. Additional trials in a commercial poultry plant using naturally contaminated carcasses were hampered by low initial levels of *Campylobacter* spp. (~1 $\log_{10}$ CFU/cm^2) but variable reductions of about 2 log cycles were obtained for pseudomonads and Enterobacteriaceae. Numbers of campylobacters were reduced, but not eliminated. It was considered that changes to appearance of skin-on carcasses or portions would be acceptable to many consumers. Unacceptable carcasses produced (or more severe treatments with greater kill potentials) could be used for production of 'skin-off' portions. Additional work has been carried out on pork, lamb (James *et al.*, 2000b), and beef (and also fish, fruits and vegetables).

The surface temperature is a critical parameter in the destruction of pathogenic and meat spoilage microorganisms in steam systems. However, measuring the temperature of the surface of the meat is a difficult procedure. There is a marked temperature profile from the surface into the environment and from the surface into the meat. Thermal modelling can be used to predict the surface temperature but reliable data on the surface heat transfer coefficient is required. An experimental protocol based on that of Creed and James (1985) has been used to determine the surface heat transfer coefficients in the atmospheric steam cabinet to enable further optimisation of the system. The overall effective surface heat transfer coefficient determined for the steam cabinet were 1215.8 $W/m^2/K$ at 100°C, much higher than those used in previous studies on modelling steam decontamination systems (Hoke *et al.*, 2003). This should allow much better prediction of meat surface temperatures and subsequently aid the design and optimisation of similar steam intervention systems.

Conclusions

A pilot scale atmospheric steam cabinet has been developed and successfully used in many experimental trials involving poultry, pork, lamb, and beef (and also fish, fruits and vegetables) both in a laboratory setting and alongside commercial processing lines in industry to demonstrate the effectiveness of steam interventions in lowering microbial loads.

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