PE4.24 Effect of early and ultimate pH in raw ham on destructured zones in cooked cured ham 85.00

Gabriel Hugenschmidt (1, 2) ruedi.hadorn@alp.admin.ch, R. Hadorn (2), M. Scheeder (3, 4), C. Wenk (2)
(1) Agroscope Liebefeld-Posieux Research Station ALP, Berne, Switzerland
(2) Institute of Animal Science, Swiss Federal Institute of Technology, Zurich, Switzerland
(3) Swiss College of Agriculture, Zollikofen, Switzerland
(4) SUISAG, Sempach, Switzerland

***Abstract* — Effects of early (1 hour post mortem [p.m.] / 3 hours p.m.) and ultimate pH (24 hours p.m.) on level and amount of destructured zones in cooked cured hams were evaluated. In experiment 1, electrically stimulated (50V, 14Hz, 2×90s) and non-stimulated carcass halves, both in combination with two cooling procedures (2°C from 30 min p.m. vs. 120 min p.m.) resulted in 1.5 to 35.2 g/kg destructured zones in silversides and 58.4 to 120.0 g/kg destructured zones in topsides. High temperature 1 hour p.m. in silversides ($P = 0.067$) and topsides ($P = 0.054$) was identified as the most important predictor for the defect. In experiment 2, cooked cured hams from topsides selected according to ultimate pH groups (pH < 5.5, pH 5.5 - 5.7, pH > 5.7) showed between 12.3 and 61.8 g/kg destructured zones. Ultimate pH was specified as most important, however statistically still not significant ($P = 0.135$) predictor for the defect.**

***Key words* — cooked cured hams, destructured zones, pH, temperature.**

I. INTRODUCTION

IN spite of intensive efforts in research as well as in industry, destructured zones remain an ongoing problem in the production of cooked cured hams. The affected zones are characterised by a light colour, a crumbly texture and alterations in the chemical constitution [1] and have to be sorted out after slicing. Batchwise, there can be an important impact by the defect on up to 40 % of the cooked cured ham slices. The occurence of destructured zones is known to be affected by the early-post-mortem (p.m.) pH course and the ultimate pH in the raw hams [2, 3]. In the present study, the influence of these two parameters on the occurrence of destructured zones in cooked cured hams was examined in two independent experiments.

II. MATERIALS AND METHODS

In the first experiment, 40 Large White pigs (20 gilts and 20 barrows) were grown up and slaughtered using electrical stunning (310 V, 2 A, 5 sec) at Agroscope Liebefeld-Posieux Research Station ALP. Every second carcass was treated by electrical stimulation (50 V, 14 Hz) 2 minutes p.m. in order to accelerate early-p.m. pH fall. Thereby, the electrodes were placed at the trunk and the right tarsal for 90 seconds in the first and at the left tarsal and the trunk in the second cycle. The left halves of all carcass were stored at 2°C from 30 minutes p.m. on (conventional cooling), whereas the right halves of all carcass were kept at 22°C until 120 minutes p.m. before being stored at 2°C (delayed cooling). Thus, four treatments were compared in a 2×2-factorial design with the two factors "electrostimulation" and "cooling" (table 1). After storing 96 hours at 2°C, topsides (*Mi. semimembranosus* and *adductor*) as well as silversides (*M. biceps femoris*) of each treatment were transformed into two batches of cooked cured hams.

In experiment 2, two batches with 800 (batch 1) and 1000 (batch 2) topsides originating from an industrial meat processing plant were classified into three groups according to their ultimate pH (24 hours p.m.) in *M. semimembranosus*: L-pH group (pH < 5.5), M-pH group (pH 5.5 - 5.7), and H-pH group (pH > 5.7) (table 1). After this classification, 24 topsides of the L-and M-pH group and 16 topsides (all samples found) of the H-pH group in batch 1 and in batch 2 again 24 topsides of the L-and M-pH group and 32 topsides of the M-pH group were selected for further ham processing. The level of destructuration in the raw muscles was determined 72 hours p.m. according to the IFIP quotation scale [4]. The processing of cooked cured hams was conducted according to practical standards using two topsides of the same pH-group per mould.

Slicing was performed in an industrial meat processing plant with a standard slicer (250 slices per minute, 1.25 mm thickness) 14 days after cooking. Destructured zones in silversides and/or topsides of the cooked cured hams were classified in 1st, 2nd, and 3rd level according to [5], cut out from the affected slices, weighed and indicated as g/kg raw muscle.

For binary logistic regressions, destructured zones of 1st, 2nd and 3rd level were weighted by the factors 1, 10 and 100, respectively and added up resulting in a new variable, which was transformed into a binary variable separating at its 80th percentile. A stepwise forward/backward elimination of variables was then performed, before the final model was calculated using the variables with the lowest "probability to remove" values.

III. RESULTS AND DISCUSSION

Effect of the early-p.m. pH on destructured zones in cooked cured ham (experiment 1)

The electrical stimulation of the carcasses 2 minutes p.m. resulted in significantly lower pH values 60 minutes (∅: 5.60 vs. 6.19) and partly 180 minutes p.m. (∅: 5.50 vs.

5.73) in silversides as well as in topsides. Delayed cooling of the carcasses led to a higher temperature 180 minutes in silversides as well as in topsides compared to conventional cooling (∅: 35.4 vs. 31.4°C). Temperature 24 hours p.m. as well as pH 24 hours p.m. were not affected by the different treatments. In both batches of cooked cured hams in the silversides as well as in the topsides, destructured zones of all three levels occurred (table 2). The topsides revealed to be more susceptible for the defect as the silversides resulting in a higher amount of destructured zones.

The binary logistic regression indicated that for topsides ($P = 0.054$) as well as for silversides ($P = 0.067$) temperature 1 hour p.m. is the most important predictor for the defect in cooked cured hams in experiment 1. These results lead to the suggestion that due to a high temperature in the early-p.m. stage, a partly denaturation of meat proteins (mainly sarcoplasmatic proteins, incl. myoglobin) occurs, supporting the development of destructurations in cooked cured hams. The positive correlation of the defect in raw meat to the slaughter weight and the lean meat content [2] may also be temperature-dependent. This is by reason of an increased thickness of the muscle layer around the center, due to larger carcasses and heavy muscling, and may be followed by a reduced heat efflux.

Effect of different ultimate pH on destructured zones in cooked cured ham (experiment 2)

The production of cooked cured hams selected according to ultimate pH in *M. semimembranosus* did not result in different amounts of destructured zones in batch 1, whereas in batch 2, the amount of the defect was significantly higher in low-ultimate-pH hams (table 3). In the cooked cured hams of each ultimate pH group of both batches, all levels of destructurations appeared. However, three times more destructurations were recorded in *M. adductor* than in *M. semimembranosus* (data not shown).

Referring to the binary logistic regression, a low ultimate pH was anyhow the most important, but still not significant predictor ($P = 0.135$) for destructured zones in cooked cured hams. Though the fact, that the destructurations of batch 1 were obviously independent from the ultimate pH in *M. semimembranosus*, indicates that ultimate pH can not be used as the only reliable indicator for the defect in cooked cured hams without considering also the course of pH and temperature fall early p.m..

In the raw material, the level of the defect according to the IFIP quotation scale was higher with a lower ultimate pH. In the H-pH group of both batches, no destructured zones at all appeared in the raw muscles. However, in the correspondent cooked cured hams produced from this meat all levels of the defect were present.

IV. CONCLUSION

High early-p.m. temperature in the raw meat was identified as an important predictor for destructured zones in cooked cured hams. This leads to the suggestion, that the temperature course early p.m. is directly involved in the development of the defect by protein denaturation. A low ultimate pH (< 5.5) of the uncooked ham can also provoke the development of destructured zones in cooked cured ham compared to cooked cured ham with a high (> 5.7) ultimate pH in the raw material. Nevertheless, choosing raw meat with a high ultimate pH or a low level of destructurations does not necessarily prevent cooked cured hams from developing the defect. Consequently, the technology of cooked cured ham processing has also to be taken into account as a potential factor contributing to the defect.

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Table 1: Design of experiments 1 and 2

Experiment 1		electrical stimulation (50 V, 14 Hz, 2 x 90 sec.	
		yes	no
Cooling	conventional (2°C, 30 min. p.m.)	A	B
	delayed (2°C, 120 min. p.m.)	C	D

Experiment 2	pH-groups (topsides)	L (pH < 5.5)	M (pH 5.5 - 5.7)	H (pH > 5.7)

Table 2: Level and amount of destructured zones [g/kg raw muscle] in cooked cured hams in topsides and silversides as affected by electrical stimulation and cooling procedure (experiment 1)

		Batch 1					Batch 2				
Muscle	Defect level	A (n=10)	B (n=10)	C (n=10)	D (n=10)	*P*	A (n=10)	B (n=10)	C (n=10)	D (n=10)	*P*
Topside	1st level	31.4	22.0	34.0	22.8	0.483	24.1	26.7	41.3	14.0	0.799
	2nd level	17.2	16.3	16.1	11.9	0.680	16.8	13.6	24.7	36.6	0.596
	3rd level	33.1	44.9	39.6	31.7	0.877	17.5	30.6	54.1	39.4	0.256
Silverside	1st level	3.1	1.5	4.5	1.5	0.371	2.6^{a}	0.4^{a}	26.3^{b}	3.0^{a}	0.021
	2nd level	1.3	0.6	2.3	0.0	0.517	2.7	1.3	8.9	0.0	0.267
	3rd level	1.3	0.0	0.0	0.0	0.392	0.0	0.0	0.0	0.0	1.000

Rows with different subscripts within a line differ significantly (Kruskal-Wallis-test, $P \leq 0.05$), A: electrical stimulation x conventional cooling, B: electrical stimulation x delayed cooling, C: no electrical stimulation x conventional cooling, D: no electrical stimulation x delayed cooling

Table 3: Level and amount of destructured zones [g/kg raw muscle] in cooked cured hams produced from topsides (*Mi. semimembranosus* and *adductor*) of different ultimate pH-groups (experiment 2).

	Batch 1				Batch 2			
Defect	pH < 5.5 (n=24)	pH 5.5-5.7 (n=24)	pH > 5.7 (n=16)	*P*	pH < 5.5 (n=24)	pH 5.5-5.7 (n=24)	pH > 5.7 (n=32)	*P*
1st level	8.3	12.2	13.8	0.593	19.1^{a}	10.5^{b}	6.8^{c}	<0.001
2nd level	5.6	6.9	4.4	0.707	32.6^{a}	15.2^{b}	4.4^{c}	<0.001
3rd level	9.4	3.2	2.0	0.142	10.1^{a}	12.3^{a}	1.2^{b}	0.001

Rows with different indices within a line differ significantly (Kruskal-Wallis-test, $P \leq 0.05$)