CARCASS CHILLING AND PORK QUALITY: EFFECTS ON DRIP LOSS, TEXTURE MEASUREMENTS AND "PSE-LIKE ZONES" HAMS FREQUENCY

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Abstract—**Two chilling rates from distinctive slaughterhouses were tested on pork carcasses selected with early ultimate pH determination (TritonX100 treated muscle samples). Meat quality parameters (early pH and ultimate pH) and carcass characteristics (sire genetic, carcass weight) were similar for the two chilling treatments, that made the comparative study possible. When chilling rate is faster, drip Loss is 21% lower and shear force after 2 days of maturation is 21% higher. The 4°c difference in the inner part of *Semimembranosus* muscle tested at 2 hours post mortem, induced in the present study a tenderization reduction in the first days post mortem without producing cold-shortening conditions. Another significant effect of chilling rate was its interaction with destructured hams defect occurrence: slow chilling increased by more than 3 times the frequency of the defect on hams with similar meat quality parameters. The Chilling rate after slaughter could be a process factor that could be useful for controlling the "PSE-like zones" defect frequency in pork industry.**

Index Terms—**drip loss, "PSE-like zones" defect, chilling, pork, meat texture.**

I. INTRODUCTION

Chilling rate of carcass is frequently mentioned as a major influence factor on meat quality parameters. Its effect on the pH decline during the first post mortem hours has been shown in several studies (Dransfield et al., 1991;Tomovic et al., 2008; Kurt and Klont, 2010) but the influence of chilling rate on ultimate pH is not that clear. Yet another question about chilling rate is its effect on the frequency of "PSE-like zones" defect of hams: some risk factors and meat quality parameters influence has been studied (Vautier et al., 2008) but chilling process may conduct to a modification of the defect occurrence, as Hugenshmidt et al. (2009) noticed.

In this study, we tried to compare two chilling process from distinctive slaughterhouses, but leading a comparative study in two slaughterhouses is not simple due to strong risks of getting biased meat quality results (different slaughterhouses, slaughter dates, stunning systems, breed and genetic). The bias-limited protocol of this study (similar ultimate and early pH, similar carcass weight and genetic) partly obtained after early ultimate pH selection with Triton X100, would make it easier to conclude on chilling rate effect.

II. MATERIALS AND METHODS

Two slaughterhouses were previously selected on their rates of chilling, using ham's internal temperature (muscle *Semimembranosus*) of carcasses with similar weight: slaughterhouse 1 (fast chilling - process including a pre-chilling tunnel: 0-5° for 2h at fast air velocity, then storage at 5°c) and slaughterhouse 2 (slow chilling, storage at 0-5° c without pre-chilling tunnel). Inner *Semimembranosus* temperature difference between slaughterhouses was about 4°c after 2 hours of chilling, for carcass weight from 83kg to 90kg (figure 1).

To avoid differences in meat quality level, carcasses from Piétrain sire pigs were selected on early ultimate pH determination (Vada-Kovacs, 1985): 5 gr. samples were taken from muscle *Semimembranosus* at 30-40 min. post mortem and homogenized with 5 ml of a 1.5% TritonX100 solution; the pH (pH TritonX100 SM) was determined after 10 minutes of incubation at 37°c (pH-meter SYDEL equipped with a Xerolyt© electrode LoT type, Mettler Toledo). Experimental design included two groups of carcasses for each slaughterhouse: low pH (5.4-5.6) and high pH (5.8-6.0).

Classical pH measurements were performed at 30-40 minutes (pH1) and 24 hours (pHu) post-mortem, in the *Semimembranosus* of carcasses selected with the early ultimate pH determination method. L*value was determined with a Minolta Chromameter CR-300 (Japan) on muscle *Gluteus Medius* (L*GM) after primary cutting and on muscle *Longissimus* (L*LT) at last rib level after deboning. The "PSE-like zones" defect quotation was done after deboning (24 hours post-mortem), according to the IFIP quotation scale (IFIP, 2005). Drip loss was determined by removing a 10gr.

sample of *Longissimus* from the 3rd lumbar vertebra, according to EZ method (Otto et al, 2004). Samples were weighed after sampling and then kept at 6°c for 24 hours. The change in weight percent over those 24 hours was taken as the drip loss. Carcass characteristics were recorded (carcass weight and lean percentage).

For each carcass, two *Longissimus* samples (two 25mm slices from deboned and defatted meat each, vacuum packed) were selected from two lumbar areas (from 1st to 3rd and from 3rd to the last lumbar vertebra) and alternatively distributed in two treatments: 2 days and 7 days of ageing. Each sample (two slices) was cooked in a steam oven at 80°c (target temperature: 75°c; Frima CM61) for texture analysis (Stable Micro Systems TA-XT Plus): Warner-Bratzler shear force test (slice 1, WBST2 and WBST7) and penetrometer test (slice 2, PEN2 and PEN7) according to Honikel (1998) recommendations.

III. RESULTS AND DISCUSSION

Early ultimate pH selection produced equal level of pH TritonX100 SM, pH24 LT and pH24SM for the two slaughterhouses (table 1). Theses results combined with the lack of significant difference in pH1 means and the selection of the same sire genetic (Piétrain) contribute to guaranty the same level of technological quality between the two slaughterhouses.

Levels of ultimate pH (pH24LT and pH24SM) noticed after the different chilling rates indicates, as Dransfield et al. (1991), Van der Wall et al. (1995) and Tomovic et al. (2008) mentioned, that chilling rate tested in this study has no effect on ultimate pH.

Usual relations between "PSE-like zones" defect class and meat quality parameters appears in the table 1: hams that present a severe defect (class 3+4) showed a lower ultimate pH (pH24SM). There was no straight relation with pH1 level, confirming that the defect is more related to ultimate pH level than early pH values (Vautier et al., 2008). The defect is more than 3 times less frequent when chilling rate is fast than when it is slow (6.0% vs 23.2% of defect class 3+4). Theses results identifies chilling rate during the first 2 hours post mortem as a critical risk factor for structure defect occurrence, as described in Hugenschmidt et al. (2009) study.

Figure 1: internal Semimembranosus temperature decline according chilling rate (slow chilling vs fast chilling) for similar weight carcasses.

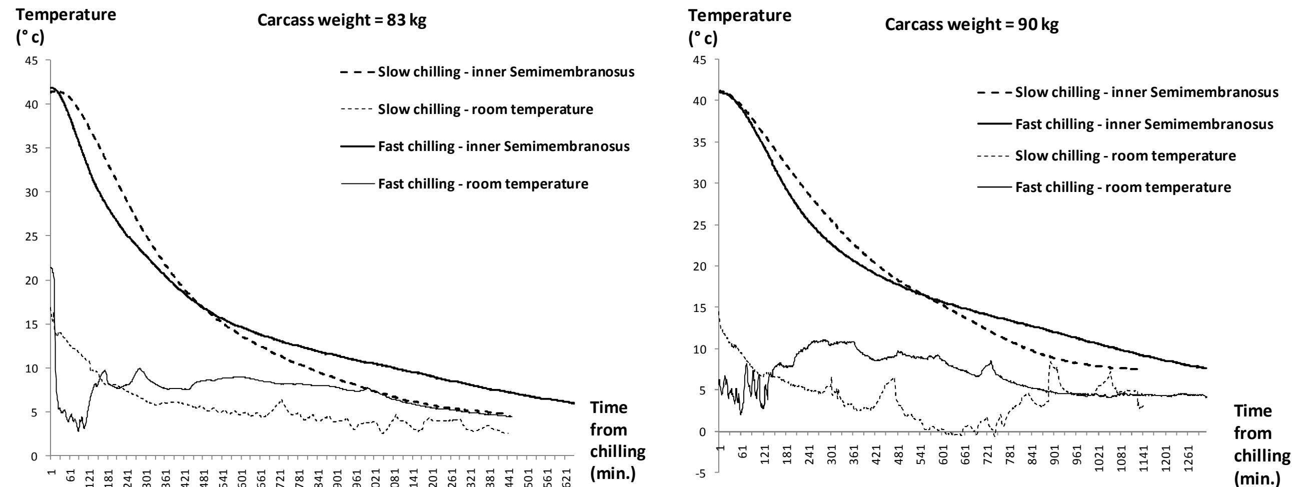

Table 1: meat quality results (hams) and carcass characteristics by destructured hams defect class.

Defect class n=136	Defect frequency (%)		pH 1	pH 24SM	L* GM	Carc. weight (kg)	Lean percent. (%)
	Slow chilling	Fast chilling					
1	53.6	80.6	6.40	5.77 $_a$	47.0 $_a$	93.5	58.6
2	23.2	13.4	6.27	5.68 $_{ab}$	49.2 $_b$	96.6	60.0
3	14.5	6.0	6.38	5.54 $_b$	50.5 $_b$	96.3	60.3
4	8.7	0.0	6.53	5.48 $_b$	50.0 $_{ab}$	93.0	60.3
p.=	0.0023		0.0266	< 0.0001	0.0004	ns	0.0535

Chilling rate has no significant influence on *Longissimus* and *Gluteus Medius* muscles brightness (L*GM and L*LT), as described by Van der Wall et al. (1995) and Tomovic et al. (2008).

Drip loss is lower when the chilling rate is faster (3.02% vs 3.81%, fast chilling and slow chilling respectively, p.=0.02, table 2). This results agrees with previous studies focusing on chilling rate: Van der Wall et al. (1995), Sammel et al.

(2002), Hambrecht et al.(2003), Tomovic et al. (2008) and Kurt and Klont (2010). Chilling rate influence on drip loss may result from the temperature effect on post-mortem energy metabolism and/or the temperature effect on the distribution of water in the muscles (Tomovic et al., 2008).

Warner Bratzler Shear Force Test reveals a significant difference of texture for cooked *Longissimus* muscle samples: after 2 days of ageing, shear force is higher for meat samples from fast chilling than from slow chilling (23.1N vs 19.1N, respectively, p.<0.0001) and that difference is not present after 7 days of ageing (18.3N vs 19.4N, respectively, ns). These observations agrees with Rees et al. (2002) data showing a significant rise in shear force values for accelerated boning (versus rigor boning) at 2 days of ageing but not at 6 days of ageing. That means fast chilling could reduce proteolysis activity during the first days of tenderization, without producing cold-shortening conditions as Rees et al. (2002) mentioned. The fast chilling effect on tenderization is “softer” than classical cold-shortening conditions because in this experiment fast chilling did not produced typical rise in drip loss as described by Honikel et al. (1986) and Rees et al. (2002). No significant differences were noticed in penetrometer measurements with the chilling rate.

Table 2: meat quality results (hams and loins) and carcass characteristics by chilling rate and pH level.

	Chilling rate		Slow chilling		Fast chilling		p.=		
n=140	slow	fast	LOW pH	HIGH pH	LOW pH	HIGH pH	R	C	R x C
pH 1	6.37	6.37	6.40	6.34	6.39	6.36	ns	ns	ns
pH TritonX100	5.73	5.71	5.54 $_{a}$	5.91 $_{b}$	5.49 $_{a}$	5.92 $_{b}$	ns	< 0.0001	ns
pH 24 SM	5.72	5.73	5.58 $_{a}$	5.87 $_{b}$	5.59 $_{a}$	5.86 $_{b}$	ns	< 0.0001	ns
pH 24 LT	5.65	5.64	5.56 $_{a}$	5.75 $_{b}$	5.52 $_{a}$	5.76 $_{b}$	ns	< 0.0001	ns
L* GM	48.0	47.9	50.0 $_{a}$	46.0 $_{b}$	49.4 $_{a}$	46.5 $_{b}$	ns	< 0.0001	ns
L* LT	48.4	47.9	50.0 $_{a}$	46.7 $_{b}$	50.0 $_{a}$	45.8 $_{b}$	ns	< 0.0001	ns
Drip Loss (%)	3.81 $_{a}$	3.02 $_{b}$	4.86 $_{x}$	2.76 $_{y}$	4.22 $_{x}$	1.81 $_{y}$	0.0249	< 0.0001	ns
WBST2 (N)	19.1 $_{a}$	23.1 $_{b}$	18.9 $_{x}$	19.4 $_{x}$	22.6 $_{y}$	23.6 $_{y}$	< 0.0001	ns	ns
WBST7 (N)	19.4	18.3	19.2	19.5	18.7	17.9	ns	ns	ns
PEN2 (N)	51.8	49.7	54.3 $_{a}$	49.2 $_{ab}$	52.9 $_{ab}$	46.5 $_{b}$	ns	0.0066	ns
PEN7 (N)	37.1	36.9	38.4 $_{ab}$	35.8 $_{ab}$	39.1 $_{a}$	34.6 $_{b}$	ns	0.0034	ns
TMP (%)	60.1 $_{a}$	58.2 $_{b}$	60.5 $_{x}$	59.5 $_{xy}$	58.3 $_{xy}$	58.1 $_{x}$	0.0005	ns	ns
Carc. weight (kg)	94.7	95.1	92.6 $_{ab}$	96.8 $_{ab}$	91.4 $_{a}$	98.8 $_{b}$	ns	0.0006	ns

R: chilling rate; C: rapid ultimate pH class

IV. CONCLUSION

The two industrial chilling rates tested in this experiment were distinct enough to notice a temperature difference in the inner part of hams: a 4 degrees difference was registered after 2 hours of chilling. As seen previously in many studies, fast chilling reduced drip loss level (-21%) and increased Warner-Bratzler shear force (+21%) of cooked Semimembranosus muscle at 2 days of ageing, but had no influence on the shear force after 7 days of ageing. These results indicate a time-restricted reduction of tenderization when fast chilling, but chilling difference was not enough to induce cold-shortening conditions.

The chilling rate had a strong influence on hams “PSE-like zones” defect frequency: at equal level of ultimate pH level, early pH and carcass weight, the frequency of severe defect grades (3+4) is more than 3 times higher when chilling rate is slow. Despite that early pH level is not strongly related to the defect frequency in this study, the chilling rate and the pH-decline during the first post mortem hours (Kurt and Klont, 2010) could be a process factor that could be useful for controlling the “PSE-like zones” defect frequency.

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