Incidence of pH_1 <6.00 in the *Mm. longissimus thoracis et lumborum* of pig carcases in South Africa

P.H. HEINZE, J.F.G. KLINGBIEL* & J.D. SNYMAN

ADSRI, Private Bag X2, Irene, 1675 Republic of South Africa.
*Meat Board, PO Box 40051, Arcadia, 0007 Republic of South Africa.

SUMMARY: pH_1 values (*Mm. longissimus thoracis et lumborum*) at the P_2 position of 3384 pig carcases at seven abattoirs were measured 60 minutes *post mortem*. Five of the abattoirs were visited on two occasions, and two on one occasion only. Sex condition, fat thickness (P_2), warm carcase mass and producer were recorded for each carcase, and *ante mortem* animal handling evaluated.

In total 21.7 % of the carcases had a pH_1 value <6.00, which ranged from 6.8 to 54.9 % at the different abattoirs. Day of slaughter influenced the incidence of pH_1 values <6.00 at three of the abattoirs visited on two occasions. Sex condition had an influence at only one abattoir. Fat thickness did not influence the incidence of pH_1 values <6.00. However, carcase mass seemed to influence the incidence of low pH_1 values at two abattoirs, but on further investigation it was established that these differences were the result of producer differences rather than carcase mass *per se*.

The results indicate that differences in the incidence of low pH_1 values between the abattoirs probably were more the result of differences in *ante mortem* animal handling, rather than stress susceptibility amongst the pigs.

INTRODUCTION: pH values *post mortem* has been studied widely in pig carcases as it gives an indication of possible meat quality defects. One of the most important defects, namely pale, soft and exudative (PSE) meat (TAYLOR *et al.*, 1973) is commonly associated with a pH value 45 (McGLOUGHLIN *et al.*, 1975) or 60 minutes (MITCHELL *et al.*, 1980) *post mortem* of below 6.00. The interest in PSE is as a result of the possible financial losses which flow from them. These losses are for example higher cooking losses (KLINGBIEL & NAUDÉ, 1976), losses in mature bacon yield, fresh meat drip losses, etc. (SMITH *et al.*, 1982).

MATERIALS AND METHODS: Seven large South African abattoirs were visited during November and December 1990. Of these, three abattoirs (abattoirs 4, 6 and 7) were private and slaughtered pigs for own meat processing, whereas the remaining four abattoirs all belonged to the South African Abattoir Corporation. pH_1 values were measured in the *Mm. longissimus thoracis et lumborum* 60 minutes *post mortem* in the region of the P_2 position using an Orion Research pH meter (Model 201) fitted with a needle-shaped combination glass electrode (Orion Ross cat. nr. 8163). The pH meter was calibrated using pH buffers 4 (Beckman cat nr SA 3506) and 7 (Beckman cat nr SA 3501). If the spinal vertabrae was already removed, the pH_1 value was measured directly in the exposed *Mm. longissimus thoracis et lumborum*. Additional information was also collected: sex type (boars or gilts/barrows), fat thickness at P_2 position, hot carcase mass which included the head, and name of producer. Fat thickness and carcase mass were coded as shown in Table 1.

All pigs were stunned electrically. The handling of animals prior to stunning as well as stunning variables and procedures were evaluated in an effort to explain possible differences in percentage pH_1 values <6.00 between the different abattoirs.

Table 1: Fat thickness and warm carcase mass codes used

Variable	Code										
	1	2	3	4	5	6	7	8	9	10	11
Fat thickness (mm)	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	>50
Carcase mass (kg)	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	>109

The data was analysed using the one way analysis of variance and Chi square tests of the computer programme Statgraphics Version 3.0 (Statistical Graphics Corporation, U.S.A.).

RESULTS AND DISCUSSION: The mean pH_1 value of the 3384 pig carcases 60 minutes *post mortem* was 21.7 %. Considering that the drop in pH value from 45 to 60 minutes *post mortem* is about 0.1 pH units for excited pigs using

electrical stunners (KLINGBIEL, 1975), a pH value of at least <5.9 should be used 60 minutes *post mortem* for comparisons with pH_1 values taken 45 minutes *post mortem*, which was calculated to be 16.6 % in the current survey. This is slightly less than the 17.6 % calculated from the percentage pH_1 values <6.00 (45 minutes *post mortem*) found by KLINGBIEL (1975) in South Africa. It would therefore seem that the introduction of the halothane test in the National Pig Performance and Progeny Testing Scheme of South Africa in 1978 (although resulting in a slight reduction of Landrace halothane reactors from 14,4 % in 1978 (ROSSOUW, 1982) to 12.7 % in 1989 (BROWN, 1991)) and other measures to optimise pre-slaughter animal handling have had little effect on the incidence of pH_1 values <6.00, and therefore probably on the PSE incidence in South Africa. This is in contrast to the results in Switzerland where the halothane reactors were reduced and simultaneously the incidence of PSE from 32.7 % in 1978 to 7.1 % in 1983 (REBSAMEN *et al.*, 1984). Although the pH_1 values do not correlate 100 % with the PSE incidence, it can be used as a guide for the incidence of PSE, a ratio that is assumed to be fairly constant (CHADWICK *et al.*, 1983).

Mean fat thickness and carcase mass values are given in Table 2. The mean pH_1 values differed significantly ($P \leq 0.01$) between the different abattoirs (Table 2). Of great concern is the mean pH_1 value at abattoir 5 ($pH_1 = 5.91$) which was less than 6.00. This was similar to the mean pH value 45 minutes *post mortem* at an abattoir which in the past employed captive bolt stunning (KLINGBIEL, 1975), a procedure that is known to stimulate PSE meat production (KLINGBIEL *et al.*, 1972). This method of stunning was not generally used at any of the sampled abattoirs, with the exception of slaughtering very large pigs (n = 9 in current study). Of more interest is the incidence of pH_1 values <6.00 at the different abattoirs (Table 2) which differed significantly ($P \leq 0.01$) between the abattoirs, and ranged from 6.8 % at abattoir 7 to 54.9 % at abattoir 5.

Sex condition in general did not influence the incidence of pH_1 values <6.00, although it was found to differ ($P \leq 0.05$) at abattoir 6 (Table 2), the reason which is still unclear. Slaughter day influenced the incidence of pH_1 values <6.00 at 3 of the 5 abattoirs visited on two occasions. These day differences could partly be explained by the different workers

Table 2: Mean values, standard deviations (sd) and % pH_1 values <6.00 and statistical analysis ofthe influence of sex condition, slaughter day, fat thickness, warm carcase mass and producer on the % pH_1 values <6.00

VARIABLE	Abattoir 1	Abattoir 2	Abattoir 3	Abattoir 4	Abattoir 5	Abattoir 6	Abattoir 7
BETWEEN ABATTOIRS:							
n	700	353	387	582	592	345	425
Mean fat thickness (sd); mm	13.1 (8.6)	15.7 (4.5)	12.6 (7.3)	23.9 (4.7)	12.2 (4.7)	15.9 (3.9)	19.9 (2.9)
Mean warm carcase mass (sd); kg	49.90 (14.02)	48.39 (10.23)	46.73 (16.41)	70.52 (7.12)	50.10 (12.10)	61.22 (10.59)	58.49 (4.46)
Mean pH_1 (sd)	6.36^a (0.37)	6.19^b (0.36)	6.37^a (0.35)	6.46c (0.30)	5.91^d (0.32)	6.21^b (0.43)	6.37^c (0.26)
% pH<6,00	14.6^a	27.8^b	12.1^a	6.9^c	54.9^d	27.5^b	6.8^c
WITHIN ABATTOIRS:							
Sex condition:	NS	NS	NS		NS	*	
Boars: n	177	120	124		331	134	
% pH_1 <6,00	17.0	21.0	14.5		54.1	20.7	
Gilts/castrates: n	523	233	263	582	261	211	425
% pH_1 <6,00	13.8	31.3	11.0	6.9	55.9	31.8	6.8
Slaughter day	NS	*	**	NS	**		
Day 1: n	341	179	124	263	255	354	425
% pH_1 <6,00	12.9	33.2	17.5	5.3	62.0	27.5	6.8
Day 2: n	359	174	263	319	337		
% pH_1 <6,00	16.2	22.4	8.4	8.2	50		
Fat thickness	NS	NS	NS	NS	NS	NS	NS
Warm carcase mass	NS	NS	**	NS	NS	*	NS
Producer	**	NS	**	NS	**	**	*

[abcd] Values in rows with different superscrips differ $P \leq 0.05$
NS = $P > 0.05$; * = $P \leq 0.05$; ** = $P \leq 0.01$

in the prestunning and stunning areas, and different workers operating the electrical stunners on the two days. Fat thickness had no influence on the incidence of low pH_1 values. It was found that carcase mass had an influence on the low pH_1 incidence at abattoirs 3 and 6 (Table 2). However, on subsequent further analysis it was found that these differences were not a result of carcase mass *per se*, but rather of producer differences (Table 3). It was found that in the mass groups that differed from the rest of the mass groups, the carcases in these mass groups were made up of pigs from producers with a relative high/low overall incidence of low pH_1 values. The incidence of pH_1 <6.00 differed significantly between the pigs from different producers at 5 of the abattoirs. These producer differences could be attributed to mode of transport, transport distance, lairage time and breed or breed-cross. These factors still need evaluation.

In general *ante mortem* animal handling ranged from very good to very poor, as was the case with the use of the electrical stunners (Table 4). In the case of abattoir 5, pigs were prodded excessively, and the pigs were jammed into a restrainer in which they remained for an extended period which probably put the the pigs under severe stress. At this abattoir stunning was not optimal. Although the electrical stunner at abattoir 5 was equipped with an automatic cut-out switch set for 5 sec., the pigs were generally stunned for 2 to 3 such periods. Prolonged periods of stressful handling and stunning times have been indicated to stimulate the release of catecholamines, resulting in a rapid *post mortem* decline in muscle pH, and subsequently PSE musculature (VAN DER WAL, 1978). Short stunning times (VAN DER WAL, 1978) and high stunning voltages (>300 V (AUGUSTINI, 1982, as cited by HARR, 1989)) with good *ante mortem* animal handling procedures should result in a lower incidence of pH_1 values <6.00. This was the case at abattoirs 4 and 7 which had the lowest percentage pH_1 values <6.00. Both use automatic stunners set at between 500 and 600 V applied for only 2 sec., without a holding period of pigs in the restrainer. It is therefore clear that these variables are of the utmost importance to ensure a lower incidence of low pH_1 values, especially if cognisance is taken of the fact that abattoir 7 is in the same area as abattoir 5. Prodders were used at 5 of the abattoirs. It seemed as if the prodders were probably used with discretion at abattoirs 4 and 7, and that prodders used correctly will not necessarily

Table 3: The relationship between the influence of carcase mass and producer in explaining the incidence of pH_1 values <6.00 at abattoirs 3 and 6

VARIABLE	Mass code									
	1	2	3	4	5	6	7	8	9	10
ABATTOIR 3										
% pH1 <6,00 (n)	67 (3)	22 (27)	16 (116)	13 (121)	8 (38)	3 (34)	0 (36)	25 (4)	0 (6)	0 (1)
Differed P≤0,05 from mass codes	*	7	7	7			2,3,4	*	*	*
% carcases in mass code from producers which had ≥3 % pH1 <6,00		100	100	96			11			
ABATTOIR 6										
% pH1 <6,00 (n)			25 (8)	13 (61)	27 (51)	26 (151)	43 (68)	40 (5)	0 (1)	
Differed P≤0,05 from mass codes				7		7	4, 6	*	*	
% carcases in mass code from producers which had ≥40 % pH1 <6,00				98		60	25			

* Not included in analysis as number of carcases was too small

increase the incidence of PSE, although the generally accepted opinion is that the use of prodders should be phased out in order to minimise PSE meat (HARR, 1986) as they may easily be abused. Although stress susceptibility also causes the occurrence of low muscle pH_1 values, results in this survey indicate that *ante mortem* animal handling and stunning procedures are probably responsible to a much greater extent for the high incidence of pH_1 values <6.00 in South Africa than stress susceptibility.

Table 4: Use of prodders, impression of animal handling and stunning variables at the different abattoirs

VARIABLE	Abattoir 1	Abattoir 2	Abattoir 3	Abattoir 4	Abattoir 5	Abattoir 6	Abattoir 7
Use of prodder	No	Yes, excessive	Yes	Yes	Yes, excessive	No	Yes
General impression of animal handling[a]	5	2	3	4	1	4	4
Stunning period (sec.)	7-15	8	3	2	10-15	4-8	2
Stunning Voltage (V)	180	230	290	500	Variable	220	600

[a] 1 = Very poor; 5 = Very good

CONCLUSIONS: The results indicate that *ante mortem* animal handling as well as stunning practises were found to be sub optimal in five of the seven abattoirs in the survey. The incidence of pH_1 values <6.00 could be lowered substantially in the light of the low incidence of 6.8 and 6.9 % found at two abattoirs relative to the 12,1 to 54,9 % found at the other abattoirs. This indicates that stress susceptibility amongst slaughter pigs might be of less importance in South Africa, and that sub optimal management practises are probably responsible for the high occurrence of pH_1 values <6,00. Education of workers in animal handling and stunning procedures should result in a substantial lowering in the incidence of pH_1 values <6.00.

REFERENCES:

BROWN, A. (1991): Personal communication. ADSRI, Irene, Republic of South Africa.

CHADWICK, J.P. & KEMPSTER, A.J. (1983): A repeat national survey (ten years on) of muscle pH values in commersial bacon carcasses. *Meat Sci.* 9: 101-111.

HARR, G. (1989): Qualitätsabweichungen beim Schweinenfleisch: Ursachen und Massnahmen zur Verhinderung. *Fleischwirtsch.* 69: 1246-1248.

KLINGBIEL, J.F.G. (1975): Faktore wat 'n rol speel by die voorkoms van bleek, sagte en waterige varkvleis. M.Sc. thesis, University of Pretoria.

KLINGBIEL, J.F.G. & NAUDÉ, R.T. (1972): The effect of two stunning techniques on the pH_1 values of muscles in carcasses of bacon pigs. *S. Afr. J. Anim. Sci.* 2: 105-107.

KLINGBIEL, J.F.G. & NAUDÉ, R.T. (1976): Effect of immediate preslaughter stress on certain meat quality characteristics of bacon pigs. *Agroanimalia* 8: 7-12.

McGLOUGHLIN, P. & McLOUGHLIN, P.V. (1975): The heritability of pH1 in longissimus dorsi muscle in Landrace and Large White pigs. *Livest. Prod. Sci.* 2: 271-280.

MITCHELL, G. & HEFFRON, J.A.A. (1980): The occurrence of pale, soft, exudative musculature in Landrace pigs susceptible and resistant to the malignant hyperthermia syndrome. *Br. vet. J.* 136: 500-506.

ROSSOUW, P. (1982): The National Pig Performance and Progeny Testing Scheme of South Africa. *Meat Board Focus* Nov/Dec, 32-46.

REBSAMEN, A., BLUM, J. & SCHWÖRER, D. (1984): Jahresbericht 1983 der Schweizerischen Mast- und Schlachtleistungsprüfungsanstalt (MLP) Sempach. *Der Kleinviehzüchter* 32: 390-425.

SMITH, W.C. & LESSER, D. (1982): An economic assessment of pale, soft, exudative musculature in the fresh and cured pig carcass. *Anim. Prod.* 34: 291-299.

TAYLOR, A.McM., DANT, S.J. & FRENCH, J.W.L. (1973): Processing Wiltshire bacon from PSE-prone pigs. *J. Fd Technol.* 8: 167-174.

VAN DER WAL, P.G. (1978): Chemical and physiological aspects of pig stunning in relation to meat quality - a review. *Meat Sci.* 2: 19-29.