STUNNING PROCEDURES AND MEAT QUALITY*

W.Sybesma and W.Groen

Introduction

A trial was conducted to investigate the difference between the effect of the CO_2 - and the electrical stunning procedure under practical circumstances on the meat quality of Dutch Landrace slaughterpigs.

The stunning of pigs brings about conditions of "stress" ,not only caused by the stunning itself but also by the way the pigs are led into the stunning place.
Electrical stunning itself produces rather intensive muscle contractions wheraas CO_2 - stunning causes a state of anoxia which favours the loss of glycogen in the muscles. In Holland electrical stunning mostly is carried out in a pen with several pigs together. In the CO_2 stunning each pig has to be brought in line before the animals one by one are shoved into the CO_2 tunnel. The procedure prior to the CO_2 stunning seems to be more stressful than that prior to the electrical stunning. The present investigation was concerned with the effect of the stunning on meat quality characteristics under practical circumstances.

Slaughterblood analysis was performed in order to get information about physiological pre-stunning reaction. Meat quality measurements were taken at the end of the slaughterline approximately 45 minutes post mortem.

Bendall (1966) showed the impact of nervous muscle stimulation

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on the extent of the pH fall post mortem.

Bouman (1968) mentioned the effects of the various stimuli during and before killing on the pattern of the early post mortem changes of the muscle glycogen content.

- the adrenergic excitation caused by fright and pain will greatly intensify the glycogenolysis
- the muscular activity of struggling is a powerful stimulus for glycogenolysis
- the anoxia condition also causes a rapid depletion of the muscle glycogen (stores) by anaerobic glycolysis

Handling and stunning therefore might be of considerable importance in shaping the pattern of the early biochemical post mortem changes. The role played by the nervous and endocrine system during stunning is still obscure. In electrically stunning the intensive muscle contraction by nervous stimulation seems to predominate whereas the state of suffocation inoked by the CO_2 srunning facilitates the massive adrenergic discharge (Bouman, 1968).

Material and methods

Procedure

The trial consisted of 363 Dutch Landrace pigs, originating from several piggeries located at distances ranging from 20 - 40km from the factory. All the pigs had already arrived two hours before the experiment started. The environmental temperature was 25°C with a relative humidity of 68%.

The animals were randomized into four groups.

A. CO_2 stunning in an oval tunneltype at a speed of 180 animals per hour;(70 % CO_2).

B. Same procedure as in A but with a speed of 90 animals per hour;

C. Electrical stunning (75 V, 435 mA);

D. Electrical stunning as in C but after the animals passed the tunnel (without CO_2).

Blood analysis

Bloodsamples were collected from the slaughterblood after sticking.

Lactate was determined with an UV teast Boehringer no. 15972 based on lactate, LDH and NAD interrelationship. Levels of GOT and glucose were determined in an Autoanalyzer according to resp. Reitman Frankel and Hoffman.

Meat quality parameters

In the slaughterline, 45 minutes post mortem, pH readings were taken from the m. semimembranosus and m. long dorsi with the equipment and accoring to the method described by Van Logtestijn (1965).

At the same time the rigor mortis development according to Sybesma (1966) and the temperature with a Braun temperature device were measured.

Results and discussion

Blood analysis

The results of the various determinations are presented in table 1, whereas a frequency distribution is given in the supplement (p. 7).

TABLE 1. Bloodconcentrations is the different groups (mean and S

	n	GOT mU	glucose mg%	lactate mg%
A	101	70 ± 55	142 ± 33	74 ± 31
B	81	79 ± 63	138 ± 30	92 ± 43
C	82	70 ± 83	130 ± 23	102 ± 35
D	89	87 ± 81	149 ± 44	107 ± 36

Under stress circumstances the GOT and glucose levels increase : glucose by liverglycogen mobilisation and GOT as a consequence of tissue damage. Lactate tends to rise due to anaerobic glycolysis in the muscle during exercise , excitation and struggling. The re- sults of statistical analysis according to the distribution tree x^2 method are presented in table 2 . With regard to the levels found, three classes were arbitrarily formed.

TABLE 2. The statistical analysis of the bloodfigures.

Method	classes I	II	III	IV	Overal	Between methods	within CO_2	Within elec.
GOT-(mU)	< 50	50 - 75	>75		$<0.005^{x}$	<0.50	< 0.20	<0.000
glucose (mg %)	<120	120 - 140	140-160	> 160	$<0.05^{x}$	<0.30	< 0.40	$<0.01^{x}$
Lactate (mg %)	< 75	75 - 125	>125		$<0.0005^{x}$	$<0.0005^{x}$	$<0.05^{x}$	<0.30

Between the stunning method: significant differences existed as the lactate concentration in the slaughterblood, the electrically stunned animals begin the highest.

Within the stunning methods: the electrically stunned group (through the CO_2 tunnel), showed significant higher concentrations of GOT and glucose than group C.
The CO_2 group B (90 animals/hour) demonstrated a significant higher lactate concentration than group A (180 animals/hour).
Between all the groups: a significant difference existed as to GOT, glucose and lactate. Group C had the lowest GOT and glucose levels whereas group D had the highest blood values, lactate included.

Meat quality measurements

In table 3 the mean values are presented of the meat temperature, pH and rigor (see for frequency distributions the supplement).

TABLE 3. Post mortem readings in the different groups (mean and Sx).

	n	muscle temp. /°C/	pH_1 semim.	pH_1 m.l.d.	rigor
A	101	40.9 ± 0.6	6.12 ± 0.28	6.25 ± 0.28	3.7 ± 4.0
B	81	41.0 ± 0.7	6.19 ± 0.29	6.28 ± 0.28	3.9 ± 4.0
C	82	40.7 ± 0.7	6.33 ± 0.27	6.30 ± 0.28	4.1 ± 3.6
D	89	41.1 ± 0.6	6.21 ± 0.29	6.13 ± 0.28	6.6 ± 3.9

In table 4 the statistical computation according to the distribution free x^2 analysis reveals the following.

Table 4. Statistical analysis of the meat quality figures.

Method	Classes			Overall	Between methods	Within CO_2	Within electr.
	I	II	III				
Muscle t° in °C	<40.5	40.5-41.5	>41.5	<0.001^x	<0.80	<0.20	<0.0005^x

pH_1 semi membran.	< 6.1o	6.2o–6.5o	> 6.5	< 0.05^x	< 0.01^x	< 0.5o	< 0.4o
pH_1 musc long dor	< 6.1o	6.2o–6.5o	> 6.5o	< 0.1o	< 0.8o	< 0.9o	< 0.01^x
rigor	< 5	6–9	> 9	< 0.05^x	< 0.1o	< 0.6o	< 0.01^x

Between the methods : the pH_1 level of the m.semimembranosus was significant higher in the group of electrical stunning.

Within the methods : group D had a significant lower pH_1 of the m.long.dorsi and a significant higher rigor and temperature of the ham musculature than group C.

Between all groups : there existed a significant difference for most readings (except for those of the pH_1 of the m.long.dorsi P < 0.10).

In table 5 are presented the percentages of animals per group with a rapid post mortem muscle metabolism, wether rigor, temperature or pH fall.

Table 5. Percentages of animals with quick pH fall, high rigor and temperature.

	pH sem.< 6.00	rigor > 10	meat t° > 41.0	pH sem. < 6.00 + rigor > 10
A	27	15	55	9
B	22	15	57	9
C	11	7	41	1
D	18	27	62	9

This table illustrates the differences in meat quality parameters. Especially the combination low pH and high rigor pointed to a favourable post portem metabolism in group C.

Discussion

From the blood analysis and the post mortem measurements in the muscles, it appeared that group D, which had passed through the tunnel, was the most stressed group (see GOT,glucose, lactate levels) with the quickest post mortem metabolism (glycolysis-pH_1- in the m.long.dorsi, meat temperature and rigor).

C showed the reverse picture of group D, so it seems that the electrical stunning procedure itself connot be held responsible for the unfavourable effects.

These results leads us to the conclusion that the pre-stu ning handling combined with tunnel passing creates a stress condi tion which acclerates the post mortem muscle metabolism.

The electrical stunning seems to increase the lactate concen tration in the blood probably caused by the induced intensive mus cle contractions.

Whether there exists a relation between the lactate concentra tion and the pH fall post mortem however, could not be established, only in group D the pH of the m.long.dorsi showed evidence of accu mulation of lactate in the muscle tissue together with a higher blood lactate.

Conclusion

The conclusion seems to be justified that the pre-stunning conditions around the, in this experiment used, CO_2 procedure affects unfavourably the meat quality in comparison with those of the normal electrical stunning.

The electrical stunning procedure increases the lactate le vels in the blood, possibly caused by the induced muscle contrac tions. Further work in this lanoratory is required to study the more specific effects of stünning methods itself on the post mor tem carbohydrate metabolism in the muscle i.e. on the meat quali ty.

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Supplement : Frequency distribution in %.

Table 6. The distribution of the GOT concentrations

GOT mU	<5o	5o-75	75-1oo	1oo-125	125-15o	15o-175	175-2oo	>2oo
Gr. A	31	44	14	9	2	-	-	1
B	23	41	13	12	5	2	-	4
C	47	36	9	4	-	-	-	4
D	2o	45	12	9	6	2	-	5

Table 7. The distribution of the glucose concentrations

Gluc.mg%	< 1oo	1oo-12o	12o-14o	14o-16o	16o-18o	18o-2oo	>2oo
Gr. A	7	12	35	24	8	5	7
B	6	2o	3o	19	16	6	2
c	3	26	34	26	8	1	2
D	3	23	22	24	8	7	13

Table 8. The distribution of the lactate

Lactate mg%	<5o	5o-75	75-1oo	1oo-125	125-15o	> 15o
Gr. A	22	32	28	1o	7	1
B	13	29	25	11	8	13
C	2	17	39	3o	3	11
D	4	1o	27	35	12	11

Table 9. The distribution of the temperature in the mm smimembra nosus

Gr	37.o	37.5	38.o	38.5	39.o	39.5	4o.o	4o.5	41.o	41.5	42.o	42.5	43.o
A	-	-	-	-	-	4	11	31	31	15	8	1	-
B	-	-	-	-	1	-	9	31	21	18	16	2	-
C	-	-	-	1	2	4	2o	31	24	12	2	3	-
D	-	-	-	-	-	-	5	34	26	2o	13	3	-

Table 10. The pH_1 distribution in the m.semimem and the m.long. dorsi

Class.	<5.9	6.o-6.1	6.2-6.3	6.4-6.5	6.6-6.7	6.8-6.9	7.o-7.1
M.semi mem							
Gr. A	27	27	28	8	9	2	-
B	22	22	26	18	11	1	-
C	11	19	24	24	15	4	1
D	18	21	25	21	14	1	-
M.l.dor si							
Gr. A	12	24	26	24	14	-	-
B	12	21	22	32	9	4	1
C	13	14	26	3o	14	2	-
D	24	22	27	2o	6	1	-

Table 11. The distribution of the rigor in the m.semimem.

		0-1	3-5	6-8	9-11	12-14
Group	A	49	21	11	1o	9
	B	46	18	15	13	8
	C	39	28	18	11	4
	D	2o	28	21	14	18

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