Heart rate counting from photolethysmographic records, as an aid in the search better methods of handling hogs before slaughter.

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INTRODUCTION

Many workers in the field have demonstrated an effect on meat quality of excitement of hogs before slaughtering[1]. It is known that rather important differences in meat quality result from differences in reaction of the living animal on its environment and/or from differences in the way hogs are treated. Important parameters of meat quality are e.g. post-mortem pH decline, water binding capacity and cooking losses.

Charpentier and Goutefongea[2] found an increase in pH 45 min. and 24 h., in several muscles, when the animals were stressed by means of an electric driving rod, ½ to 16 hours before bleeding. This effect could not be obtained if the treatment took place 5 minutes before bleeding. The authors thought it possible that handling and stunning of the hogs provoked an unavoidable stress, responsible for a rapid decrease in pH of the meat after bleeding.

Lannek[3] who investigated the influence of muscle activity shortly before slaughtering on meat quality, worked with trained and untrained animals. The control animals of both groups were killed in their pens. It turned out that the water binding capacity and colour of the meat of the trained control animals significantly excelled those of all other groups. Evidently, stress symtoms were less because the animals of this group were used to being handled by men.

This demonstrates the importance of psychical conditioned excitation just before slaughter, particularly in the very last moments before bleeding. A strong stress reaction seems to work like a trigger action for violent biophysical processes which — the homeostatic conditioned regulation being disorganised — leads to a rapid pH fall after bleeding.

It is evident that excitation must be avoided as far as possible. By our work to improve the slaughtering plant in this sense, we needed a method

by which excitation and stress could be measured in a reliable and easy way. One of the best parameters of stress is the heart rate.

Forrest et al.[4] determined heart rates — using an electrocardiograph — of stressed hogs just before slaughtering. In their experiments, high heart rates were associated with rapid post-mortem muscle pH decline and other P. S. E. symptoms. At the Zwanenberg Laboratories[5] we used heart rates as an indication of stress in hogs during CO_2 immobilization. At that time, we read the heart rates from an ECG. However, taking an ECG under slaughterhouse conditions has several drawbacks. Therefore a better method of heart rate counting was felt necessary. The application of telemetry was rejected because of the rather rough circumstances transmitter and receiver should stand and the interference picked up from the air.

MATERIALS AND METHODS

The photoplethysmograph, modified by de Pater et al.[6] proved a useful tool in measuring heart rates. Photoplethysmography is a modification of plethysmography, frequently used for clinical purposes. The sensor of the apparatus, called scattereys, is composed of a cadmiumsulphide photoresistance and a very small lamp, both pointed in the same direction. When placed on the skin, the electrical resistance of the photoresistance depends on the amount of blood in the skin. We used the instrument on two different locations:

1. On the vagina wall of gilts
   This gave us the advantage of very easy fixing and absence of light interference. However, the scattereye we had at our disposal only delivered useful signals if the animals were standing quietly or lying down (we think it possible that modification of the design will eliminate this restriction).
2. In the underside of the tail.
   In this case the tail was cleaned and the underside freed from thair by shaving.
   The scattereye was placed against the skin, about 5 cm from the trunk. It was fastened with sterilized gauze, smeared with quick hardening two component plastic.

For experiments taking longer than one hour, the hog was supplied with a jacket to which the electrical connections of the scattereye were fastened. From this jacket, a microphone cable was fastened to the ceiling and kept taut by a simple device but allowing the hog freedom to move through the pen. This pen was situated in a quiet environment and its floor surface was about 25 m^2. The length of the cable was also sufficient for measurements

PEN RECORDING OF THE PLETHYSMOGRAPHIC SIGNAL

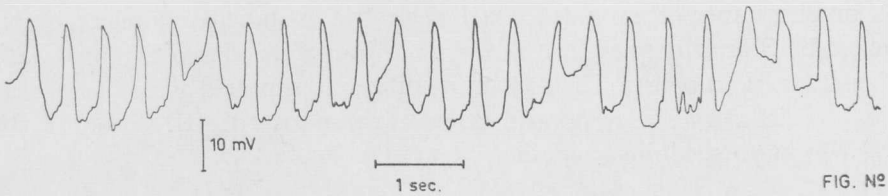

FIG. Nº 1

to take place in the CO_2 immobilizer. On the other end of the cable, a carrier wave of about 2 Kc was modulated by the signal of the scattereye. The audible signal was recorded on a small commercial battery powered tape-recorder. This record was made visible by means of a pen recorder (fig. No. 1).

Hogs were taken at random from the unloading platform at the time of arrival. They belonged to the dutch landrace. Live weight 95—110 kilos.

In addition to the measurement of heart rates, the quantity of corticosteriods and glucose in the plasma of blood was estimated. This also gave an indication of the degree of stress.

First series of experiments

Ten hogs received separately the following treatment. After isolating from the rest of the load and fixing the scattereye, the animals were rested for approx. 2 hours. Straw, water and food was given. Then, the free moving hogs were submitted to a mild form of stress by grasping them by the head and covering the eyes with the hand. After another 2 hours rest, these animals were stressed with an electric driving rod, type »Hü» (Borgonjen, Deventer) for 2 seconds. Then they were completely rested again for approx. 42 hours. This enabled us to measure resting values of heart rate, blood plasma corticosteroids and glucose. A further benefit was that the animals were not anymore aware of the scattereye and the jacket.

On the morning of the second day after arrival, the hogs were placed in a small iron cage. Blood samples were taken (8 animals). Thereafter the hogs were transported in the cage to the slaughterhouse pens. This took about 8 minutes, after another 15 to 40 minutes waiting in the cage they were slaughtered. The rigor of hams and shoulders was estimated about 20 minutes after bleeding. pH was measured 24 hours after bleeding. The hams were cured, canned and pasteurized.

Second series of experiments

From various numbers of hogs, who had not been given the extra day's

rest, heart rates were taken at different moments in the period between the arrival at the pens and bleeding.

A small number of animals in each series was stunned with electris tongs (supplied by Stoppelberg, Zeist), the rest was immobilized in a CO_2 installation (designed by Wernberg). The CO_2 immobilizer is supplied with hogs from a corridor, which serves as a store, necessary for un-interrupted supply, further referred to as »restraining corridor», (length 12 meter).

RESULTS

General observations

It seemed that the hogs were not at all bothered by the scattereye. During the time the animals were under observation, none of them rubbed their hindquarters against the wall to get rid of the scattereye on the tail. The hogs very quickly got used to wearing the jacket. One animal tried to dislodge the jacket against the floor but gave upp after a few minutes.

All animals reacted very enthousiastically to the presence of straw in the pen. However only about 60 % of the animals did take food or water in the first 30 minutes, probably because of nervous tension. After transport to the slaughterhouse, most of the hogs tried to join the other hogs in the slaughterhouse pens. Attempts to break out of the cage resulted sometimes in a rather high rise in pulse rate, e.g. to 140 and 170 beats/min. (animal no. I and no. II of the first series).

Heart rate counting signals, recorded during the time the animals were in the CO_2 immobilizer were most of the time illegible.

First serie of experiment:

Table 1. *Heart rate (beats/min)*

	n	range	median
just after isolating the animal	10	80–150	115
during fixing of the scattereye	10	70–140	100
after grasping on the head	10	150–250	175
after using an electric driving rod	10	170–260	200
lowest value during rest	10	55– 85	75
during sampling of blood	10	85–150	105
after arrival at the slaughter house	10	75–170x	115
just before the restraining corridor	10	90–120	105
just after the restraining corridor	xx6	140–230	160
maximum in the CO_2 immobilizerxxx	6	145–220	200

n = number of animals

x trying to escape from cage

xx the other four animals were stunned with tongs just after leaving the cage.

xxx before the excitation phase

Table 2. *Bloodsplasma analysis of 8 rested animals, 4 of these immobilized with CO_2, the others stunned with electric tongs*

Animal no.	CO_2 *or E.T.*	*Glucose mg/100 ml*		*Corticosteriods 1/100 ml*	
		Sample from ear vein, resting value	*Sample at bleeding*	*Sample from ear vein, resting value*	*Sample at bleading*
I	CO_2	117	139	15,5	38,4
II	CO_2	94	164	18,8	27,6
III	CO_2	99	134	18,5	24,0
IV	CO_2	99	207	8,2	22,4
Mean & S.E.M.*		102 ± 5	161 ± 17	15,2 ± 2,5	28,1 ± 3,6
V	E.T.	97	118	21,0	46,8
VI	E.T.	119	107	29,3	33,2
VII	E.T.	104	121	18,6	21,6
VIII	E.T.	97	106	17,2	29,6
Mean & S.E.M.		104 ± 5	113 ± 4	21,6 ± 2,7	32,8 ± 5,2

* S.E.M = Standard error of the mean.

Table 3.

Animal number		*rigor (20 min.)*		*pH 24 hrs.*	*canned pasteurized hams*				
		ham	*shoulder*	*M. adductor*	*cooking loss %*	*color*	*variegation of color*	*coherence of slices*	*holes*	*blood spots*
I	CO_2	2	2	5,60	9,8	3	3	3	several big holes	0
II	CO_2	2	2	5,45	9,7	3	4	5	some holes	10
III	CO_2	2	2	5,60	7,9	5	4	4	—	0
IV	CO_2	2	2	5,50	10,9	5	4	4	—	0
	Mean:	2,0	2,0	5,54	9,6	4,0	4,8	4,0		
V	E.T.	5	3	5,75	8,4	8	6	7	—	15
VI	E.T.	6	4	6,25	9,4	7	8	6	—	0
VII	E.T.	7	5	5,60	10,6	6	6	6	—	15
VIII	E.T.	7	3	5,70	9,6	5	2	5	—	0
	Mean:	6,3	3,6	5,83	9,5	6,5	5,5	6,0		

Legend

Rigor: 2 soft, 9 hard

Color: 2 very pale, 9 very dark.

Variegation of color: 2 unquestionable two-toned
9 very uniformly coloured

Blood spots: counts of very small spots on 12 slices taken equally divided from the ham

Second serie of experiments

Table 4.

	n	*range*	*median*
in the lorry at arrival	6	90—150	115
after unloading	22	110—170	145
after 30—60 minutes of rest	12	100—145	125
just after the restraining corridor*	18	150—260	230

*as far as the signals were legible, heart rates in the CO_2 immobilizer never exceded these in the corridor

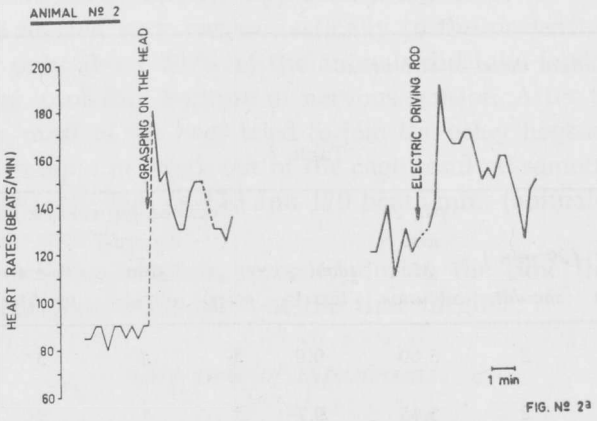

FIG. Nº 2a

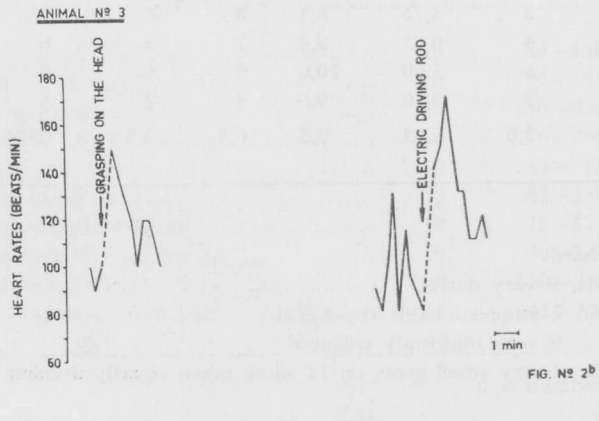

FIG. Nº 2b

DISCUSSION

Evidently, grasping the animals on the head resulted in a significant rise in heart rate, nearly as much as the use of the electrical driving rod. However the stress after use of the driving rod persisted longer (fig. 2). Sampling of the blood had relatively little effect, possibly because of the fact that the animals were used to be handled in the days before. Attention must be drawn to the fact that the animals stunned with electric tongs subdued no psychical stress and performed no physical effort between leaving the cage and stunning. This, in fact, is not a normal procedure. The rise in heart rate after passing the restraining corridor is remarkable; probably due to the stress caused by struggling and jamming in the corridor. The larger increase of glucose and corticosteroids in the blood plasma can as well be attributed to this.

Table III should be regarded with care because of the very small numbers of animals, taken from a heterogeneous population. The figures of Table IV display the same trend those as in Table I. However, in the second series of experiments it was unavoidable to arouse psychical interference by the measurements. This is particularly the case on the lorry at arrival. Therefore in general the heart rates on the lorry will probably be lower than measured. The signals of the scattereye during CO_2 immobilization after the onset of the excitationphase were indistinct.

ECG FROM AN HOG JUST LEAVING THE CO_2 IMMOBILIZER

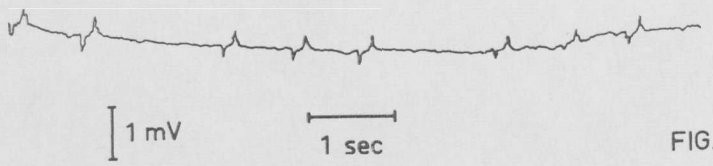

FIG. Nº 3

We attribute this partly to heart block, caused by suffocation (fig. 3) and partly to the rather wild movements of the animals. Further, disturbances of the blood flow in the smaller vessels 7) must have detrimental influence on the plethysmographic measurements.

CONCLUSION

Heart rate counting by photolethysmography proved a useful parameter

for the condition of stress in hogs at slaughterhouse circumstances. Fairly good agreement has been found with the quantity of corticosteroids and glucose in the blood plasma. However, during CO_2 immobilizing the plethysmografic method proved not to be superior the the electrocardiografic method.

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LITERATURE

Conclusions of the symposium »*Recent points of view on the condition and meat quality of pigs for slaughter*», held from 6 till 10 May 1968 in the Research Institute for Animal Husbandry »Schoonoord» at Zeist, in the Netherlands — June 1968.

J. Charpentier et R. Goutefongea Ann. Zootechn. 1966, 15 (4) 353—359.

N. Lannek, Dtsch. tierartzl. Wschr. 1967, 74 (13) 321—324.

J. C. Forrest, J. A. Will, G. R. Schmidt, M. D. Judge and E.J. Briskey. J. App. Physiol. 1968, 24 (1) 33—39.

J. H. Luyerink, Zwanenberg's Laboratories, Sept. 1967 Unpublished.

L. de Pater, J. W. van den Berg and A. A. Bueno, Acta Physiol. Pharmacol. Neerl. 1962 10 378—390.

I. Savić and R. Tadić. Paper presented on the Conference of Meat Research Workers Moscow 1962.