A SURVEY OF THE EFFICACY OF ELECTRICAL AND CARBON DIOXIDE STUNNING ON INSENSITIVITY IN SLAUGHTER PIGS.

Velarde A., Faucitano L., Gispert M., Oliver M.A. and Diestre A.
IRTA, Centre de Tecnologia de la Carn, Granja Camps i Armet, 17121 Monells (Girona), Spain.

BACKGROUND

In the western society it is a legal requirement that all animals destined for meat consumption should be rendered instantaneously and remain insensitive to pain until a complete loss of brain responsiveness due to exsanguination (Council Directive 93/119/C). This is the main concern when the suitability of a stunning method is analyzed from an animal welfare point of view. The two most popular stunning methods used for pigs are electroanaesthesia and carbon dioxide stunning.

The electrical stunning system is the most widely used method, and it consists of passing electricity through the brain to produce instantaneous insensibility. Stunning is achieved by inducing a tonic/clonic epileptic fit, before any pain stimulus associated with the application itself is detected and transmitted to the central nervous system (15 ms). Due to its adverse effects on meat quality and on animal welfare (recovery of sensibility) in many Spanish abattoirs the traditional head-only electrical stunning has been replaced by the head-to-chest electrical stunner combined with the chest-belt restrainer (Midas system). The application of the cardiac arrest cycle has a major animal welfare advantage in that it promotes the start of death at the point of stun and relegates sticking to a method of removing blood from the carcass (Wotton and Gregory, 1986).

As in other countries the use of carbon dioxide stunning has recently increased in popularity in Spain. However its acceptability on welfare grounds has been questioned by several authors. Gregory *et al.* (1987) examined the effectiveness of a compact stunner and suggested that insensibility is not instantaneous and narcosis began 30 to 39 s after the start of immersion procedure. Additionally, the exposure to the gas stimulates breathing frequency and may lead to respiratory distress (Raj and Gregory, 1996). On the other hand, from the study of the changes occurring in the EEG patterns of pigs Forslid (1987) observed that pigs reach insensibility before the onset of the violent motor activity.

The aim of this study was to evaluate under practical conditions the effectiveness of the head-to-chest electroanaesthesia and CO_2 stunning systems on the loss of sensibility of pigs.

MATERIAL AND METHODS

A total of four commercial pig abattoirs in Spain were surveyed. They were chosen as representing the two new stunning methods for pigs. The abattoirs were located in different areas, with different access roads, lairage conditions and general handling. Two of them (A and B) were equipped with the MIDAS Stunning System (Stork RMS, Holland), that combines a chest belt with an automatically applied head-only and head-to-chest electrical stunner. The stunning current was applied between the eye and ear, spanning the brain at 220 volts, 800 Hz for 2.4s between the two electrodes. The electrodes were designed to pierce the skin to reduce impedance to a minimum and hence maintain optimum current levels. During the head application, a further electrode was applied to the chest of the pig and the cardiac arrest cycle (110 volts at 50 Hz for 1.7-2.0s) was induced. During stunning the pigs were moved out of the stunner falling onto a moving top table. The pigs were exsanguinated in a lying position within approximately five seconds after stun. The system was equipped with a registration system where time and the current amplitude were sensed, rectified and recorded automatically on a computer.

The other two abattoirs (C and D) used a Compact Carbon Dioxide Stunning Unit (Butina Aps, Copenhagen). The unit was a six-chair *paternoster* type conveyor loading manually two pigs at a time and dispatching them to the base of a well which was filled with carbon dioxide (83%). Finally the animals were returned to an unloading position alongside the loading point and exsanguinated vertically on the bleed-rail. The time taken from launching to docking the pigs was from 1.03 to 4.40 min.

Of the 4 plants studied, plants C and D operate a low line speed (260 and 380 pigs/hour respectively), A operates a medium line speed (400) and plant B operates the highest line speed (550).

Sensibility loss evaluation

Each abattoir was visited for three days and a total of 9,469 animals were assessed in order to evaluate the efficiency of the stunning method applied (Table 1). In the abattoirs equipped with the electrical stunning system the information recorded was: position of the tongs and incidence of re-stunning. In the four abattoirs, corneal reflex (tapping the cornea with a finger), response to pain (nose-prick) and absence of rhythmic breathing (observation of the flanks) were recorded as signs of effective stunning and insensibility before sticking. The animals were evaluated while they were in a lying position on the shackling table.

In the abattoirs using the CO_2 system the physical reflexes of the pigs, such as loss of posture (recumbent state) and relaxed extremity were tested before they were conveyed from the shackling table to the rail. Once animals were hoisted onto the bleeding rail additional recordings, such as presence of arched-back righting reflex, floppy head and rhythmic breathing were made to evaluate possible stun recovery. The data were analyzed by the Statistical Analysis System (SAS, 1988), using a General Linear Models (GLM), where the stunning method and the abattoir were considered as main effects.

RESULTS AND DISCUSSION

Least squares means of the proportion of animals showing absence of rhythmic breathing, corneal reflex, sensibility to pain and their combinations according to the stunning method and the abattoir are presented in Table 1. There was a significant abattoir effect on all the indicators of effective stunning, whereas the stunning method only had a significative effect on the percentage of animals showing no corneal reflex ($p<0.10$) and on the percentage of animals where either the absence of corneal reflex and rhythmic breathing were absent ($p<0.10$). By comparing the two stunning systems the proportion of animals showing absence of corneal reflex was lower on exiting the CO_2 stunner than after electrical stunning (61.8 vs. 98.9%). With respect to the abattoir effect on the combined onset of corneal reflex and rhythmic breathing (1+2), plant D registered lower indices than the other plants evaluated. Indices at plant C were intermediate and significantly lower than the remaining two plants equipped with the electrical stunning system (A and B).

Under the commercial conditions studied carbon dioxide stunning is less effective in terms of the rapid onset of insensibility in pigs. This may be due to the stop/start manual nature of the system which can lead to a certain variability in the time of exposure to the gas of the pigs in the different positions in the well. In abattoir C the mean exposure was 110 and in abattoir D 95 s. The exposure time of animals in each well position depends on the cradle loading speed and on the CO_2 concentration in different positions of the installation. These times could explain the higher incidence of sensitive animals (1+2+3) in abattoir D which had the shortest gas exposure time. 12.81% of the hoisted animals in plant C and 33.3% in plant D were registered as having signs of recovery from the stun, such as arched-back righting reflex, floppy head and rhythmic breathing. Whereas the pigs stunned electrically did not show any signs of recovery on the bleeding rail.

In agreement with Wotton and Gregory (1986), the utilization of the head-to-chest device for pig stunning led to the instantaneous and irreversible onset of insensibility (1+2+3) in 98.7% of the animals, although in 15.75% (plant A) and 16.62% (plant B) of the cases studied it was observed that the electrical tongs were not exactly positioned between the eyes and ears on the pig's head. This would be unacceptable according to the electrode placement efficacy criteria established by Grandin (1996). It seems, therefore, that if a high voltage current is applied on the head, the accuracy of the electrode placement on the head is not so important.

CONCLUSIONS

The administration of an electrical current with 220 V and 800 Hz spanning the brain in combination with an electrical current with 110 V and 50 Hz passing through the heart was more effective than the CO_2 stunning system from the animal welfare point of view. In terms of CO_2 stunning system effectiveness, the exposure time to the gas and the stun to stick interval must be considered carefully in order to prevent the animals from regaining sensitivity after stun. The differences in the efficiency of the two CO_2 stunners evaluated would underline the importance of correct handling of the system.

REFERENCES

Forslid, A. 1987. Transient neocortical, hipocampal and amygdaloid EEG silence induced by one minute inhalation of high concentration CO_2 in the swine. *Acta Physiologica Scandinavica* **130**: 1-10

Grandin, T. 1996. Survey of stunning and handling practices in federally inspected, beef, veal, pork, and sheep slaughter plants. Project No 3602-3200-002-086. Beltsville, Md: USDA-Agriculture Research Service.

Gregory, N., Moss, B. and Leeson, R. 1987. An assessment of carbon dioxide stunning in pigs. *Veterinary Record* **121**:517-518

Raj, A.M. and Gregory, N. 1995. Welfare implications of gas stunning of pigs 2. Stress of induction of anaesthesia. *Animal Welfare* **5**: 71-78

Wotton, S. B. and Gregory N.G. 1986. Pig slaughtering procedures: time to loss brain responsiveness after exsanguination or cardiac arrest. *Research in Veterinary Science* **40**: 148-151.

Table 1.- Least squares means and residual standard deviation (RSD) of the proportion (%) of pigs showing absence of rhythmic breathing, corneal reflex and response to pain after electroanaesthesia or CO_2 stunning (N= 9,469)

	Stunning method		Abattoir				RSD	Significance level	
	Electrical	CO_2	A	B	C	D		Stun	Abattoir
Rhythmic breathing (1)	99.14	99.60	98.59^{b}	99.70^{b}	99.34^{ab}	99.86^{a}	0.42	ns	*
Corneal reflex (2)	98.89	61.79	98.25^{a}	99.55^{a}	73.12^{b}	50.45^{b}	8.99	+	*
Response to pain (3)	99.40	77.23	99.09^{a}	99.70^{a}	97.35^{a}	57.11^{b}	2.63	ns	***
1 + 2	98.71	61.49	97.88^{a}	99.55^{a}	72.63^{b}	50.53^{c}	8.87	+	*
1 + 2 + 3	98.70	52.93	97.84^{a}	99.55^{a}	71.81^{b}	34.04^{c}	8.92	ns	**

Means with different superscripts are significatively different ($p<0.05$).
***: $p<0.001$; **: $p<0.01$; *:$p<0.05$; +:$p<0.1$; ns: not significant.