THE EFFECTS OF ELECTRICAL WATERBATH- AND HEAD-ONLY-STUNNING ON BROILER WELFARE AND MEAT QUALITY

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SUMMARY

Broilers were either electrically 'whole-body' stunned in a waterbath (electrical current through whole body; 200 Hz AC, 100 V, 4 s; n=30) or electrically 'head-only' stunned (electrical current through the head only; 200 Hz AC, 25 V, 4 s; n=30), while shackled by their feet. Muscle reactions and meat quality variables in breast and thigh muscles were compared. Welfare aspects after head-only stunning (200 Hz AC, 25 V, 4 s; n=14) were studied using electro-encephalograms.
Limited convulsions were observed after whole-body stunning. However, more convulsions were observed after head-only stunning. Differences in ultimate pH were negligible. Head-only stunning resulted in significantly ($p \leq 0.01$) darker (lower L*-value) and more red (higher a*-value) breast muscles than whole-body stunning. Head-only stunning resulted in a significantly ($p \leq 0.01$) lower degree of haemorrhaging in the thigh than whole-body stunning. The stunning methods did not result in differences in degree of haemorrhaging in breast muscles, although the haemorrhages in the breast muscles were located more distal after head-only- than after whole-body stunning. Head-only stunning, with a voltage of 25 V, resulted in a general epileptiform insult, which lasted on average 32 s (SD 21). As the shortest insult lasted 17 s, neck cutting should be performed within this time. It is concluded that, as compared to whole-body stunning, head-only stunning is advantageous regarding haemorrhages and is not detrimental to broiler welfare.

Introduction

Stunning of slaughter animals is firstly applied to induce a state of unconsciousness and insensibility before neck cutting is performed. Moreover, this state should be of sufficient duration to ensure that the animal does not recover during exsanguination. Secondly, stunning is applied to immobilise the animal, and thereby facilitate neck cutting. It is generally accepted that animals are unconscious during a general epileptiform insult, by analogy with human experiences. During a general epileptiform insult the brain is in a stimulated condition and unable to react. For the occurrence of such an insult a minimum amperage is required. Higher current levels, recommended to protect broiler welfare, may result in a higher prevalence of muscle haemorrhaging (Veerkamp et al., 1987; Gregory and Wilkins, 1989). During the conventional waterbath-stunning of broilers the electrical current passes the whole body, which results in a direct muscle stimulation. Supercontraction, movement between muscles and an abnormal position of the animal during stunning may result in rupture of blood vessels and muscle damage (Leet et al., 1977; Veerkamp et al., 1987; Lambooy and Sybesma, 1988; Hillebrand, 1993). The conflict between welfare and meat quality makes it necessary to explore alternative stunning methods. Therefore, in this study welfare and meat quality aspects of conventionally waterbath-stunned broilers and head-only stunned (electrical current only applied to the head) broilers were compared.

Material and Methods

Meat quality:

In an experiment 60 broilers were slaughtered at an age of 6 weeks (live weight ca. 2.0 ± 0.2 kg), using 2 different stunning methods. The broilers were caught and transported to the pilot plant the day before slaughter. From 12 h before slaughter the broilers had only water at their disposal. After shackling 30 broilers (15 male

and 15 female) were electrically 'whole body' stunned in a waterbath (electrical current through whole body; 200 Hz AC, 100 V, 4 s; Stork RMS, Lichtenvoorde, The Netherlands) and 30 broilers (15 male and 15 female) were electrically 'head-only' stunned (electrical current through head only; 200 Hz AC, 25 V, 4 s). The head-only stunning was applied using a pair of tongs by which the electrodes were placed on the left and right side of the broilers' head and penetrated the skin. The degree of muscle reactions (convulsions) was subjectively scored. Neck cutting was performed 15-20 s after the start of stunning and the time of exsanguination was 2 min. Scalding (4 min., 50 °C) and plucking was done automatically. After evisceration the birds were packed in plastic bags and stored at 2 °C. At 1 day post mortem the carcasses were cut-up and meat quality traits were determined.

The ultimate pH was measured in the breast (*M. pectoralis major*) and thigh (*M. flexor cruris medialis*). Colour L*-, a*- and b*-values (Hunter) were measured in breast (ventral side of *M. pectoralis major*, presented as a mean value of the measurements in 4 locations equally distributed over the muscle) and thigh muscles (*M. iliotibialis cranialis* and *M. flexor cruris medialis*). Haemorrhages in breast (dorsal side of *Mm. pectoralis major and minor*) and thigh muscles (medial side) were quantified by a visual grading system in which the muscles are compared with 4 reference-photographs to classify them in 5 categories. Category 1 through 5 indicate increasing prevalence of haemorrhages. The classification was performed by 3 persons. Haemorrhaging in the wings was classified in 3 categories (1=no/hardly any haemorrhages, 2=medium haemorrhaging, 3=severe haemorrhaging). The number of broken furcula was scored.
Results for meat quality traits were statistically analysed with the student t-test, results for haemorrhaging were statistically analysed with the Mann-Whitney-test.

Electroencephalograms:

Fourteen boilers (10 male and 4 female) were anesthesized (0.9 cc Nimatek® + 0.2 cc Rompun® per animal) and 3 steel electrodes with a length of 2 mm were implanted in the skull to measure brain activity by means of an electroencephalogram (EEG). The electrodes were placed on the line connecting the caudal eye corners; one electrode was placed on the left side of the skull, another electrode was placed on the right side and an earth electrode was placed in the middle.

The broilers were head-only stunned with a pair of tongs by which the electrodes were placed on the left and right side of the broilers' head and penetrated the skin. During stunning the broilers were positioned in a funnel. The broilers were stunned during 4 s with an electrical current with a frequency of 200 Hz. Seven of the broilers were first stunned with 25 V and after ca. 3 h a second time with 75 V and the remaining broilers were stunned in a reversed order. During stunning, the voltage applied was measured, while the registration of the EEG was blocked to protect the equipment. The EEG was recorded just before, and during 3 min after stunning. The reaction of the animal to peripheral stimuli by applying an electrical current (18 V, from beak to anus) was used to check unconsciousness.

Results and Discussion

Muscle reactions:

During whole-body stunning (200 Hz AC, 100 V, 4 s) no movement of the broilers was observed. After whole-body stunning 37 % of the broilers showed no movement immediately after stunning, 10 % of the animals only showed convulsions during the first 30 s after stunning, 10 % of the animals up to ca. 60 to 90 s after stunning and 43 % between 60 to 120 s after stunning. After head-only stunning (200 Hz AC, 25 V, 4s) only 6 % of the broilers trembled during stunning and showed no movements immediately after stunning, 47 % of the animals showed convulsions during the first 30 s after neck cutting and were quiet afterwards, and 47 % of the animals showed violent convulsions during exsanguination, up to 90 s after stunning. In general, whole-body stunning with a high frequency resulted in limited convulsions, while head-only stunning with a high frequency resulted in more convulsions. Apparently, convulsions which are observed after a stunning-induced epileptiform insult are partly suppressed by the application of a high frequency current to the whole body.

Meat quality:

The results for meat quality traits of whole-body and head-only stunned animals are presented in Table 1. In the thigh and breast muscles no significant difference in ultimate pH was measured. Only a trend ($p \leq 0.1$) for a higher ultimate pH in the breast muscle of head-only stunned animals, compared to whole-body stunned

animals, was observed. Although no differences in ultimate pH were observed, the rate of pH-decline may be different for the two stunning methods. The difference in degree of muscle reaction after the two stunning methods may result in differences in the rate of post mortem pH-decline, but not necessarily in differences in ultimate pH (Mohan Raj et al., 1990; Hillebrand, 1993). Furthermore, the direct stimulation of the electrical current that passes the muscles during whole-body stunning may also accelerate post mortem pH-decline (Petersen and Blackmore, 1982).

Head-only stunning resulted in significantly ($p \leq 0.01$) darker (lower L*-value), more red (higher a*-value) and more blue (lower b*-value) breast muscles than whole-body stunning. In contrast, whole-body stunning resulted in more red (higher a*-value) thigh muscles than did head-only stunning (*M. flexor cruris medialis*, $p \leq 0.05$; *M. Iliotibialis cranialis*, trend, $p \leq 0.1$). Factors directly or indirectly affecting meat colour are fat content and the amount, and the degree of oxidation, of muscle pigments, like myoglobin, haemoglobin and cytochrome. The processes of oxidation and oxygenation are depend on, amongst others, the rate of post mortem pH decline and the ultimate pH. Both these factors are also of major importance for water-holding capacity, and hence for the absorption and reflection of light. The different stunning methods used in this study did not result in differences in ultimate pH and the rate of pH decline was not determined. Another factor, not measured in this study, that may explain the differences in colour, is the percentage of blood loss after neck cutting.

After whole-body stunning 9 of the 30 broilers, and after head-only stunning only 4 of the 30 broilers had a broken furculum. The stunning methods did not result in differences in the prevalence of haemorrhaging in wings and breast muscles, although, the haemorrhages in the breast muscles were located more distal after head-only than after whole-body stunning. The observed haemorrhages in the breast muscle of head-only stunned broilers towards the humerus-coracoïd-joint may be caused by the more violent convulsions that occur after this stunning method. The electrical current that passes the muscle during whole-body stunning may be, directly or indirectly, responsible for the haemorrhages in the middle of the breast muscles of whole-body stunned broilers. The classification for haemorrhaging was significantly ($p \leq 0.01$) lower (lower prevalence of haemorrhaging) for thighs of head-only stunned broilers than in thighs of whole-body stunned broilers. Apparently the circuit of the electrical current affects only the level of haemorrhaging in the thigh, but not in the breast muscles when broilers are shackled by there feet during stunning.

Electroencephalograms:

After the stunning current was applied the EEG of the broilers exhibited an epileptiform insult as described by Hoenderken (1978) in pigs and Lambooy (1982) in sheep; in some animals the characteristics were suppressed. After head-only stunning with a voltage of 25 V or 75 V the epileptiform insult lasted for 32 s (SD 21) or 30 s (SD 15), respectively. The duration of the epileptiform insult seemed to be longer after the second stun. The shortest insult measured lasted 17 s after stunning with adjustment to 25 V as well as 75 V. The measured average voltage, with adjustment to 25 V or 75 V, was 27 V (SD 3) or 90 V (SD 5), respectively.

This study, with a limited number of animals, shows that neck cutting should be performed within 17 s after stunning, since this is the duration of the shortest insult measured. The higher standard deviation for the duration of the second stun was, in both groups, caused by 1 animal (per group) that showed a very long insult. The average duration of the insult is for both voltages longer after the second than after the first stun. Possibly, after 3 h there was still an effect of the first stun, when the second stun was applied. In another experiment with pigs a similar effect was not observed (Lambooy, 1994). The method of stunning may be important in causing this effect. The electrical current for the head-only stunning was applied by means of a pair of tongs, in which the head of the broiler was pinched. The pinching of the broilers' head may cause damage to the brain. The stunning current in the pigs was applied by implanted electrodes.

Conclusion

It is concluded that, compared to whole-body stunning, head-only stunning is advantageous with regard to haemorrhages and is not detrimental to broiler welfare.

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References

Gregory, N.G. and Wilkins, L.J. (1989). Effect of stunning current on carcase quality in chickens. Vet. Rec., 124: 530-532.
Hillebrand, S.J.W. (1993). The sensory quality of turkey meat -with special reference to the effects of electrical stunning and chilling rate-. Thesis, University of Utrecht, The Netherlands.
Hoenderken, R. (1978). Electrical stunning of slaughter pigs. Thesis, University of Utrecht, The Netherlands.
Lambooy, E. (1982). Some aspects of the effectiveness of stunning in sheep by captive bolt. Meat Sci., 7: 51-57.
Lambooy, E. an Sybesma, W. (1988). The effect of environmental factors such as preslaughter treatment and electrical stunning on the occurrence of haemorrhages in the shoulder of slaughter pigs. Proc. 34th ICoMST, pp. 101-103.
Lambooy, E. (1994). Electrical stunning by direct brain stimulation in pigs. Meat Sci., in press.
Leet, N.G., Devine, C.E. and Garey, A.B. (1977). The histology of blood splash in lamb. Meat Sci., 1: 229-234.
Mohan Raj, A.B., Grey, T.C., Audsely, A.R. and Gregory, N.G. (1990). Effect of electrical and gaseous stunning on the carcase and meat quality of broilers. Brit.Poult. Sci., 31: 725-733.
Petersen, G.V. and Blacmore, D.K. (1982). The effect of different slaughter methods on the post mortem glycolysis of muscles in lambs. N.Z. Vet. J., 30: 195-198.
Veerkamp, C.H., Rincker, A.H.H., Pieterse, C. and de Vries, A.W. (1987). Onderzoek naar de verdovingscondities op de kwaliteit van slachtkuikens. COVP uitgave 469, Beekbergen , The Netherlands.