Effect of different electrical stunning conditions on meat quality in broilers

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Abbreviated title: Electrical stunning conditions in broilers

Summary

Electrical water bath stunning is still the dominant method in slaughtering of broilers. Usually, AC stunning is applied with a minimum current of 120 mA per bird according to the actual EU regulations for stunning of chicken. To investigate the impact of electrical stunning conditions on effectiveness of stunning more deeply in a first step various combinations of voltage, voltage frequency and current were tested for stunning success. In a second step the most efficient stunning conditions (DC 70-600 Hz, 100-200 mA; AC 70-600 Hz, 100-200 mA) were applied during broiler slaughtering. Carcass quality (blood loss, broken bones, bruises, hemorrhages) and meat quality (colour, cooking loss, texture) were determined. DC stunning resulted in higher blood loss and in fewer cases of red wing tips, broken wish bones and hemorrhages, whereas effects on meat quality criteria were minor.

Keywords: broilers, electrical stunning, meat quality, carcass quality, blood loss, hemorrhages

Introduction

According to legislation of the European Union (Council Directive 93/199/EC) stunning of animals before slaughtering is prescribed. Electrical stunning using a water bath stunner is the most common method to stun poultry (Bilgili *et al.*, 1992). The electrical current passes through the body and the brain of the chicken. This may cause muscle contractions depending on frequency and current. The consequences are carcass and meat quality defects like broken bones, hemorrhages and impaired texture of the meat due to a disturbed development of rigor mortis. It has been observed that higher electrical currents may cause a higher incidence of broken bones (Gregory and Wilkins, 1990) and muscle hemorrhages (Hillebrand *et al.*, 1996). In contrast, it is reported that higher voltage frequencies may reduce the incidence of broken bones (Gregory and Wilkins, 1990). But, increased stunning voltages resulted in decreased blood loss (Veerkamp and de Vries, 1983).

The objectives of the present project were set to evaluate the effects of a broad variety of different electrical stunning setups which have been proven to definitely render birds unconscious on carcass and meat quality in broiler chickens.

Materials and methods

In two consecutive shifts a total of 120 male and 120 female 35 days old Ross broilers were used. Average life weight in the first shift was 1.6 kg for male broilers and 1.5 kg for female broilers, whereas, in the second shift average life weights amounted to 2.1 kg and 1.9 kg, respectively.

Stunning and slaughtering conditions

Broilers were individually stunned in an electrified water bath for 10 seconds. As water bath a plastic basin was used filled with salted water (conductivity 4 mS). The bottom of the water bath was covered with a metal electrode (plus pole). The feet of the chickens were fixed into a grounded metal shackle. To improving conductivity feet were moistened with water. For applying electricity a commercial Meyn Quest Stunner (Meyn Quest Cabinet, Meyn Food

Processing Technology, Oostzaan, The Netherlands) was used. Waveform, frequency and amperage were combined to result in 10 stunning settings (Table 1).

Table 1 Settings of stunning

Waveform	Frequency (Hz)	Amperage (mA)
AC (sinus form alternating current)	70	100
	70	150
	400	100
	400	150
	600	200
DC (pulsed direct current)	70	100
	70	150
	400	100
	400	150
	600	200

In preliminary experiments a distinct variation of electrical resistance was observed for individual birds. Therefore, stunning current was recorded for each bird with a Fluke 123 Scope Meter (Fluke Corporation, Everett, USA) and was used to adjust the actual current on an individual basis.

After stunning body weights of broilers were recorded before killing by neck cutting and after 3 minutes of bleeding out for determining blood loss. After bleeding broilers were scalded in a one stage scalding tank and feathers were plugged off automatically on a Meyn slaughter equipment. Evisceration was done by hand and after measuring pH and conductivity (LF) carcasses were chilled in a cooling chamber (4°C) for 24 hours before subjective evaluation of carcass quality and filleting.

Assessment of downgrading

Wing tips and breast muscles (*Pectoralis major* and *Pectoralis minor*) were subjectively assessed for the occurrence and the intensity of hemorrhages. A scale from 0 (no hemorrhages) to 3 (strong hemorrhages) was applied. Furthermore, the occurrence of broken *claviculae* (wish bones) was recorded.

Assessment of meat quality

The pH value and the electrical conductivity were measured 15 minutes and 24 hours *post mortem* in the breast muscle (*Pectoralis major*) using pH-meter Testo 206 (Testo, Lenzkirch, Germany) and the Conductometer WTW LF 191 (WTW, Weilheim, Germany), respectively. After 24 hours the color of the *Pectoralis major* (medial side) was determined with the photometer color-guide 45/0 (bvk-Gardner, Geretsried, Germany) according to the CIE L*a*b*-System.

Statistical Analysis

The data were analyzed with a two-factorial MANOVA with the statistic program JMP® 8.0 (SAS Institute, Cary, NC).

Results

Results for cooking loss and texture are not presented due to missing effects. Stunning conditions significantly ($P<0.05$) influenced conductivity measured after 15 min and 24 h, whereas, no clear effects were observed on pH values (table 2). In general, LF values were higher for DC. Significant effects of frequency/ amperage combinations on pH and LF did not show a clear tendency.

Table 2 Effect of different electrical stunning settings on pH value and conductivity 15 minutes and 24 hours *post mortem*

	Waveform		Current Frequency (Hz)/Amperage (mA)				
	AC	DC	70/100	70/150	400/100	400/150	600/200
pH_{15}	6,76	6,72	6,73	6,71	6,77	6,79	6,70
pH_{24}	6,07	6,10	6,10	6,13	6,01	6,11	6,10
LF_{15}	$1,91^{b}$	$2,16^{a}$	$2,03^{b}$	$2,24^{a}$	$1,93^{b}$	$1,96^{b}$	$2,02^{b}$
LF_{24}	$2,03^{b}$	$2,35^{a}$	$2,55^{a}$	$2,08^{b,c}$	$1,84^{c}$	$2,30^{ab}$	$2,18^{a,b,c}$

[a,b] Means within a row with differing superscript are significantly different (P < 0,05)

Blood loss was significantly higher (P<0.05) for DC than for AC (table 3). Stunning by 400 Hz/ 100 mA resulted in the highest blood loss and 70 Hz/ 150 mA in the lowest. Redness of breast meat was significantly higher (P<0.05) for stunning frequency 70 Hz than for higher frequencies.

Table 3 Effect of different electrical stunning settings on blood loss (%) and on a*-value (redness) of breast muscle

	Waveform		Current Frequency (Hz)/Amperage (mA)				
	AC	DC	70/100	70/150	400/100	400/150	600/200
Blood loss (%)	$3,17^{b}$	$3,52^{a}$	$3,35^{a,b}$	$3,15^{b}$	$3,60^{a}$	$3,27^{b}$	$3,35^{a,b}$
a^{*} (redness)	- 0,25	- 0,28	$0,05^{a}$	$0,19^{a}$	$- 0,72^{b}$	$- 0,44^{a,b}$	$- 0,44^{a,b}$

[a,b] Means within a row with differing superscript are significantly different (P < 0,05)

Female broilers showed a higher incidence of broken wish bones (table 4), whereas, in male broilers more red wingtips and breast muscle hemorrhages (levels 2 and 3) were observed. AC stunned chickens had a higher incidence of broken wish bones, red wingtips and hemorrhages in the *P. major*. DC stunning resulted in a higher incidence of hemorrhages in the *P.minor* than for AC stunning.

Table 4 Effect of sex and waveform on the occurrence of broken claviculae, red wingtips and breast muscle hemorrhages

Frequency of occurrence (%)	Female	Male	AC	DC
Broken wish bones	28,2	21,5	29,2	19,7
Red wingtips	9,1	11,1	12,3	7,6
Hemmorhages Breast muscle (*P.major*)	15,4	23,6	21,7	16,9
Hemmorhages Breast muscle (*P.minor*)	25,0	32,1	27,6	29,8

For AC stunning a tendency for a higher incidence of red wing tips (hemorrhages levels 2 and 3) was observed (figure 1), whereas, for DC no clear tendency was visible. The incidence of broken wish bones decreased for AC and increased for DC with increasing frequency and amperage.

DC stunning conditions resulted in a decrease of hemorrhages in both breast muscles with increasing frequency/ current (figure 2). For AC stunning conditions no clear effect of stunning setups was visible.

Discussion

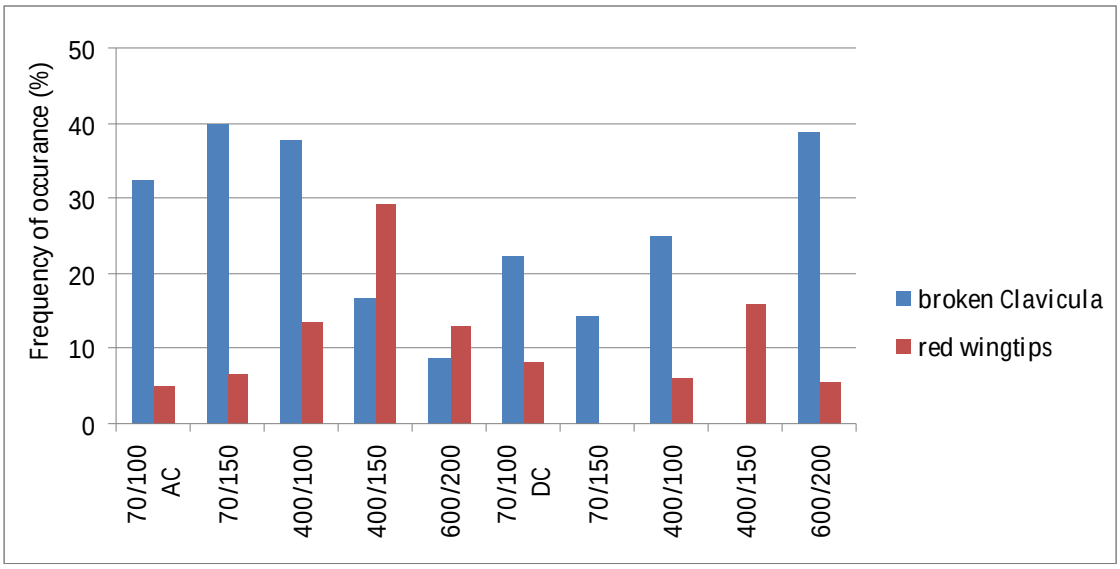
Stunning setups significantly affected indicators of meat quality (pH, LF), but, observed differences were minor and did not indicate impaired meat quality.

Blood loss was significantly higher for pulsed DC. Obviously, birds have not been stunned to death by DC. Action of the heart supported blood loss during bleeding. In Contrast in some studies no effect of blood loss from animals with or without ventricular fibrillation was observed. Only the rate of blood loss during bleeding was different (Raj and Gregory, 1991; Schütt, 1982). This observation was not paralleled by redness of the breast meat. Redness was not different between AC and DC. This may indicate that the content of blood remaining in breast muscle tissue is not

relevant for meat color. On the other hand, stunning setups with 70 Hz voltage resulted in more redness of breast meat. This may be caused by differences in the incidence of convulsions following stunning (Prinz *et al.*, 2009).

Figure 1 Incidence of broken claviculae and red wingtips depending on stunning setups

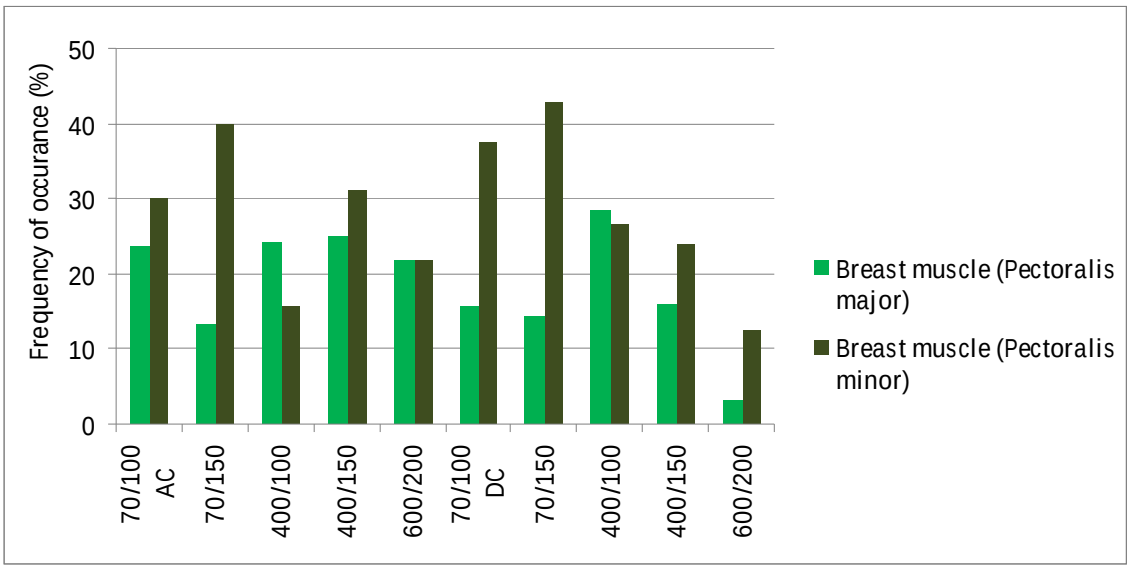
*the occurrence means hemorrhages graded by level 2 and 3



The observed higher incidence of broken wish bones, red wingtips and hemorrhages for AC stunning setups confirms the expected higher incidence of convulsions for AC stunning (Prinz *et al.*, 2009). The higher proportion of hemorrhages in male broilers may be explained by the higher muscle mass which is mainly the result of increased diameter of muscle fibers. On the other hand, bigger muscles may exhibit higher forces. In contrary, the higher incidence of broken wish bones in female broilers may be caused by weaker bone stability.

Figure 2 Incidence of hemorrhages in breast muscles depending on stunning setups

*the occurrence means hemorrhages graded by level 2 and 3



In conclusion, the different stunning setups had a minor effect on early post mortem indicators of meat quality. But, distinct effects could be observed on carcass quality. Obviously, AC stunning setups result in higher incidence of post-stun convulsions causing broken wish bones, red wingtips and hemorrhages.

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