Influence of electrical stunning voltages on bleed out and carcass quality in slaughtered broiler chickens

Einfluss der Betäubungsspannungen beim Schlachten auf das Ausbluten und die Schlacht-körperqualität von Broilern

Abdalla S.A. Ali¹, Moira Anne Lawson², Anne-Helene Tauson¹, J. Fris Jensen¹ and A. Chwalibog¹

Introduction

The initial steps in processing poultry, specifically electrical stunning, severing neck blood vessels and bleed-out are important in the production of poultry meat for human consumption. The presence of blood in broiler meat represents a major quality defect, and therefore, to optimize meat product and carcass quality, adequate bleeding is necessary. Carcass quality defects leading to downgrading have been reported with electrical stunning when the applied current is either too low or too high (WABECK, 1988; MURPHY et al., 1988; DICKENS and LYON, 1993). A major goal of processing plants is to reduce meat and carcass defects and optimize bleed-out of poultry at this stage, as improved bleeding can improve the quality of the meat during storage (SCOTT, 1978).

It is widely thought that electrical stunning is a cause of many forms of downgrading. In particular, it is believed that high voltages in a water-bath stunner can lead to poor bleeding. Inadequately bled birds can be condemned because of excessive blood in all or some portion of the carcass (HARRIS and CARTER, 1976; GREGORY and WILKINS, 1989; FLETCHER, 1993). In addition, proper bleeding will decrease the quantity of blood diffusing from each carcass into the scald water, increase the possibility for maximization collection of blood for recycling purposes and thus decrease the cost of treating plant wastewater to reduce its organic load (KUENZEL and INGLING, 1977).

There are conflicting observations on the rate of bleed out after low and high voltage stunning. KOTULA and HELBACKA, (1966a) reported that electrical stunning resulted in significantly more retained blood in the saleable parts of the carcass as opposed to either physical stunning or non-stunned birds. The authors also observed that electrical stunning did not significantly affect total blood loss as a percentage of live bird weight, but as a percentage of total blood volume. When different stunning techniques and circuits were evaluated, KUENZEL and INGLING, (1977) found that an AC circuit connected to a brine stunner at a voltage setting of 50 volts was best for maximizing bleed-out of electrically stunned male broilers. When stunning voltages were increased, it has been reported that bleed out was hindered (VEERKAMP and DE VRIES, 1983). This result has been disputed, as GRIFFITHS, (1983), GRIFFITHS et al., (1985) and DICKENS and LYON, (1993) reported that electrical stunning had no effect on blood loss or carcass appearance of broiler chickens.

The effect of a beating heart on the rate of bleed out is not clear. Reports have shown similar levels of bleed out independent of whether or not the heart was beating (WARRIS, 1984). The author concluded that the heart cannot pump blood out of the organs and muscles of the body without displacing it with more blood. GREGORY and WILKINS (1989a) reported that improper bleeding, or not bleed out at all, seems to have a greater effect on carcass quality parameters. In a later study, (1993) the authors found that although the initial spurt of blood was less following cardiac arrest; the ultimate amount of blood lost from the bird was not significantly decreased. Heart failure by electrical stunning is generally recommended from the welfare point of view (HEATH, 1984; GREGORY and WOTTON, 1986; MEWS, 1993; GYBELS, 1993; LAMBOOIJ, 1993).

Stunning and slaughtering techniques can have a major effect on the incidence of a number of carcass defects, such as haemorrhages in muscle tissue, red wingtips and broken bones. It has been reported in numerous studies that muscle tissue haemorrhages can be caused by pre-slaughter electrical stunning (HILBERAND et al., 1996; KRANEN et al., 1998), especially in the breast muscle the cut of the bird with the highest economic value (LYON and COLE, 1986, VEERKAMP, 1987) Susceptibility of muscle haemorrhages caused by electrical stunning depends on the individual impedance of the birds; genetic and environmental factors such as cold weather conditions intensify this problem.

While muscle haemorrhages are a major problem in the sale of broiler parts, red wingtips and broken bones. It has been reported in numerous studies that muscle tissue haemorrhages can be caused by pre-slaughter electrical stunning (HILBERAND et al., 1996; VEERKAMP and DE VRIES, 1983). The authors found that stunning at 200 V resulted in significantly more red wingtips and tails than broilers stunned at 75 V. There may well be numerous causes of this defect as HEATH, (1984) blamed rupture of blood vessels during the plucking process a cause of red wingtips, while GREGORY et al., (1989) reported that the defect is associated with incidence of wing flapping during the shackling process at the slaughterhouse.

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The occurrence of broken bones in broiler carcasses has been mainly attributed to processing as physical damage in live birds is not a common problem (Gregory and Wilkins, 1989). There are several causes associated with the incidence of broken bones in broilers. Most studies have found that the plucking process was the major contributor to broken bones (Andrews and Goodwin, 1973; Wabeck and Littlefield, 1972), but high stunning voltages cannot be ruled out as a cause (Gregory and Wilkins, 1989).

The objectives of the following experiments were to determine the effects of different electrical stunning voltages on rate of bleed out and carcasses quality in slaughtered broiler chickens.

Materials and Methods

Birds and management

Two experiments involving 420 birds were conducted to determine the influence of electrical stunning on carcass quality defects and blood retained by chicken carcasses. The birds used in this study were 40-d-old (Ross 208) broiler chickens, from the same flock, hatched and raised commercially under similar environmental and nutritional conditions and weighing about 2 kg. Feed was withdrawn from broilers 8 to 9 hours prior to slaughter. All birds were stunned in a water-bath stunner (Linco, Lindholst water-bath stunner). In the first experiment (Exp 1), eleven treatment groups were set up with twenty mixed-sex birds each. In the second experiment (Exp 2), two hundred birds were allocated to ten groups with twenty male birds each. Due to the large variations in the impedance of individual birds, stunning was carried individually at 0, 23, 33, 38, 43, 48, 53, 58, 63 and 103 volt alternating current in Exp 1 and 2. Stunning at 193 volt alternating current was used only in Exp 1. The time between stunning and slaughter was 12 s, the current (mA) for each stunning voltage was not determined.

Processing

Stunning, slaughter and processing were carried out at a commercial processing plant with a capacity of 5100 birds per hour. The time between hanging and stunning was 35 s; stunning duration was 10 s (head to feet). Birds were slaughtered manually by severing the jugular veins and carotid arteries on both sides of the neck, after which the birds were bled for 135 s. The carcasses were then scalded for 100 s at 60.5°C in a thermostatically controlled scalding tank (Linco Scald) equipped with a circulating pump discharging the water at the top of the tank and over the immersed birds. Plucking was done using a mechanical plucker (Linco Tunnel Picker) for a period of 45 s. The birds were eviscerated using an automatic viscera removal apparatus (Stork auto. eviscerator). Chilling time was 35 minutes in a counter-current chiller (Linco Chiller). To quantify the defects of red wingtips, breast blood spots and broken bones of slaughter carcasses, the study adopted a visual grading system in which the carcasses were individually examined and evaluated by a trained panel (Ali et al., 1996).

Calculation of bleed out

To calculate the bleed out of the broiler the following measurements were executed: The weight of each bird was measured before stunning and the weight was measured again 135 seconds after slaughter. The water up-take of the broilers was measured with other birds at the same time from the same flock. The calculation of bleed out was then made using the following equation:

\[ Y = X - X_t + W_t \]

In which \( Y \) = weight of bleed out t seconds after stunning
\( X \) = live weight
\( X_t \) = weight t seconds after stunning
\( W_t \) = amount water uptake t seconds after stunning.

The total blood volume of the individual broilers was calculated using the formula of Kotula and Helbacka, (1966 b):

\[ Y = 2.251 * X^2 - 11.1 * X + 20.49 \]

In which \( Y \) = total amount of blood as percentage of live weight
\( X \) = live weight in Kg.

The bleed out was expressed as a percentage of the total blood volume to exclude influences of the differences in average weight between the different samples.

Statistical analysis

The data was analyzed using the GLM procedure of the Statistical Analysis System (SAS, 1990) using a model where the fixed effects of experiment (Exp. 1 or Exp. 2) and eleven stunning voltages (0, 23, 33, 38, 43, 48, 53, 58, 63, 103 and 193) on the dependent variables were tested. Differences between treatments were considered significant if \( p<0.05 \).

Results and discussion

Bleed out

Results are summarized in Table 1 and 2. At lower stunning voltages, the rate of bleed out by broiler carcasses increased as the stunning voltage increased, at voltages greater than 58V, blood loss again decreased. The authors have no explanation for this phenomenon. The bleeding rate was variable between the birds in the same group, which may be due to the individual impedance of the chickens, which varies greatly from bird to bird. Wolley et al., (1986b) have shown that ranges of impedance in otherwise similar birds were between 1000 and 1500 ohms. This variation will be increased by differences in conductivity between shackle and legs (Kuenzel et al., 1978; Wolley et al., 1986b). As Shown in Table 1 and 2, low stunning voltages (0 to 23 V AC) caused the chickens to leave the stunner squeaking loudly flapping their wings in a vain effort to flee and resulted in poor bleed-out (40%), high incidence of broken bones (20%) and red wingtips (10%). Due to these defects carcasses were classified as B grade (Table 3). Moderate stunning voltages (53 - 63 V) increased bleed out by carcasses to over 50% and resulted in fewer incidences of broken bones (8%). Therefore, a high proportion was classified as A grade. High stunning voltages (193 V) resulted in negative effects such as red wingtips (24%), broken bones (19%) and blood spots (79%). Carcasses in this group were graded class B due to the high incidences of breast blood spots.

Data in Table 1, 2 and 3 show clearly that stunning at 53 - 63 V to be more effective in bleed-out and resulted in fewer incidences of breast blood spots, broken bones and red wingtips compared to higher (100 - 193 V AC) or/and lower (0 - 23 V AC) applied voltages. These results are in close
agreement with those of Kuenzel and Inglint, (1977); Veerkamp and De Vries (1983); Wabeck, (1988) and Dickens and Lyon, (1993) who found that 50 V AC was superior for maximizing bleed-out in processed chickens as compared to 100 - 200 V AC stun. However, these results were inconsistent with Griffiths, (1983) who observed no difference between the amount of bleed out from broilers stunned at 55, 80, 105, or 200 volts and with Dickens and Lyon (1993) who reported that stunning with either 50 or 200 V AC had no effect on bleed out of broilers. Obviously, the results in Table 1, 2 and 3 shows that sex differences (mixed / male) between the groups had no impact either on the rate of blood loss and/or carcasses defects due to the applied electrical stunning.

### Table 1. Exp. 1. Effect of different electrical stunning voltages on bleed out in mixed-sex broilers

<table>
<thead>
<tr>
<th>Volt</th>
<th>N</th>
<th>LW g</th>
<th>BL g</th>
<th>TBV %</th>
<th>BL / LW %</th>
<th>BL %</th>
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<td>2120</td>
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<td>20</td>
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<td>43</td>
<td>20</td>
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<td>48</td>
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<td>2238</td>
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</tr>
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<td>53</td>
<td>20</td>
<td>2170</td>
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<td>3.64</td>
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*p-value (volt) 0.001*  
*p-value (experiment) ns*

**Abbreviations:** LW = live weight; BL = bleed out; TBV = Total blood volume; RMSE = Root Mean Square Error; ns = not significant

### Table 2. Exp. 2. Effect of different electrical stunning voltages on bleed out in male broilers

<table>
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<tr>
<th>Volt</th>
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<td>5.17</td>
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*p-value (volt) 0.001*  
*p-value (experiment) ns*

**Abbreviations:** LW = live weight; BL = bleed out; TBV = Total blood volume; RMSE = Root Mean Square Error; ns = not significant

Stunning effects

The researchers’ recommendation of a minimum stunning current of 120 mA that results in heart failure or immediate death (Heath, 1984; Gregory and Wotton, 1986; Mews, 1993; Gybels, 1993 and Lambooij, 1993) was based solely on achieving optimum welfare and not on avoiding meat and carcasses defects (Van Hoof 1992). However, it is well documented that stunning at high current is one of the major factors that causes downgrading in meat and carcasses quality (Veerkamp, 1987; Gregory and Wilkins, 1989; Ali et al., 1996). The use of high current lengthens the bleeding time (Gregory and Wilkins, 1993), hinders plucking efficiency (Gregory 1989) and delays rigor devel-
opment (PAPINATO and FLETCHER, 1995; CRAIG and FLETCHER, 1997) in the carcass. This study suggests an alternative slaughter method which combines a low stunning current should be investigated in order to eliminate the conflict between animal welfare and quality of products. In addition, it is essential that both carotid arteries and jugular veins are cut as soon as possible after stunning in order to aid rapid bleed-out and hence rapid death. The instrument used to perform slaughtering must be extremely sharp to facilitate the quick cutting of the blood vessels. The ensuring rapid drainage of blood causes anoxia and often prevents the bird from regaining consciousness during the subsequent 80 – 90 s (BILGILI, 1999). BLACKMORE and DELANY, (1988) reported that in order to ensure that a slaughter process is humane, it is important to know the time taken for an animal to become insensible from the slaughtering procedure alone. FLETCHER, (1999) reported that stunning, neck cutting and bleeding should be considered a continuous slaughter process and not as distinct steps.

It was concluded that the applied electrical voltage for stunning significantly affects the rate of bleed out in broilers. The number of carcass defects increased with increasing of the electrical stunning voltages. With increased attention to the humane treatment of food animals during slaughter, the 50 - 63 V AC stun could prove to be more humane if it is combined with an effective method of slaughter that achieves rapid bleeding. Stunning at 53 V AC for 10 s maximized bleed out to over 50%. Low electrical stunning voltages (0 - 23 V AC) resulted in poor bleed-out (40%) and downgrading carcasses that were classified as B grade. High stunning voltages (103 to 193 V AC) are sufficient to satisfy birds’ welfare issues but resulted in other side effects such as physical damage, breast blood spots, red wingtips and broken bones. High stun carcasses were classed as B grade. Moderate stunning (53 to 63 V AC) seems to be more effective in bleed-out (50%) and resulted in better carcass quality, which were graded as A. Finally, this study confirms that a beating heart is not necessary in order to ensure effective bleed-out. In addition, it is difficult to think of any scientific, religious, economic and humanitarian grounds for removing the last possible drop of blood. Since stunning at high currents is a major cause of carcass downgrading, the stun-to-death method neither achieved the goal to satisfy processors nor fulfilled consumers’ demands. We fully agree with VAN DE NIEUWLAAR (1993) that the method of stun-to-death will result in a frustrating cat and mouse game between the inspection authorities and poultry processing industry. Moreover, the question of what constitutes cruelty has remained unanswered.

### Table 3

<table>
<thead>
<tr>
<th>Volt</th>
<th>n</th>
<th>Red wingtips %</th>
<th>blood spots %</th>
<th>Shoulder hæmorr. %</th>
<th>broken bones %</th>
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<td>-</td>
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<td>-</td>
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</table>

### Perspectives
- All technical means should be used to avoid high voltage electrical stunning
- The level of consciousness of the birds and the quality of the product are the most important aspects that determine the voltage adjustment.
- Alternative slaughter methods in combination with a low electrical stunning should be investigated in order to hopefully eliminate the conflict between animal welfare and meat quality

### Acknowledgements
The authors wish to thank Rose Poultry Processing Plant for providing facilities and birds and the Danish Institute of Agricultural Sciences, Foulum, Dept. of Product Quality, for the technical assistance.

### Summary
Two experiments involving 420 birds were conducted to determine the influence of electrical stunning on meat quality and blood retained by chicken carcasses. The birds used in this study were 40-d-old (Ross 208) broiler chickens, from the same flock, hatched and raised commercially under similar environmental and nutritional conditions and weighing about 2 kg. In the first experiment, eleven treatment groups were set up with twenty mixed-sex birds each. In the second experiment, two hundred birds were allocated to ten groups with twenty male birds each. Birds in both experiments were individually stunned at 0, 23, 33, 38, 43, 48, 53, 58, 63, 103 and 193 Volt (only exp 1). The total blood volumes of the individual chickens were calculated. It was concluded that the applied electrical voltage for stunning significantly affects the rate of bleed out in broilers. Carcass defects were increased with the increasing of the electrical stunning voltages. With increased attention to the humane treatment of food animals during slaughter, the 50 - 63 V AC stun could prove to be more humane if it is combined with an effective method of slaughter that achieved a rapid bleeding. Stunning at 53 V AC for 10 s maximized bleed out to over 50%. Low electrical stunning voltages (0 to 23 V AC) resulted in poor bleeding (40%) and high incidence of carcasses defects that classified as B. High stunning voltages (103 to 193 V AC) sufficient to satisfy birds welfare issues but resulted in other side effects such as physical damage, breast blood

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**Stichworte**

Broiler, Elektrische Betäubung, Spannung, Ausbluten, Schlachtkörperrqualität

**References**


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