Welfare During Stunning and Slaughter of Poultry

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ABSTRACT

This paper describes research on the electrical stunning of poultry and the problems of achieving an effective humane stun with water bath stunners. The welfare and meat quality advantages of using gas mixtures to stun and kill birds are then described. The evidence strongly suggests that chickens and turkeys can be killed very humanely using either 90% argon in air or a mixture of 30% carbon dioxide and 60% argon in air.

(Key words: electrical stunning, gas stunning, slaughter, welfare)

INTRODUCTION

Most developed countries have humane slaughter laws for food animals, which cover poultry species. These laws are designed to ensure that animals are killed quickly, painlessly, and without suffering in other ways. These laws usually mean that the animals are stunned prior to killing, and, in the case of poultry species, the stunning is usually electrical. However, electrical stunning is not completely effective; occasionally some birds are not properly stunned. This is of great concern from a welfare point of view and there is also evidence that meat quality may be reduced. These problems have led to a search for alternatives to electrical stunning, and the development of one of these, the use of gas mixtures to stun and kill birds, is described.

ELECTRICAL STUNNING OF POULTRY

Electrical stunning using a water bath stunner is the most common method employed to slaughter poultry under commercial conditions. The purpose of electrical stunning is to induce insensibility in order to perform humane neck cutting and to avoid recovery of consciousness and wing flapping during bleeding. From the welfare point of view, the minimum current required per bird in the water bath stunner can be determined using three criteria: 1) induction of epileptiform activity in the brain, 2) abolition of somatosensory evoked potentials (SEP) in the brain, and 3) induction of cardiac arrest at stunning.

Epileptiform Activity

The basic principle involved in electrical stunning is that an electric current is passed through the brain to induce epilepsy. The occurrence of grand mal epilepsy, characterized by bipolar, high amplitude low frequency electrical activity, is considered to be an indicator of the state of unconsciousness, based on the human analogy. However, chickens do not always show grand mal epileptic activity in the brain following electrical stunning. Instead, some birds show polyspike activity—unipolar, high amplitude low frequency electrical activity. Gregory and Wotton (1987) interpreted these polyspike activities, which can be induced with a very low current (e.g., 28 mA), to be similar to that of petit mal activity in humans, which is not always associated with unconsciousness. However, it has been suggested that if chickens show this kind of activity immediately followed by a quiescent phase in their electroencephalogram (EEG), it can be assumed that they are adequately stunned (Schütt-Abraham et al., 1983). The absence of epileptiform activity in some birds during electrical stunning might cast some doubt on the effectiveness of the stun.

The biochemical manifestations of epileptiform activity in the brain following head-only electrical stunning of sheep is well documented. Glutamate and aspartate are the major excitatory amino acid neurotransmitters in the central nervous system and, when they are released into the extracellular space as a consequence of electrical stunning, they facilitate epileptiform activity in the brain (Meldrum, 1975). Gamma amino butyric acid (GABA) is a major inhibitory neurotransmitter that is also released into the extracellular space following electrical stunning.
These GABA-ergic effects can occur independently of the excitatory amino acid effects (Cook et al., 1992), and an enhanced GABA-ergic effect can prevent the manifestation of epilepsy (Meldrum, 1984). This occurrence would imply that the presence or absence of epileptiform activity in the brain following electrical stunning could depend upon whether the excitatory or inhibitory pathways are activated by the current, the amount of neurotransmitter released, and the uptake by the receptors. It appears that the glutamate:GABA ratio in the cerebral cortex is very critical in determining the end result. However, in contrast to mammals, in birds, the neurons that are homologous to the mammalian neocortex are located deep within the cerebral hemisphere instead of on the surface (King and McLelland, 1984).

Due to the lack of development of the neocortex in birds, it can be assumed that the release of other neurotransmitters in the subcortical structure of the brain could also influence the manifestation of epilepsy following electrical stunning. For example, noradrenaline and dopamine are present in abundance in the brain stem. Noradrenaline release could enhance the glutamate-induced excitation (Radisavljevic et al., 1994), whereas dopamine could decrease the amplitude of depolarization and action potentials induced with glutamate, i.e., it could inhibit glutamate-induced excitation. These effects have been demonstrated in mice (Cepeda et al., 1992).

However, research has also shown that some chickens fail to develop epileptiform activity in the EEG following electrical stunning with high currents (> 100 mA per bird; Gregory and Wotton, 1987) but nevertheless lose their SEP (Gregory and Wotton, 1989). This result indicates that neurotransmission can be disrupted following stunning with high currents even when epilepsy is not induced, and it can therefore be assumed that the birds are unconscious under these conditions. By contrast, when low stunning currents (< 40 mA per bird) are used, SEP could quickly return. For example, 3 out of 10 birds that were epileptic following stunning with this low current level showed recovery of SEP from the end of the epileptic phase in their EEG (Gregory and Wotton, 1989).

In recent years, new electrical stunners have been developed that use high frequencies and modified wave forms. However, the relationship between the various electrical parameters (frequency, wave forms, current levels) at stunning and the occurrence of epilepsy in the EEG are not known.

**Loss of SEP**

It should be noted that the SEP in the brain, which can be induced by stimulating a peripheral mixed nerve with a low voltage electric current, are present during anesthesia, but their absence indicates brain dysfunction. A current of greater than 120 mA per bird is required to induce a sustained loss of SEP in chickens after electrical stunning with either a 50 Hz sinusoidal AC (Gregory and Wotton, 1990a) or 350 Hz pulsed DC (Gregory and Wotton 1991a).

In the case of turkeys, currents greater than 250 mA per bird are required to abolish SEP following stunning with a 50 Hz AC (Gregory and Wotton, 1991b).

**Cardiac Arrest**

Inducing cardiac arrest at the point of electrical stunning has welfare advantages (but is not a prerequisite) in chickens, because a delay between the end of stunning and neck cutting and the efficiency of neck cutting become less important. If cardiac arrest is induced at stunning, it results in cessation of the supply of oxygenated blood to the brain. This effect would certainly eliminate the potential problem of resumption of consciousness. When a 50 Hz AC with sinusoidal wave form is used, the current necessary to induce cardiac arrest in 99% of chickens is 148 mA per bird (Gregory and Wotton, 1987). More recent research into the electrophysiology of chickens also shows that a current of greater than 120 mA is required to induce cardiac arrest and also abolish SEP following stunning in the majority of birds (Gregory and Wotton, 1990a).

In the case of turkeys, Schütz-Abraham et al. (1983), using a multiple-bird stunner, reported a 90% incidence of cardiac arrest with 175 mA for toms and 157 mA for hens. However, Gregory and Wotton (1991b), using a constant current single-bird stunner, found that 198 and 250 mA per turkey was needed to achieve cardiac arrest in 90 and 100% of birds, respectively. A major welfare concern with the turkeys is that the current required to induce cardiac arrest is less than the current required to disrupt brain responsiveness. For example, Gregory and Wotton (1991b) found that 4 out of 11 turkeys, although suffering cardiac arrest after stunning with a 250 mA current, retained SEP for a considerable time (1 min) following electrical stunning. It seems very likely that SEP were abolished in these birds, not by stunning per se, but by the anoxia induced in the brain by the cardiac arrest. This view is supported by the fact that visual evoked potentials (VEP) were present in anesthetized turkeys for 64 and 90 s following severance of both of the carotid arteries and the induction of cardiac arrest with intrathoracic needle electrodes, respectively (Gregory and Wotton, 1988). It should be noted that the absence of SEP indicates brain dysfunction, whereas the absence of VEP indicates brain death. Therefore, it is apparent that the humanitarian advantages of inducing cardiac arrest at stunning are less pronounced in turkeys than in chickens. Current levels higher than 250 mA, which would abolish SEP following electrical stunning, need to be established for turkeys. From the welfare point of view, head-only stunning of turkeys using 400 mA per bird followed by neck cutting within 15 s seems to be the best option (Gregory and Wotton, 1991b). However, this high an amperage may not be feasible under commercial conditions with high throughput rates.

A commercial disadvantage of using conventional water bath stunners (delivering 50 Hz AC) is that, at
currents greater than 105 mA per chicken and 150 mA per turkey, there is an increase in the incidence of hemorrhaging in the breast and leg muscles, broken bones in the carcass, and the appearance of carcass downgrading conditions (Gregory and Wilkins, 1989a, b). Therefore, these current levels have been recommended as acceptable for these two species (Gregory and Wotton, 1989, 1991b), although they are lower than those found to be ideal as determined by loss of SEP following stunning. Nevertheless, stunning chickens with 105 mA per bird induces cardiac arrest in about 80% of birds (Gregory and Wotton, 1989) and provides at least 52 s of apparent insensibility (based on the time to return of neck tension) in the unfibrillated birds (Gregory and Wotton, 1990a). This time to return of neck tension using the water bath electrical stunning system is twice as long as the time to return of neck tension (26 s) after head-only stunning of chickens with a hand-held stunner delivering 336 mA for 7 s (Gregory and Wotton, 1990b). This difference could be due to the fact that electrical current flows through the whole body of chickens in a water bath and this could result in longer time to recovery of neuromuscular tone. Therefore, the longer period of stun (based on the time to recovery of muscle tone) achieved with a water bath could be an apparent rather than a real effect (Gregory and Wotton, 1990b).

Stunning turkeys with 150 mA per bird induces cardiac arrest in about 97% of birds (Gregory and Wotton, 1991b); however, the duration of apparent insensibility induced with this current in nonfibrillated turkeys is not known. Because a considerable proportion of chickens and turkeys would not suffer cardiac arrest at stunning with 105 and 150 mA, respectively, they would have to be bled immediately to induce anoxia in the brain. Prompt ventral neck cutting aimed at severing both the carotid arteries is therefore essential to ensure humane slaughter.

A practical problem with the conventional electrical water bath stunning system is that the electrical impedance varies considerably between birds and therefore it is not always possible to deliver exactly the current required to induce cardiac arrest in each individual bird using a constant voltage stunner. However, a water bath stunner that can deliver a preset constant current to each bird in the water bath has been developed recently (Sparrey et al., 1993), and this improvement could enhance bird welfare.

The conflict between welfare and meat quality with a conventional electrical water bath stunning system using 50 Hz AC has provided the incentive for further developments in the area of stunners using high frequencies (>100 Hz, AC or pulsed DC) and modified wave forms (e.g., fractional sine wave, full wave rectified, square wave). It is likely that currents of different frequencies and wave forms have different dose responses in terms of disrupting brain function or inducing cardiac arrest in birds, and these require investigation to establish acceptable minimum currents.

The major welfare concern is that, although a sufficiently high current (e.g., a constant current of 105 mA per bird) delivered with high frequency electrical stunners (>100 Hz) in a water bath could induce a satisfactory stun, it also reduces the prevalence of cardiac arrest in birds. Therefore, high frequency electrical stunning, irrespective of the wave forms, requires a prompt severance of both the carotid arteries supplying blood to the brain to cause rapid death through blood loss. Failure to sever the two carotid arteries could result in the unacceptable resumption of consciousness during bleeding.

The required duration of insensibility produced with high frequency electrical stunning systems should be the sum of the time from the end of stunning to neck cutting and the time it would take for brain failure to occur through blood loss. Different neck cutting methods could also influence the time to onset of brain failure through bleeding. It is therefore necessary to establish these parameters for all novel electrical stunning systems.

**Problems Associated with Electrical Stunning**

Electrical water bath stunning systems require the uncrating and shackling of live birds prior to stunning. It is likely that these handling procedures impose a considerable stress on the birds, particularly turkeys because of their large size. Besides this inevitable stress, there are other welfare concerns with existing electrical stunning systems that need to be addressed. Firstly, prestunning electric shocks can occur if the birds’ wings make contact with the water bath before their heads do. Once again, this is more of a potential problem with turkeys than with chickens. This problem occurs because the wings of turkeys hang lower than their heads when they are hung inverted from the shackle. A survey of turkey processing plants in the U.K. showed that birds at five of the six plants and, on average 43% (range = 0 to 87%) of all birds, received prestun electric shocks (Wotton and Gregory, 1991). Three methods of reducing this potential welfare problem have been tried, either singly or in combination under commercial conditions. Firstly, the shackle line is dipped downwards at 17 to 19° at the entrance of the stunner. Secondly, the entrance to the stunner is isolated from the rest of the stunner, which is electrically live, using a perspex overlay with spacer washers between it and the original ramp of the stunner. The third method involves an infrared sensing device that detects the presence of a bird in the right position at the entrance to the water bath and switches on the stunning current for a preset duration. This system would only work efficiently in single-bird water bath stunners. In spite of these developments, a considerable proportion (6%) of turkeys still receive prestun electric shocks (Wotton and Gregory, 1991).

**GAS KILLING OF POULTRY**

**Potential Advantage and Problem of Gas Killing**

Considering the stress associated with the handling of poultry prior to electrical stunning, the Farm Animal...
Welfare Council in the U.K. suggested that research should be carried out to test the suitability of using carbon dioxide for stunning poultry while they are still in their transport containers.

Although there is no doubt that this method of slaughtering poultry would eliminate some of the welfare problems associated with the electrical stunning, it is important that the induction of anesthesia with the stunning gas or gas mixture itself should not be aversive to the birds, and that the induction of anesthesia should also be rapid. A potential problem is that birds tend to regain consciousness rapidly on exit from the gaseous atmosphere unless they have been killed. For example, broiler chickens that were not killed with either anoxia or 45% carbon dioxide in air responded to a comb pinch as early as 15 and 26 s, respectively, after returning to atmospheric air (Raj and Gregory, 1990). Therefore, in order to fully attain the welfare benefits of this novel system under practical conditions, birds in transport containers should be killed with the gas rather than just stunned.

**Stress of Induction of Anesthesia**

Carbon dioxide is an acidic gas and is pungent to inhale at high concentrations. It is also a potent respiratory stimulant that can cause breathlessness before the loss of consciousness. The welfare implication of this is that birds could experience unpleasant sensations either during initial inhalation of carbon dioxide or during the induction phase. This was illustrated by unpublished observations made on hens and turkeys. It was found that 3 out of 8 hens and 6 out of 12 turkeys tested showed aversion to entering a feeding chamber to obtain feed and water when it contained 47 and 72% carbon dioxide in air, respectively. By contrast, when argon with less than 2% oxygen was present all the hens (6 out of 6) and 11 out of 12 turkeys tested entered spontaneously and were killed with the gas. Similarly, a majority of the turkeys (>80%) did not show an aversion to entering a chamber to obtain feed and water when it contained a mixture of 30% carbon dioxide and 60% argon in air.

These studies clearly indicated that the chickens and turkeys can detect the presence of a high concentration of carbon dioxide and, given a free choice, will avoid it. However, presumably because argon is an inert gas with no taste or odor, the birds did not detect it or feel any unpleasant sensations during the induction of anesthesia with this gas. Although gasping and head shaking behaviors are also exhibited during the inhalation of 30% carbon dioxide in comparison with higher concentrations of carbon dioxide, these behaviors appeared to be less severe. From the results of the study involving turkeys, it appears that any discomfort associated with the induction of anesthesia with 30% carbon dioxide in argon was either tolerated by the birds or led to a rapid loss of consciousness before the birds could react to the presence of this gas mixture. Human experience with the inhalation of various concentrations of carbon dioxide also showed a low level of pungency and breathlessness induced with 30% carbon dioxide (Gregory et al., 1990). By implication it is suggested that, on welfare grounds, either 90% argon in air or a mixture of 30% carbon dioxide and 60% argon in air is acceptable for killing poultry.

**Time to Loss of SEP**

The rates of induction of anesthesia with the various gases were determined from the time to loss of SEP during stunning. The mean (± SE) times to loss of SEP in chickens (culled hens) during exposure to anoxia and the carbon dioxide-argon mixture were 29 (2) and 19 (2) s, respectively (Raj et al., 1992). In the case of turkeys, the corresponding times were 44 (6) and 22 (2) s, respectively (Raj and Gregory, 1994). These results showed that the carbon dioxide-argon mixture is more rapid than anoxia alone in achieving loss of brain function in both chickens and turkeys. However, turkeys’ brains appear to be relatively more tolerant of anoxia than chickens’ brains. The mean time to loss of SEP during exposure of turkeys to argon-induced anoxia was shorter than the time to loss of VEP after severance of both the carotid arteries (64 s) or after cardiac arrest induced with the intrathoracic needle electrodes (90 s) in anesthetized turkeys (Gregory and Wotton, 1988).

In terms of rate of induction of anesthesia based on the time to loss of SEP, the use of carbon dioxide for killing chickens seems to have no welfare advantage over using either 90% argon in air or 30% carbon dioxide and 60% argon in air. For example, the time to loss of SEP during exposure to 45% carbon dioxide was found to average 30 s (Raj et al., 1990). Increasing the concentration of carbon dioxide from 45 to 65% in air resulted in a reduction of only 3 s in the time to loss of posture, a behavioral indicator of onset of unconsciousness (Raj and Gregory, 1990).

In the case of turkeys, the times to loss of SEP during exposure to 49, 65, or 86% carbon dioxide in air were 20, 15, and 21 s, respectively (Raj and Gregory, 1994). These times were not significantly different from the time to loss of SEP during exposure to the carbon dioxide-argon mixture. Although the time to loss of SEP is twice as long during exposure to 90% argon in air as compared to a high concentration of carbon dioxide in air, the induction of anesthesia with argon appeared to be smooth and the birds did not exhibit any signs of respiratory distress. The respiratory discomfort that occurs with the 30% carbon dioxide in argon is likely to be less stressful than that which occurs with a high concentration of carbon dioxide in air, as indicated by the behavioral studies.

Commercial studies have shown that turkeys can be killed with argon or the carbon dioxide-argon mixture with substantial improvements to carcass and meat quality (Raj, 1994). Turkeys killed with the gases, in comparison with electrical stunning using 50 Hz sinusoidal AC, showed a very low prevalence of carcass
downgrading conditions and hemorrhaging in breast muscles.

Based on this evidence, commercial killing of chickens and turkeys using either 90% argon or other inert gases in air or a mixture of 30% carbon dioxide and 60% argon or other inert gases in air has been approved in the U.K.

REFERENCES


