Welfare assessment of Low Atmospheric Pressure Stunning (LAPS) in chickens

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What is Low Atmospheric Pressure stunning (LAPS)?

- Novel approach to pre-slaughter stunning (developed in the U.S.)
- Renders birds unconscious by progressive hypobaric hypoxia
- LAPS involves gradual decompression (280s cycle) according to a prescribed curve, which is temperature dependent.

Proposed as a new alternative to controlled atmosphere stunning (CAS) systems, whilst sharing many of its welfare advantages (e.g. reliable irreversible stunning and no shackling or loading/unloading of birds while conscious).

- US Department for Agriculture, 2010
- Canadian Food Inspection Agency, 2013
- AVMA, 2016
Objectives

• Trial 1: Behavioural, brain and cardiac responses to LAPS in broiler chickens
  - 1\textsuperscript{st} Aim: Examine broiler responses to LAPS through behavioural, electroencephalogram (EEG) and electrocardiogram (ECG) recordings.
  - 2\textsuperscript{nd} Aim: Effect of 2 temperature settings on broiler responses to LAPS.

• Trial 2: Effects of light on responses to LAPS in broiler chickens
  - Effect of illumination and sham treatment on broiler responses, through behavioural, electroencephalogram (EEG) and electrocardiogram (ECG) recordings.
Methods – Trial 1

Behavioural, brain and cardiac responses to LAPS in broiler chickens

- 2 temperature settings: TS3 (13-18ºC); TS4 (5-12ºC)
- 30 triplets of Cobb 550 male broilers at 38-39d of age (mean weight 2.4 ± 0.4kg)
- 16 triplets assigned to TS3 and 14 triplets to TS4 (weather dependent).
- In each triplet, one bird was instrumented for recording of EEG (i.e. electrical brain activity) and ECG (heart rate) responses:
  - Birds were surgically implanted (under general anaesthetic) with EEG electrodes onto the surface of birds’ skulls with two bi-polar wires inserted through the skull to sit on the dura above each hemisphere. Birds given 4d recovery post-surgery. (Lowe et al 2007; Coenen et al 2009, McKeegan et al 2011; Martin et al 2016).
  - Birds were instrumented EKG self-adhesive electrodes on the pectoralis muscle and with custom-made telemetry logging devices inserted into lycra harnesses.
  - 2 minute baseline recordings for both EEG and ECG were taken pre-LAPS.
- Behaviour (e.g. LOP, ataxia, etc.) of all birds was recorded via an infra-red camera within the LAPS chamber.

All work conducted under EU Directive 2010/63 and authorized by the University of Arkansas Institutional Animal Care and Use Committee.
Methods – Trial 1
Behavioural, brain and cardiac responses to LAPS in broiler chickens

EEG analysis: power spectra for each consecutive “artefact free” 2s epoch using Fast Fourier Transform (FFT) algorithm (1024, Hanning window, resolution 0.976 Hz bins – Spike 2), for 2 min baseline and 280s LAPS cycle.

State Key spectral ranges
Non-responsive F50 < 12.7Hz
General anaesthetic plane F50 < 6.8Hz
Isoelectric (brain death) PTOT < 170mv;
F50 > 22Hz

(Sandercock et al 2014; Martin et al 2016a, 2016b)

Linear interpolation filtering applied
(Martin et al 2016a, 2016b)
# Results – Trial 1

**Behavioural, brain and cardiac responses to LAPS in broiler chickens**

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>TS3 (13-18°C)</th>
<th>TS4 (5-12°C)</th>
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</thead>
<tbody>
<tr>
<td>Mandibulation</td>
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<td>Ataxia*</td>
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<td>Head-shake</td>
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<td>LOP***</td>
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<td>Clonic convulsions</td>
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<td>LOJ**</td>
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<tr>
<td>Motionless*</td>
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</table>

- **Slow-wave (Non-R)**
- **Slow-wave (GA plane)**
- **Isoelectric (brain death)**
- **Bradycardia***

**Time (s)**: 0, 60, 120, 180, 240, 300

**END of LAPS**
Summary – Trial 1

Behavioural, brain and cardiac responses to LAPS in broiler chickens

- Temperature effects for key behavioural latencies indicating unconsciousness, with shorter latencies at colder temperatures.
- No temperature effects on EEG indicators of loss of consciousness or brain death.
- Temperature effect for latency to bradycardia, with shorter latencies at colder temperatures.
- Collectively all measures indicate complete loss of consciousness displayed in all birds by 70s (mean 59.2s) and brain death by 140s (mean 87.7s).
Methods – Trial 2
Effects of light on responses to LAPS in broiler chickens

- 2x2 factorial design: LAPS/dark, LAPS/light, SHAM/dark, and SHAM/light
- All LAPS cycles at TS4 only
- 20 pairs of Cobb 550 male broilers at 44-45d of age per treatment (mean weight 3.0 ± 0.4kg)
- In each pair, one bird was instrumented for recording of EEG (i.e. electrical brain activity) and ECG (heart rate) responses.
- Behaviour (e.g. LOP, ataxia, etc.) of all birds was recorded via an infra-red camera within the LAPS chamber.

All work conducted under EU Directive 2010/63 and authorized by the University of Arkansas Institutional Animal Care and Use Committee.
Results – Trial 2 (sham effects)

Effects of light on responses to LAPS in broiler chickens

• In **SHAM** treatments birds:
  - displayed “conscious” behaviours (e.g. stand/sitting) and did not display LOP, ataxia or motionless.
  - displayed sleep-like EEG waveforms (illumination***)
  - bradycardia and brain death absent
### Results – Trial 2 (Illumination effects)

Effects of light on responses to LAPS in broiler chickens

<table>
<thead>
<tr>
<th>Time</th>
<th>Mandibulation</th>
<th>Ataxia</th>
<th>Head-shake</th>
<th>LOP</th>
<th>Clonic convulsions</th>
<th>LOJ</th>
<th>Motionless</th>
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<tbody>
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</table>

- ○ Slow-wave (Non-R)**
- ● Slow-wave (GA plane)***
- ○ Isoelectric (brain death)**
- ▲ Bradycardia

GLMM analysis
Summary – Trial 2
Effects of light on responses to LAPS in broiler chickens

• Sham effects for key behavioural latencies indicating loss of consciousness and bradycardia, with neither observed in sham treatment birds.
• Illumination effects in sham treatments, with birds in the dark displaying sleep-like EEG waveforms earlier and for longer periods.
• During LAPS, illumination had no effect on key behavioural latencies indicating loss of consciousness or latency to bradycardia.
• Illumination effects for EEG spectral latencies within LAPS, with shorter latencies observed in the dark compared to the light.
• Collectively all measures indicate complete loss of consciousness displayed in all birds by 60s (mean 55s) and brain death by 180s (mean 95s).
Overall conclusions

• Consistent sequence of behaviours in LAPS: ataxia, loss of posture, clonic/tonic convulsions and motionless
• Maintenance of slow-wave EEG patterns in the early part of LAPS (while birds are still conscious) is strongly suggestive that LAPS is non-aversive.
• Effects of LAPS/sham primarily related to the presence/absence of hypoxia
• Recommendation that LAPS is carried out in darkness, as is currently the case commercially.
• Collectively, these results add to a growing body of evidence that behavioural and EEG responses to LAPS are consistent and indicative of a process that is largely equivalent to controlled atmosphere stunning with anoxic gases.
• This evidence has recently been presented to EFSA to facilitate approval of the method in the EU regulatory framework.
Acknowledgements

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Questions?