

What's new in stunning technologies?

Alison Small 24 October 2019

AGRICULTURE & FOOD www.csiro.au



New???



Stunning technology is reasonably 'new'

Pre-1900s



Source: Food Inspection (McEwen, 1922)

1920s



Source: Food Inspection (McEwen, 1922)

1920s - 30s



Source: CSIRO

1930s







Source: CSIRO



Source: MLA



Lots of recent activity 1990s to date



Istituto "G. Caporale" Teramo - Via Campo Boario - 6410 *Corres

*Corresponding author: schilling@foodscience.msstate.edu



This presentation

- *Is* about:
 - Published findings in the past 5 years
 - Stunning technologies and equipment
 - Refinements to existing methods
 - Understanding more deeply factors affecting efficacy
 - Emerging technologies
- Is not about
 - Policy and opinion
 - The unstunned slaughter debate
 - Physiology and behaviour



Mechanical stunning



Optimal positioning

HIGH

A slightly higher application point has greater chance of damaging the brainstem

LOW





LOW shot position (left) denoted as the intersection of two lines drawn from the medial canthus of each eye to the opposite horn or top of the opposite ear. HIGH shot position (right) denoted as a point on midline halfway between the top of the poll and a line drawn between the lateral canthus of each eye.

> 24 months

6 - 24 months

< 1 month

• Gilliam et al. 2016



Comparison of penetrative, percussive and nonstun

- Gibson et al 2019
 - 30 mo Bulls
 - Penetrative stunned 20/20
 - Percussive stunned 8/11



- Zulkifli et al 2014
 - EEG suppression most pronounced in penetrative stun
 - Blood volume collected greatest with thoracic stick



Figure 2: Blood weight collected at sticking (as a percentage of liveweight).



Non-penetrating mechanical stun

- Very important in Australian industry halal acceptance
- EU only permitted for animals under 10kg
 - European in-plant surveys showing efficacy rates as low as 64% in grown livestock
 - Australian plants target 95-98% as a KPI
 - Why the difference?



Mechanical stunning of buffalo

- High power ballistic is effective at frontal position
 - New .357 Magnum hollow point device





Source: Meichtry et al. 2018

- Occipital/poll position for captive bolt
- Challenge:
 - Halal compliance
 - SE Asia







Source: AgriFutures Australia Ltd / CSIRO project. "Developing Appropriate Stunning Methods for Halal Slaughter of Water Buffalo"





Electrical stunning



High frequency electrical stunning

- Reduction in blood splash
- Reduction in clonic activity
 - Short pulse durations (100 μs) of 2000 Hz can reduce post-stun movement while minimising impact on pH decline
- Head-to-back HFES
 - Effective stun
 - Maintained cardiac function
 - Reduced clonic activity
 - Potential halal acceptability

(refs: Simmons et al. 2006; Farouk 2013; Sabow et al. 2017; Sabow et al. 2018)







Controlled Atmosphere



The gas controversy

- Is it humane?
 - Reports of aversive reactions to CO₂
 - Gasping, escape attempts
 - 37 sec till collapse
 - But other studies find no such responses.
 - Why?
 - Rate of increase in CO₂ concentration?
 - Genetics?
 - Something else?
- Recent research has focused on improved methods
 - Gas mixtures
 - Gas immersion parameters, e.g. multi-stage CAS systems for poultry



CAS in ruminants

- Rodriguez *et al.* 2015
 - Lambs showed head shaking and sneezing at 10 s;
 - Unconscious for 124 s (90% CO₂)
- Millman *et al.* 2015
 - Goat kids tolerated 20-30% CO₂ (n=12)
 - Loss of posture occurred between 87 and 271 s of exposure
- Kim et al 2013
 - Cattle 620-790 kg (A –lighter, B heavier)
 - 70% CO₂ for 140 sec
 - Compared against captive bolt
 - lower pH, lighter colour,
 - lower shear force in heavy cattle



Source: Kim et al. 2013

A- 620-710 kg B- 720-790 kg









LAPS

- Concept based on altitude hypoxia
 - O₂ concentration is reduced at altitude
 - Leads to dizziness and fainting
- Controlled decompression over 280 s
 - 80.6 kPa less than atmospheric air
- Open bill breathing seen at 44-57 s
- Loss of posture at 63-97 s
- Convulsions 53-147 s later
- Motionlessness at 178-222 s

Birds entering the chamber



Birds exiting the chamber





LAPS

- Successful in broiler slaughter
- What about other species?
 - Pigs?
 - Bobby Calves?
- What about on-farm disposal
 - Unwanted piglets
 - Poultry
 - Disease outbreaks?





On the horizon



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SPUC

- Pulsed ultrahigh current (5000 V, 70A)
- 38 cattle successfully stunned
- Unconsciousness lasted up to 4 min
- Elimination of clonic phase



Source: Robins et al. 2014

• Research continuing in Europe





DTS: Diathermic Syncope[®]

- Electromagnetic energy (922 MHz)
 - Focused into the brain
 - Volumetric heating

- Induced Hyperthermia
 - Above 43° C
 - Below 50° C



Fig. 1. Schematic diagram of cadaver experiment showing position of wave-guide and thermoprobes.

McLean, D., Meers, L., Ralph, J., Owen, J.S. & Small, A. 2017. *Res. Vet. Sci.*, 112, 13-17.



Fig. 3. Temperature change in cattle heads during microwave energy application (mean data from 12 cadaver heads treated at 922 MHz).



DTS: Diathermic Syncope[®]



Source: Advanced Microwave Technologies



Step 1: Anaesthetised cattle trials

- 10 anaesthetised cattle
- All applications resulted in seizurelike EEG
- EEG suppressed for 37 s to 162 s



Total EEG power (top: arbitrary units), 95% spectral edge (middle, Hz units) and median frequencies (bottom; Hz units) derived from the EEG frequency spectra of animal six, receiving 20 kW for 10 s. The time of microwave application is indicated by the black vertical line, the horizontal bar represents a 1-min duration. A low pass filter has been applied to the traces (ten-point moving average) to make them easier to interpret visually.

Rault, J.L., Hemsworth, P.H., Cakebread, P.L., Mellor, D.J. & Johnson, C.B. 2014. *Animal Welfare*, 23, 391-400.



Step 2: Pilot study on conscious animals

- 18 Aberdeen Angus cross bred heifers (350-400 kg lwt)
- DTS induced insensibility:
 - EEG suppression for 3-4 minutes.
- DTS animals remained unresponsive to stimuli:
 - No evidence of the eye beginning to focus and follow movement for 3-4 minutes post energy application;
- DTS animals maintained rhythmic breathing and a strong heart beat throughout the period of insensibility;
- Two animals showed evidence of return to consciousness, including the righting reflex, after around 4 minutes







Total EEG power (top; arbitrary units), 95% spectral edge (middle, Hz units) and median frequencies (bottom; Hz units) derived from the EEG frequency spectra of animal six, receiving 20 kW for 10 s. The time of microwave application is indicated by the black vertical line, the horizontal bar represents a 1-min duration. A low pass filter has been applied to the traces (ten-point moving average) to make them easier to interpret visually.



Meat quality attributes?

- DTS produces comparable endocrine responses in cattle to those stunned using captive bolt.
- DTS produces comparable post slaughter meat quality in beef carcases to those stunned using captive bolt.



Source: CSIRO

- No evidence of blood splash
- No significant differences in:
 - pH decline Shear force Drip loss Colour Lipid oxidation ACTH Cortisol Catecholamines β-endorphin





Roll-out conveyor

DTS control station



04/10/2017 09:38,30

Head captured for EEG recording

Animal in restraint box



Water reservoirs to absorb any leaked energy

04/10/2017 09

Nose comforter

.....

03/1

NAME OF COMPANY

Waveguide (retracted)

2

HAB 20

More to come

- Another 200 data sets collected and in pre-analysis phase
 - Consistent induction of insensibility
 - Duration of insensibility between 3 and 5 minutes
 - Use of reflexes to assess unconsciousness
 - Evidence of recoverability observed (righting reflex and visual awareness) Comparison with head-only electrical stunning (literature)

	Electrical stunning	DTS
Time from application to loss of posture	4 – > 20 s	1 – 8 s
Time from loss of posture to return of reflexes	31 – 90 s	100 – 170 s



Thank you

Alison Small Principal Research Scientist

t +61 2 6776 1435

e alison.small@csiro.au

w https://people.csiro.au/s/a/Alison-small



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