Stunning of Poultry
WPC 2000
Gas Stunning and Its Effect on Animal Welfare
GPC 2002

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Presentation Area of Focus

- transport
- unloading
- shackling
- **stunning**
- **neck cutting**
- **bleeding**
  - electrical stimulation
- scalding

2.5 to 5 minutes

< 2 minutes
Stunning

- Topical overview -

- Historical & Modern perspectives
- General concepts
- Welfare
- Electric or Gas
- Recent developments
Stunning
- Historical perspective -

- Initially Human welfare concerns working with large animals (concussion)
- Humane Slaughter Act - 1958 US
- Humane Methods of Slaughter Act - 1978 US
- Slaughter of Poultry Act - 1967 UK
Stunning
- Historical perspective -

Automated stunning of poultry -1943
1. Render animals insensible to pain prior to bleeding
2. Breathing stops prior to entering scalder
3. Instantaneously rendered insensible to pain until death supervenes - EU
Stunning
- Historical perspective -

-Why stun poultry at all?

1. Facilitates automated killing systems
2. Minimizes carcass damage (No stun)
3. Human welfare
4. Animal welfare concerns
Stunning
- Modern perspective -

- Greatly increased importance of Animal Welfare issues
  - Public policy / regulations / market demands
- Stunning current impacts carcass damage
  - Hemorrhages & broken bones
Stunning
- Modern perspective -

• Current alternative stunning systems
  – Electrical
    • AC / DC, frequency, current, stun-to-kill
  – Gas (chemical)
    • Carbon dioxide, argon
  – Mechanical (concussion)
Stunning
- General concepts -

• Renders the animal unconscious
  – Reduced unconscious muscular activity
  – Malleable for automation

• Recoverable - “stunning”

• Unrecoverable - “killing = electrocution”
Stunning
- General concepts -

- Disrupts brain function - cerebral cortex
  - Loss of consciousness
  - Loss of ability to perceive pain

- Recoverable - temporary short circuit
- Unrecoverable - permanent damage
Stunning
- Requirements -

- Time onset - “instantaneous”
  - Hard to define
- Duration - sufficient that animal does not regain consciousness prior to death
Stunning
- Requirements -

• Zero tolerance for missed birds
• **Must be humane**
  For the animal and aesthetic for human
Stages of Anesthesia
- Conscious-Unconscious-Death -

1. Analgesia - Pain relief, disorientation
2. Unconscious, Delirium - Reflexes present
3. Surgical Anesthesia (4 planes)
   1. Light - Muscle relaxation
   2. Medium - Sluggish reflexes
   3. Deep - Diminished reflexes, Respiration (-)
   4. Overdose - All reflexes absent
4. Medullary Paralysis - No Respiratory, cardiac

Guedel, 1937
Electrical Stunning and Recovery

Conscious

Unconscious

Stun duration

Time

Stun
Blood Loss and Consciousness

Blood loss decreases consciousness.

Blood loss → Unconsciousness → Death

Neck cut
Proper stunning and bleeding

- Stun
- Neck cut
- Bleeding
- Death

Blood loss

Stun duration

Conscious

Unconscious
Poor stunning and proper bleeding

Blood loss

Stun duration

Conscious

Unconscious

Stun

Neck cut

Bleeding

Death
Proper stunning but poor bleeding

Blood loss

Conscious

Unconscious

Stun duration

AMI-20
Stun-to-Kill

- Blood loss
- Conscious
- Unconscious
- Stun duration

Stun | Neck cut | Death | Bleeding
Carcass muscular activity post-stun

- Blood loss
- Conscious
- Muscular Activity
- Post-stunner

- Stun
- Neck cut
- Bleeding
- Death
**Alive**

- Unconscious but able to self-resuscitate (stunned)

**Dead**

- Unconscious but unable to self-resuscitate (respiratory failure, cardiac arrest)
- Electrocution

**30 seconds to 2+ minutes**
Stunning versus Killing

- Stunning renders the animal unconscious but is recoverable.
- Status of the animal between stun and death is ambiguous, depends if “stun” is recoverable or non-recoverable.
- Stunning and killing need to be considered to be integral steps in a single process as opposed to independent operations.
Method of Slaughter - Time to Brain Functional Failure

- Cardiac arrest
- Decapitation
- Both Carotids
- One Jug. & Carot.
- Both Jugulars
- One Jugular

(From Gregory and Wotton, 1986)
Method of Slaughter - Time to Brain Functional Failure

- Cardiac arrest
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(From Gregory and Wotton, 1986)
Who’s Welfare is it?

- **Animal welfare** - what’s least traumatic or painful for the animal
- **Human welfare** - what causes the least anxiety in the consumer
- **Corporate welfare** - market viability
Animal Welfare / Humane Death

Not scientifically defined or agreed upon

• Conscious - able to perceive pain
• Unconsciousness - not able to perceive pain

Emotional, Anthropomorphic, and Aesthetic Issues (Appearance)

• Human welfare (conscience)
Electrical Stunning
- Advantages -

- Efficient
  - Quickly renders the animal unconscious and malleable for automated bleeding

- Economical
  - Low capital cost, simple, low maintenance, and low operation cost
Electrical Stunning
- Advantages -

- Fast
  - Ideal for high-speed, in-line flexible application

- Carcass and Meat Quality
  - Reduces peri-mortem struggle (death)
Electrical Stunning
- Disadvantages -

- Welfare
  - Inconsistent application
    - Variability between birds / size
  - Stun duration
    - May regain consciousness with poor bleed
- Carcass and meat damage (high current)
  - Broken bones, hemorrhages, poor bleed-out
Problems with Electrical Stunning
- Welfare Issues -

1. Failure to adequately and consistently stun the bird
2. Insufficient duration such that the bird regains consciousness
3. Undue distress relative to induction of the electrical stun

Gregory, 1989
Electrical Stunning
- European response -

• Up to 30% of birds appeared under stunned (muscular movements)
• Recommendations:
  -105-125 mA  50Hz
- Irreversible stunning = electrocution
Electrical Stunning
- European response -

- 50Hz induces ventricular fibrillation
  (cardiac arrest)
- Similar problems not present in USA
  - Different killing methods
    EU = Unilateral - one Carotid a & Jugular v
    US = Bilateral - both Carotid a & Jugular v
Electrical Stunning
- European Problems –

1. Greatly increased carcass damage
   hemorrhages, carcass and meat defects
2. Perceived conflict between Welfare and Carcass Quality
3. Therefore the need to develop alternative, welfare friendly stunning-killing systems
Alternative Stunning Systems
(alternative to high current killing)

- Modified electrical stun-killers
  - Constant current, individual bird, head only, high-frequency
- Gas - stunning and killing
  - CO$_2$, Argon/CO$_2$, CO$_2$/ O$_2$, N$_2$
- Mechanical (not common)
  - Captive bolt, compressed air
Alternative Stunning

1. Major issue in Europe due to carcass damage from high current stunning
2. Search for stunning-killing systems that are both humane and reduce carcass and meat damage
3. Comparisons therefore are most often made between high current killing to the alternative system
Alternative Stunning

Not a major issue in United States

1. No similar situations relative to under-stunned birds
2. Use of low voltage systems that do not cause excessive carcass damage
3. Use of ventral neck cut
   - Bilateral Carotids arteries & Jugulars veins
**Electrical Stunning**

- **Under stunning**
  - Increased muscular activity, carcass damage, missed neck cuts, birds entering scalder with functional brain = cadaver
- **Over stunning**
  - Electrocuted birds, slower bleed-out, carcass damage-hemorrhage and broken bones
- **Proper stunning**
  - Unconscious birds, wings tucked, easily manipulated for auto-killing, high percentage with proper neck cut, good bleed-out, reduced muscular activity
Electrical Stunning
- Developments -

• **Electrical Current**
  – AC *versus* DC
  – High current
    • “stun-to-kill” 105 to 120 mA per bird
  – Constant current

• **Frequency**
  – At both high and low current
  – CNS *versus* Skeletal & Cardiac muscle
Electrical Stunning
- Developments -

- Individual bird stunning
  - Control of current for each bird
- Head only stunning
  - Avoid carcass damage
- Low voltage stunning
  - 12 to 14 volts
- Stunning time
  - 3-5 sec. up to 12-14 sec.
Electrical Stunning
- Developments -

- Multi-stage stunning
  - Integrated 2-stage
    12 - 14 V, pulsed DC, 500 Hz, 8 - 12 sec.
    14 V, AC, 60 Hz, 2 - 5 sec.

- Post-stunning - AC
  - Primarily turkeys to improve bleed-out
Electrical Stunning
- Future improvements -

• Stunner design
  – Reduce pre-stun shock
  – Better “capture” of all bird

• Rigor development rate
  – Effect on rate and severity of rigor
    • processing efficiency
    • meat quality
Gas Stunning
- Terminology -

- Stunning *versus* killing (stun-kill)
- "modified atmosphere killing"
  (MAK)
- "modified atmosphere stunning- killing"
  (MASK)
- "controlled atmosphere” stunning
  (CA)
Gas Stunning
- Basics -

- Deprivation of oxygen to the brain
- Fine line between “stunning” and “killing”
- Good Ergonomics / Low carcass damage
- Combination of gasses available
- Costly to install and operate
- Specialized bird handling systems
Gas Stunning
- Basics -

• Typically counter flow:
  - Entrance 40% CO₂, Final 60% CO₂

• 90% Argon / 10% Air
• 60% Argon / 30% CO₂ / 10% Air
• CO₂ / O₂
Gas Stunning-Killing Systems

**System 1**  
Unloading  
Shackling  
Gas  
Neck cut  
Bleeding

**System 2**  
Unloading  
Gas  
Shackling  
Neck cut  
Bleeding

**System 3**  
Gas  
Unloading  
Shackling  
Neck cut  
Bleeding
Electrical vs. Gas Stunning
- Issues-

1. Humane slaughter
   - Welfare status **not** established for gas
   - Regulatory constraints - instantaneous?
   - Market demands - retail or fast food

2. Product quality - EU vs. US
   - Improved carcass and meat quality defects
     (compared to high current killing)
3. Worker issues
   - Worker environment: ventilation, light, etc.
   - Worker safety / ergonomics (*turkeys*)
4. Processing plant and live haul constraints
   - Additional room for gas stunning system
   - Identify DOAs
   - Throughput and line speed flexibility
   - Integrated catching through slaughter
Electrical vs. Gas Stunning
- Issues -

5. Economics
- Capital expense and operation
- Costs versus benefits?
  EU versus US very different

6. High tech versus low tech
- Complexity of gas killing systems
- Worker availability, training & skill level
- Safety
Stunning
- Recent developments -

- EEGs - Poststun
- Decapitation
EEG Pre- and Post-Stun
- Recent developments -

1. Cutaneous snap-on electrodes
   - Requires no surgery or anesthesia
2. Monitor Prestun and Poststun
3. Able to quantify time to death
EEG Characteristic waveforms

10 sec
Pre-stun

10 sec
Epileptic Waveforms

10 sec
Death
Broiler EEG 15 V ~ US
Broiler EEG 105 mV ~ EU
EEGs Post-Stun
- Future research -

1. Detection of unconsciousness?
2. Perception of pain stimuli
3. Determine optimum current & voltage for:
   - Unconsciousness
   - Minimal muscular activity
4. Evaluate Gas stunning
Stunning - Decapitation
- Recent developments -

1. Stun – Electric / Gas / Concussion
2. Immediate decapitation
Stunning - Decapitation
- Advantages -

- Instantaneous
- Not possible to regain consciousness
- No muscular or respiratory movements
- Obvious if a bird is missed
- No cadavers
Stun-Decapitation

- Stun
- Head cut
- Death
- Bleeding

Blood loss

Conscious

Unconscious

Stun duration
Stunning - Decapitation
- Advantages -

• Post decapitation
  No longer an Animal Welfare concern
Stunning - Decapitation - Impact -

- **No impact on:**
  - Bleed-out blood loss
  - Post-stun muscular activity (less)
  - Defeathering
  - Carcass quality (broken bones)
  - Meat quality (pH, color, yield, shear)

(McNeal, Fletcher, Buhr 2003)
Stunning and Killing - Summary -

- Stunning should be instantaneous
- Stunning should render the animal unconscious until death occurs
- Status of the animal between stunning and killing is ambiguous
- Stunning and killing are integral steps in a single process, not independent operations
Stunning and Killing
- Summary -

• Animal welfare issues may be more associated with system errors than the system itself:
  - Under-stunned
  - Missed or insufficient neck cut
  - Maladjusted equipment
Summary and Conclusions

• Stunning technology has advanced greatly over the past 10 years
  – Optimizing parameters for: current, voltage, frequency, duration

• Alternative systems (gas stunning)
  – Has distinct relative advantages and disadvantages

• Expect continued development and advancement in slaughter technology
Stunning Systems for Poultry

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