Meat Processing Technology

Beef Slaughter

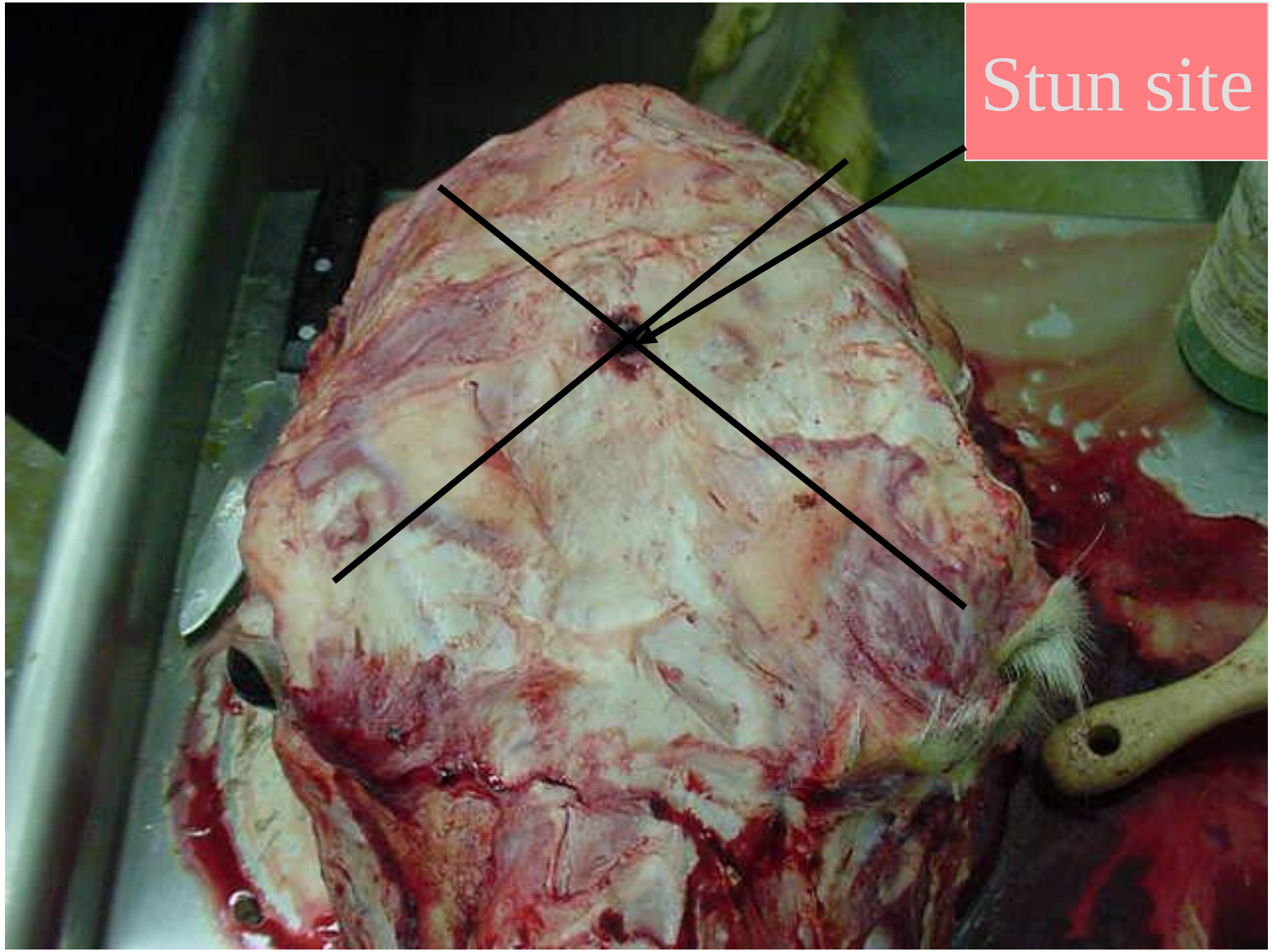
Procedures and Carcass Identification

ARI WIBOWO, Ph.D.

2022

Captive Bolt Stun Gun


Stun site


Stun site

Sticking

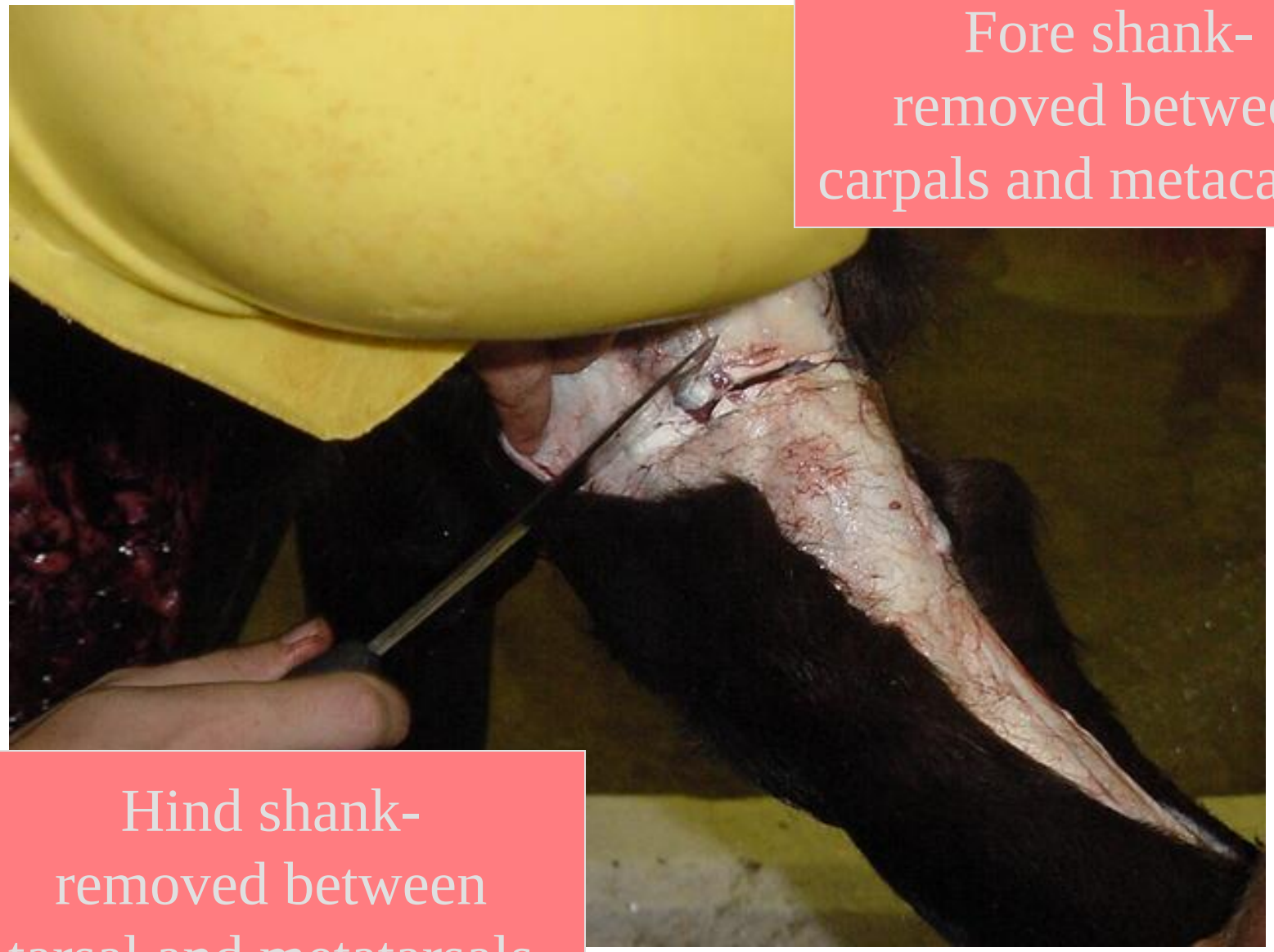
3-3.5%
of live wt.
is lost as
blood

Sticking severs
Jugular Vein
and
Carotid Artery

Removal of head between the Atlas and Axis Vertebrae


Atlas joint

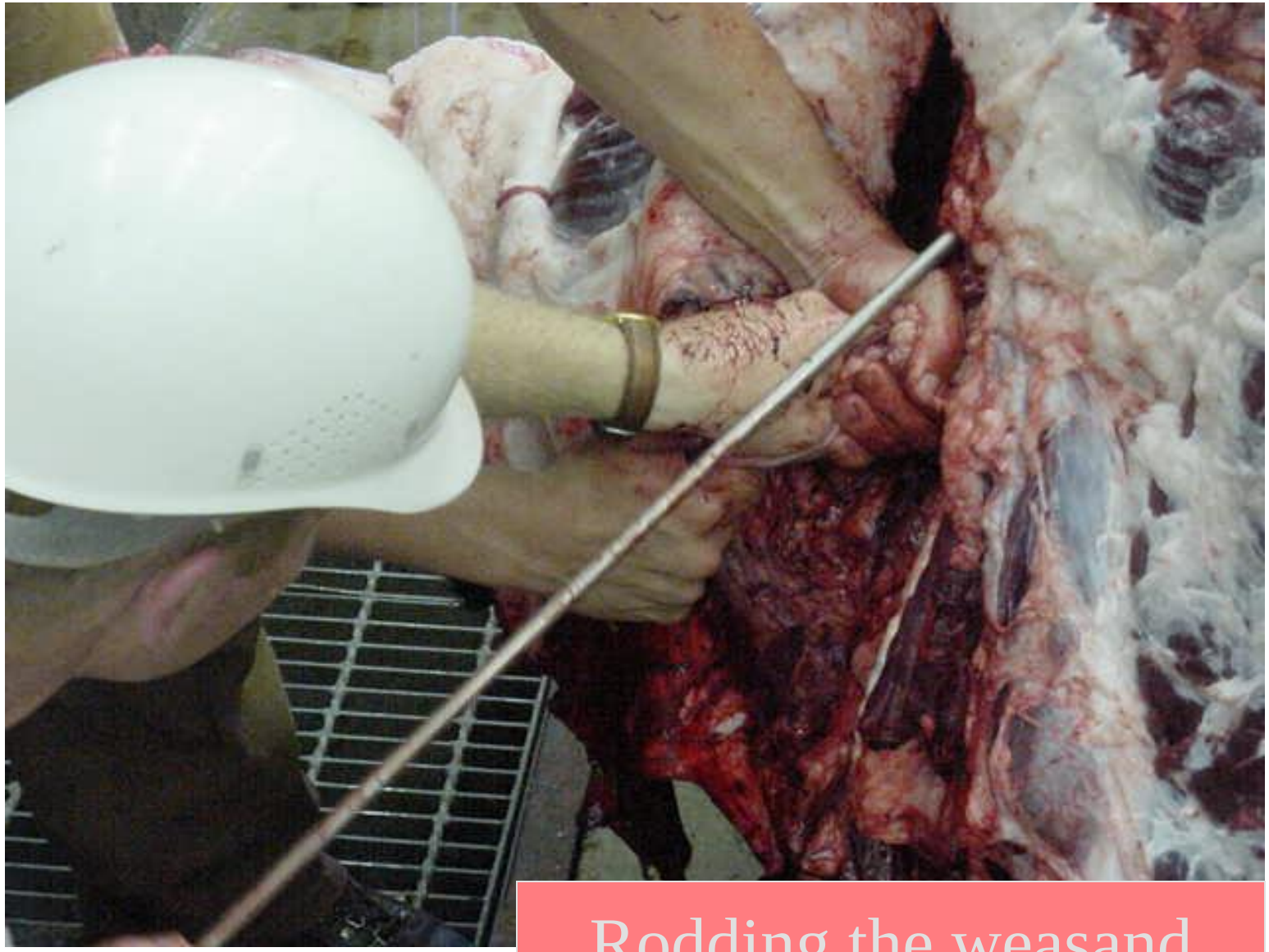
Fore shank- removed between carpals and metacarpals



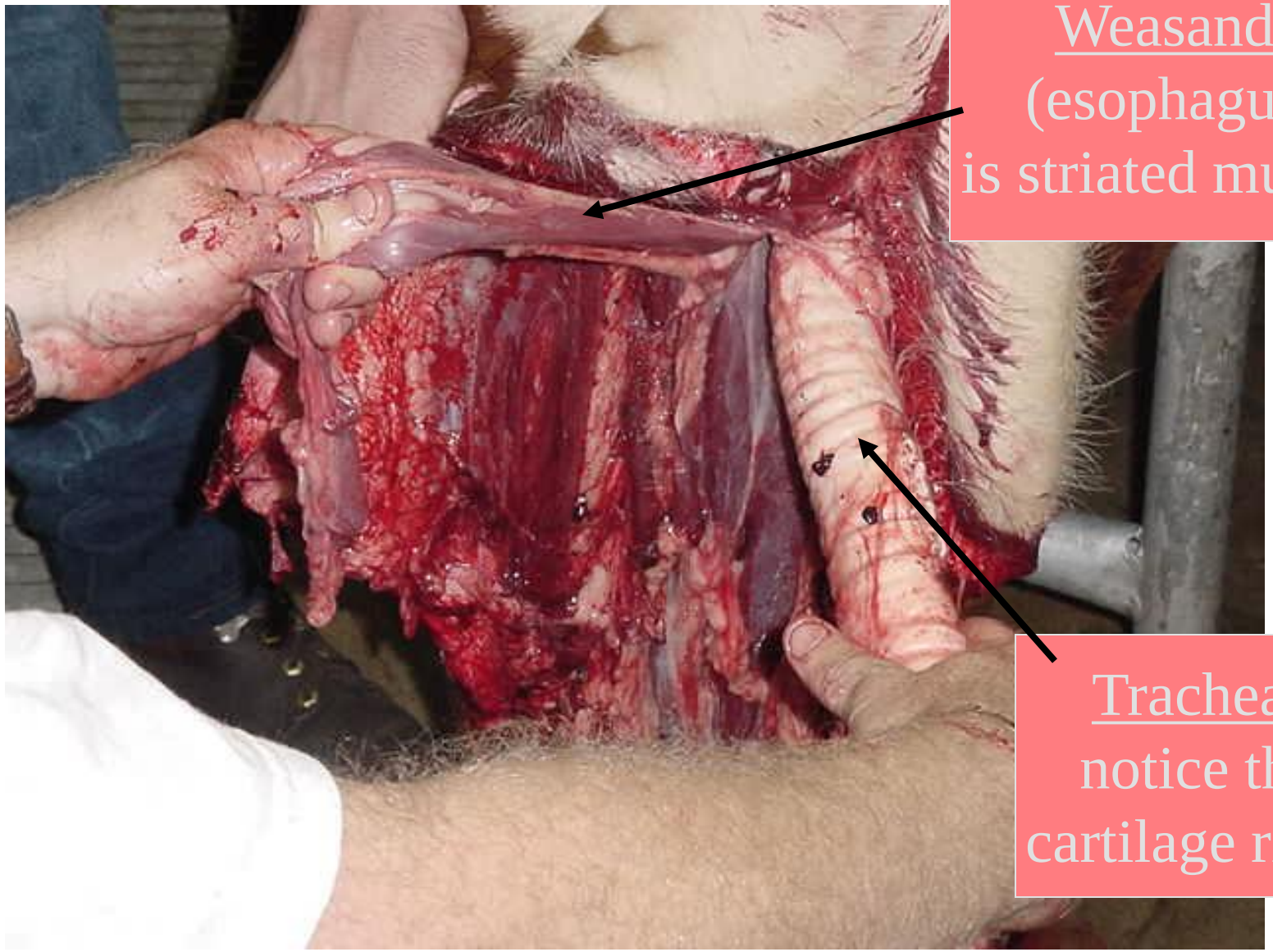
Hind shank- removed between tarsal and metatarsals

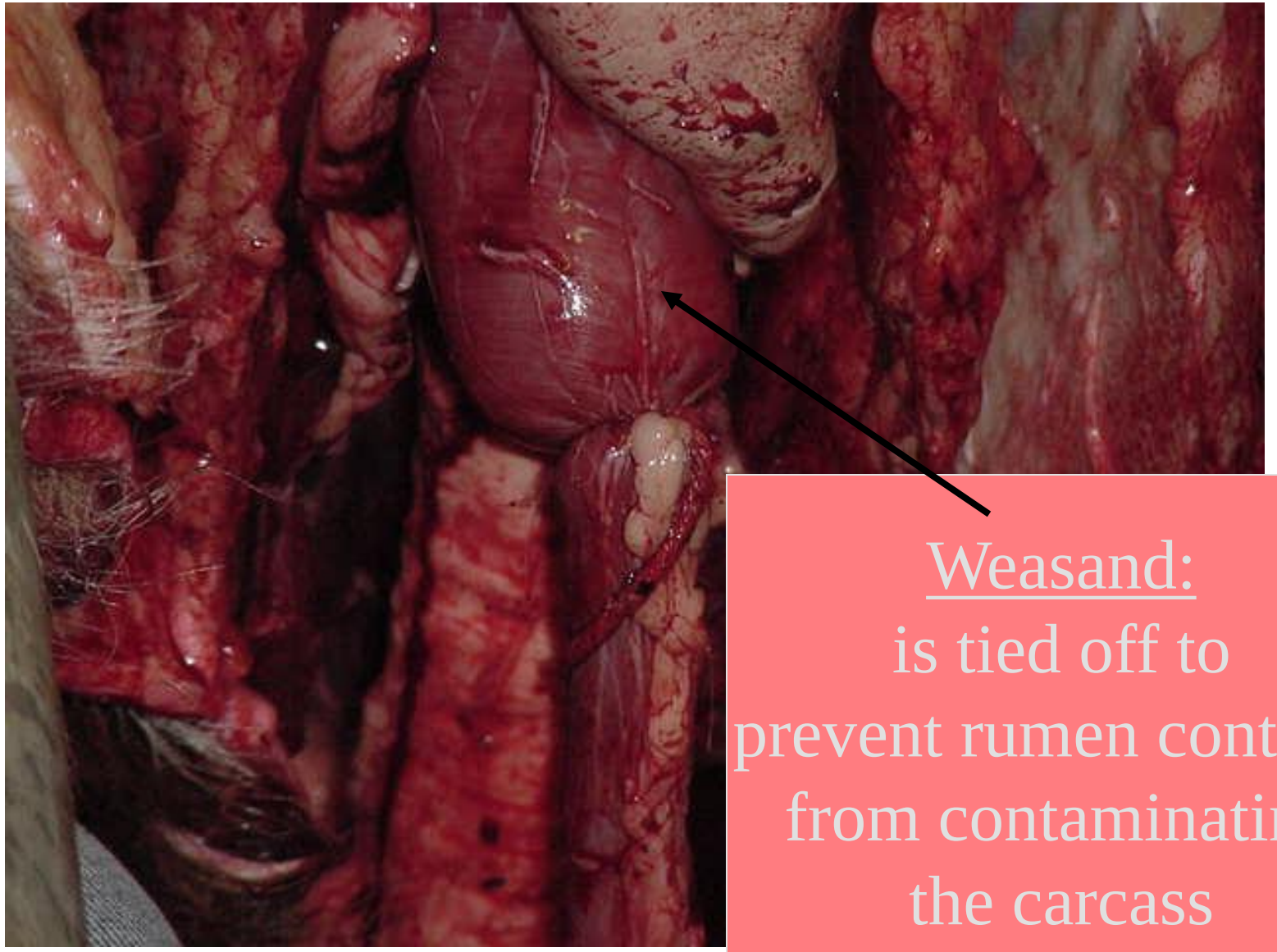
Cattle are laid in a cradle for skinning


Weasand Rod-
used to separate
the weasand from
the Trachea

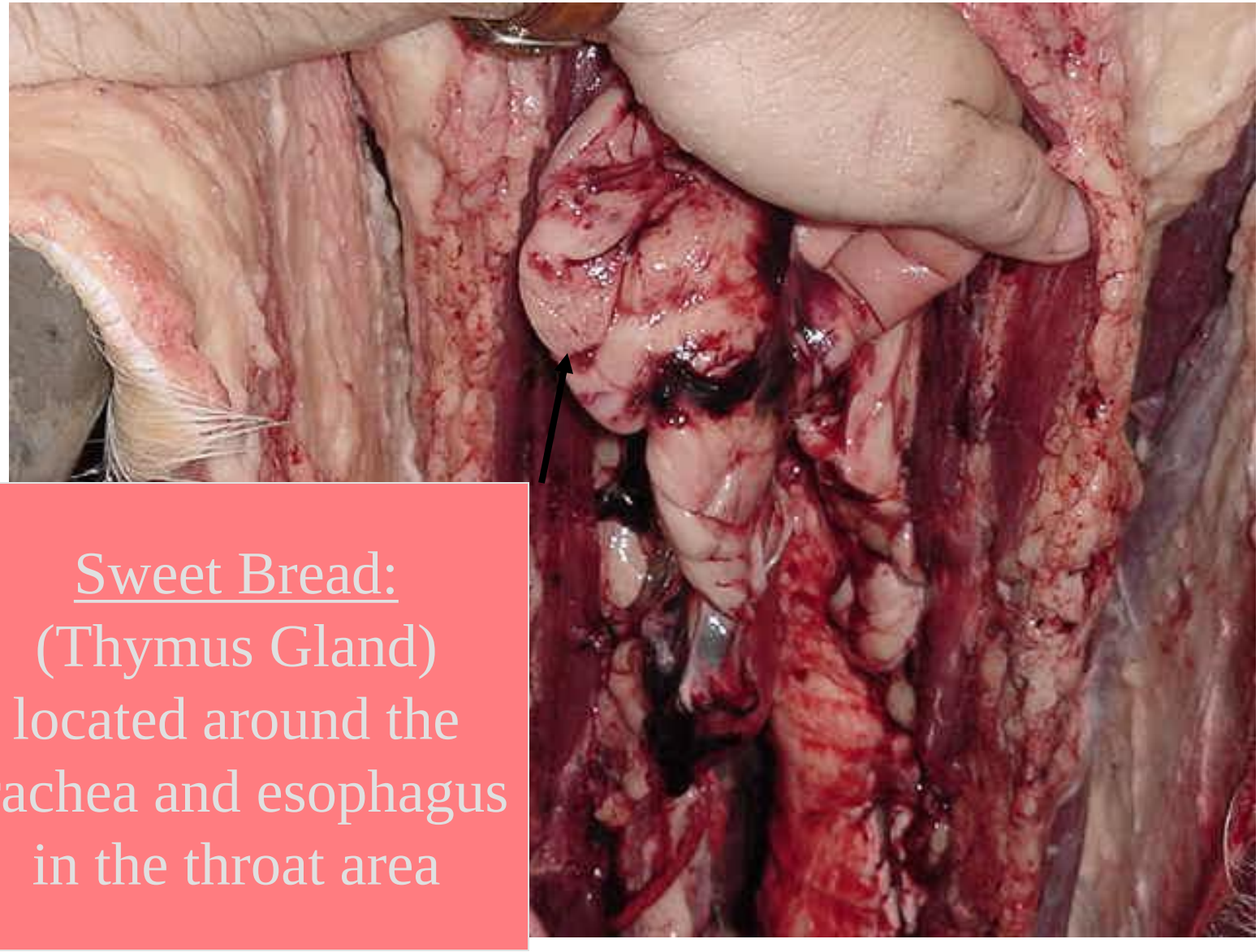


Rodding the weasand

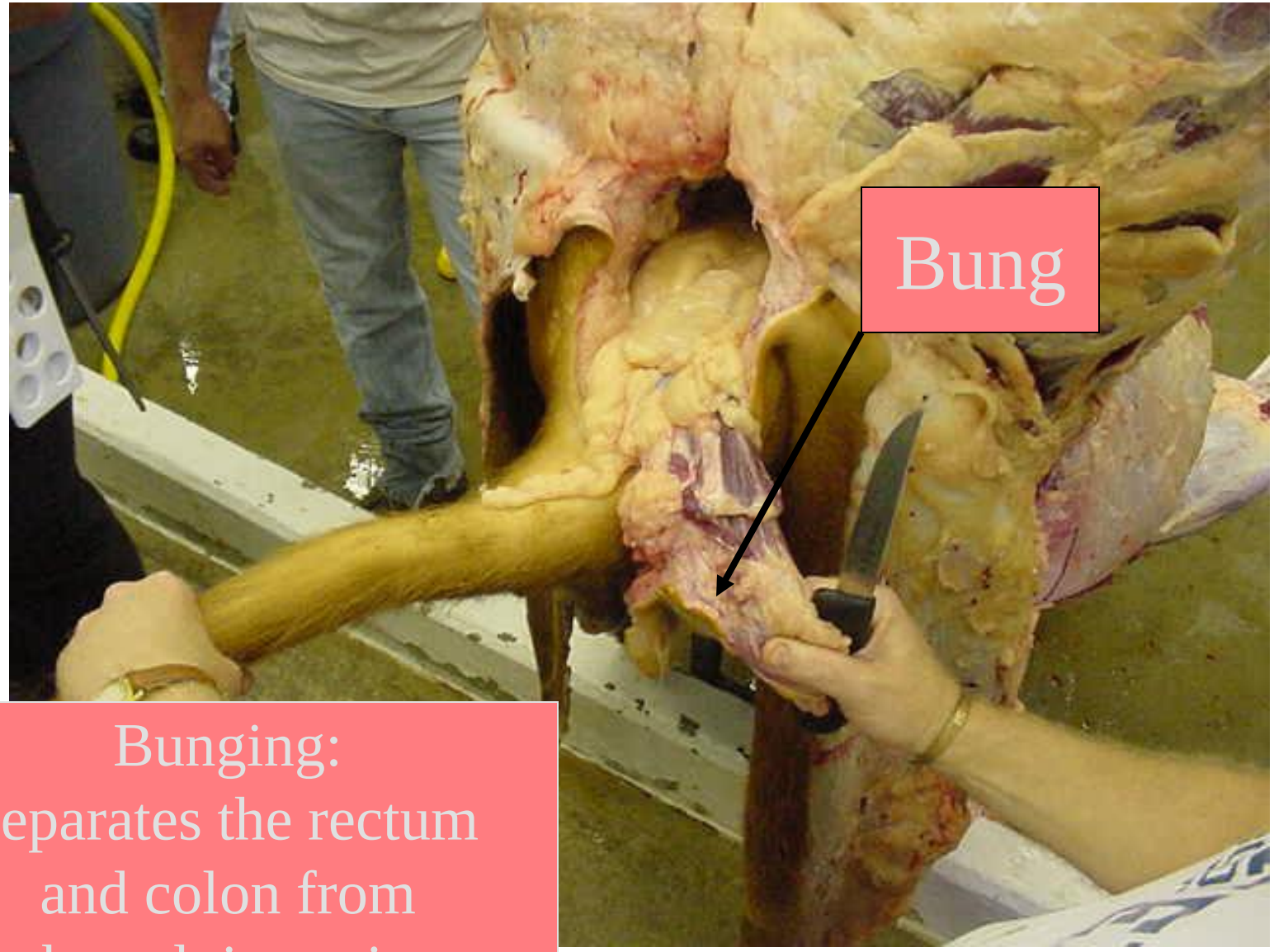

Weasand:
(esophagus)
is striated muscle
Trachea-
notice the
cartilage rings



Weasand:
is tied off to
prevent rumen contents
from contaminating
the carcass



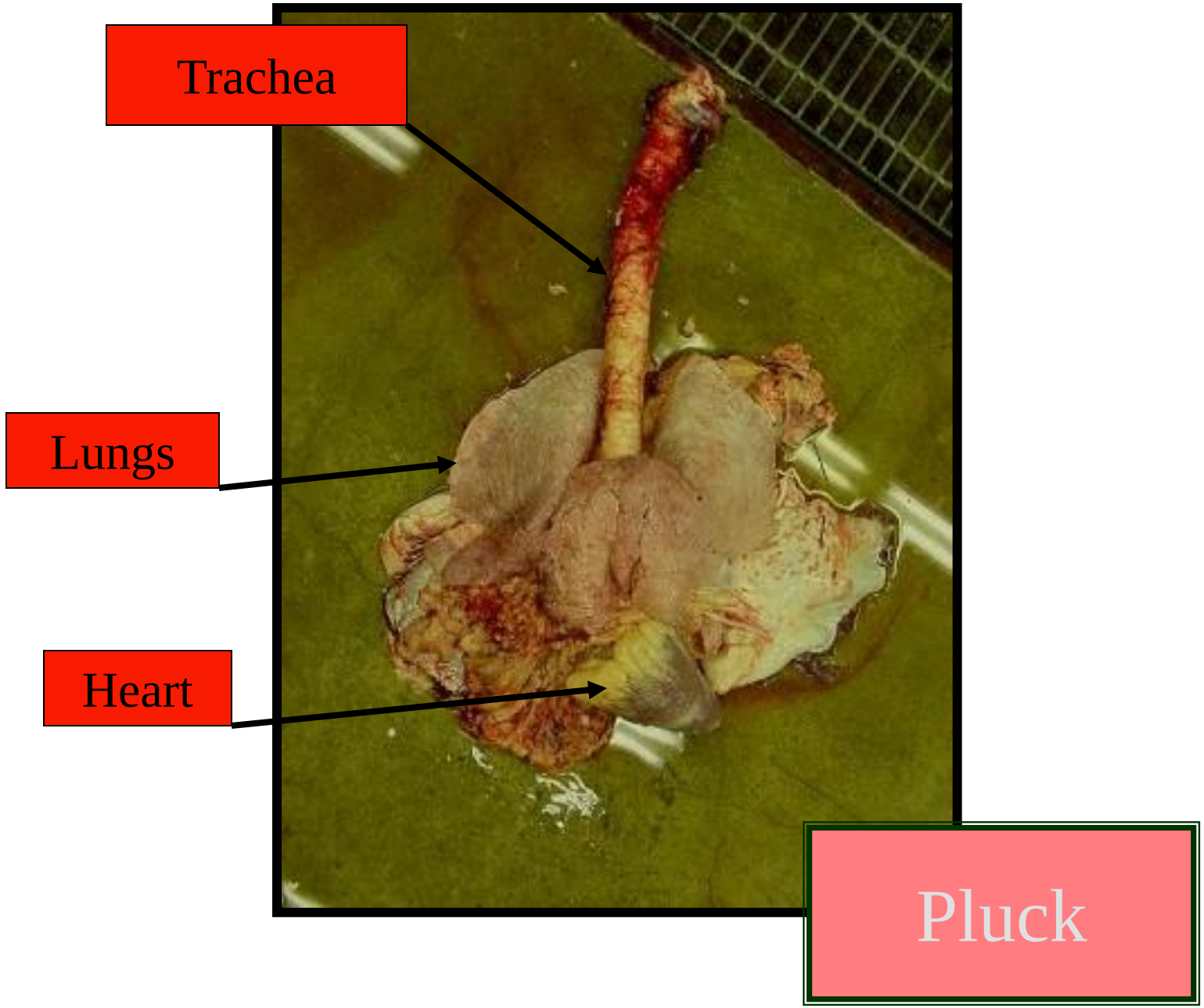
Sweet Bread:
(Thymus Gland)
located around the
trachea and esophagus
in the throat area

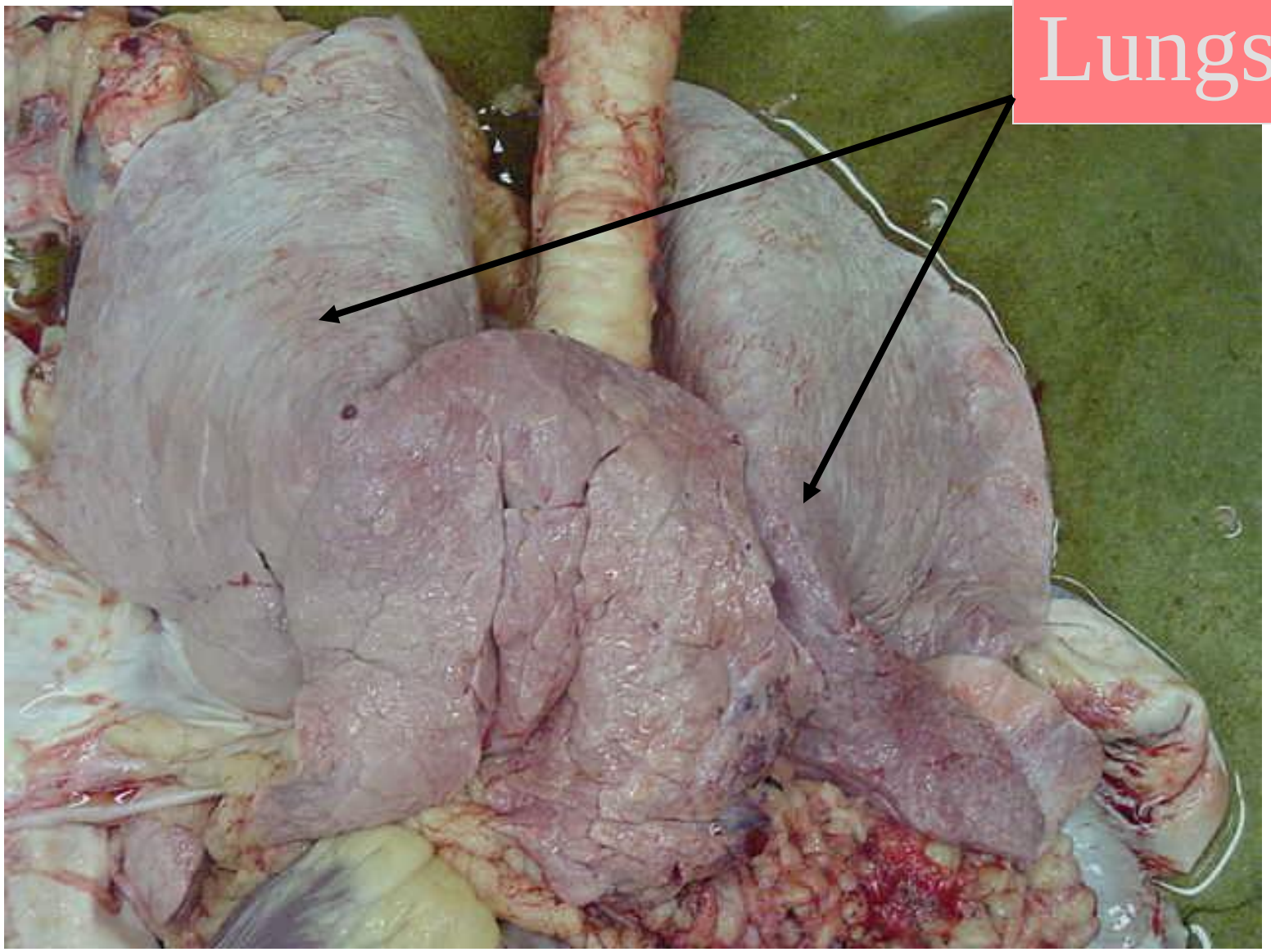


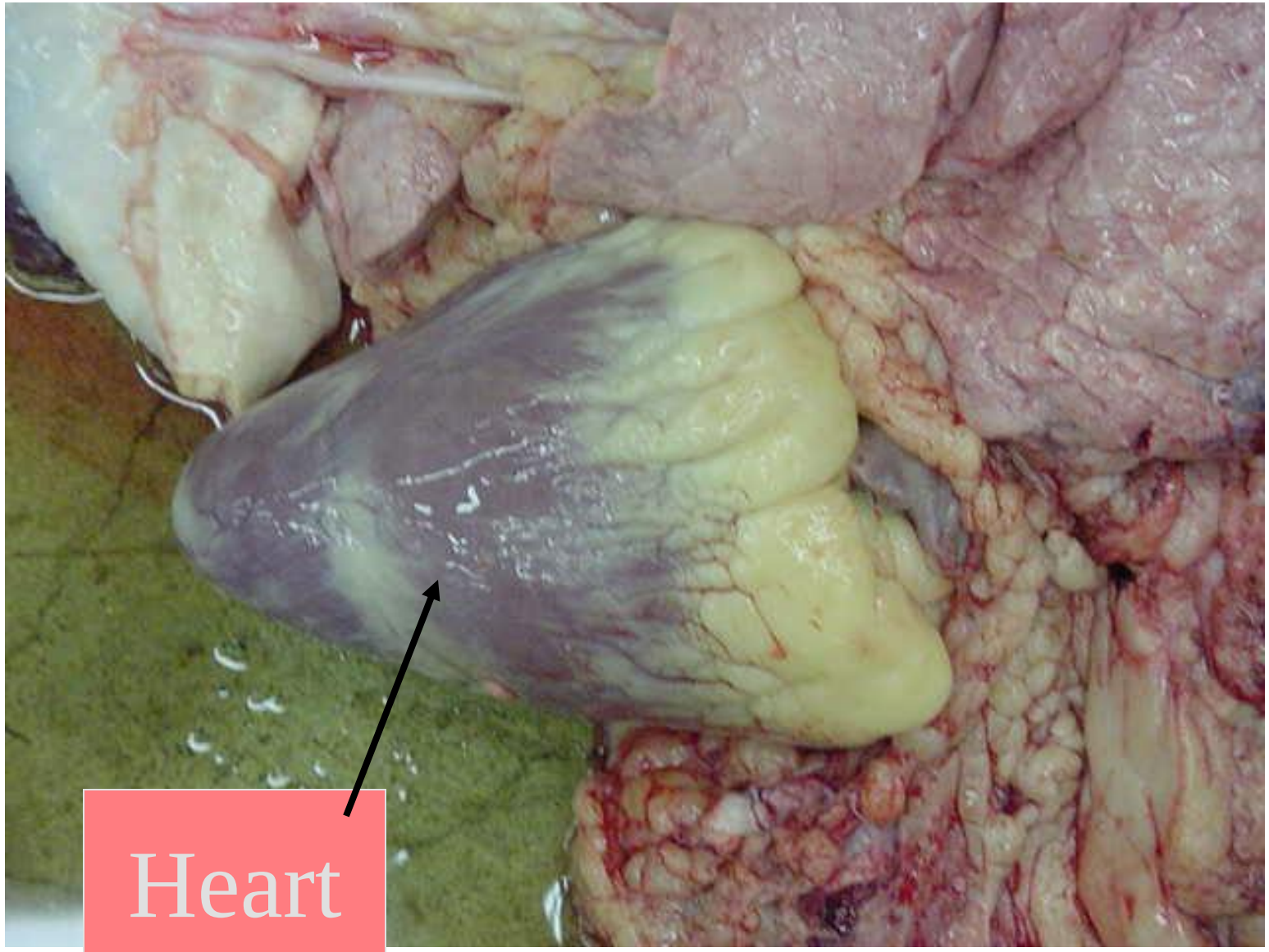
Bunging:
separates the rectum
and colon from
the pelvic cavity

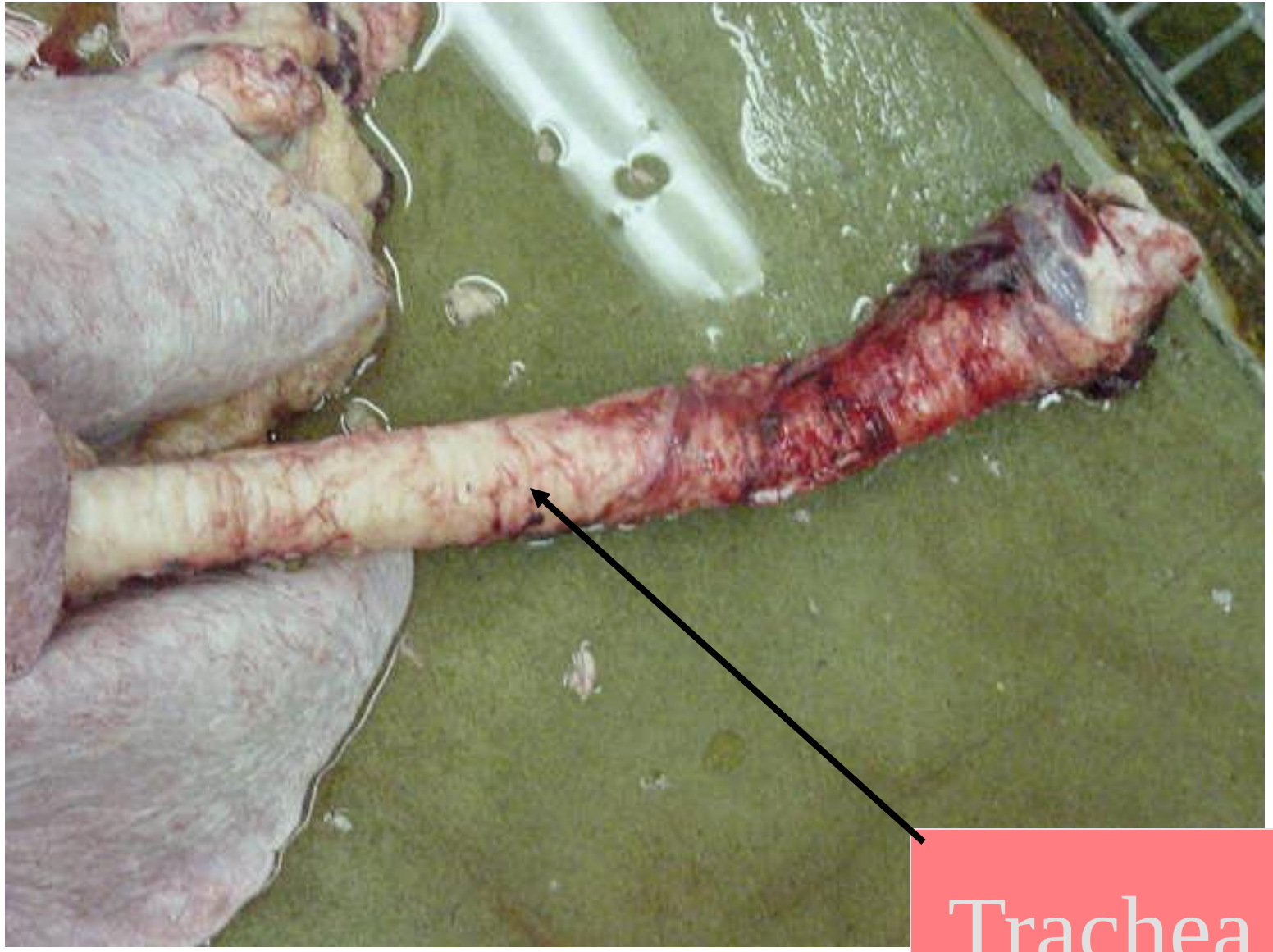
Evisceration

Removing viscera


Trachea
Lungs
Heart
Pluck

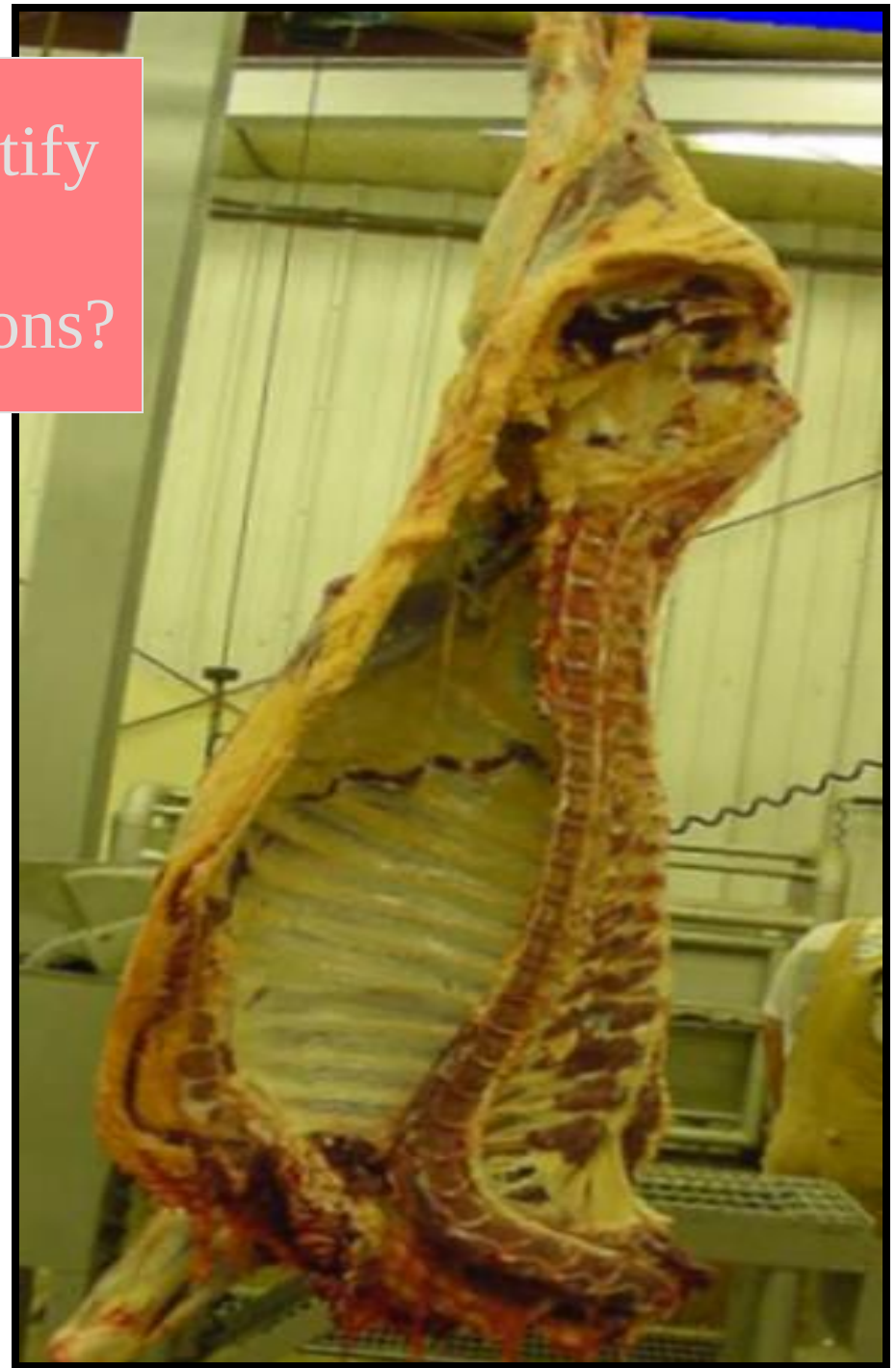

Lungs


Heart

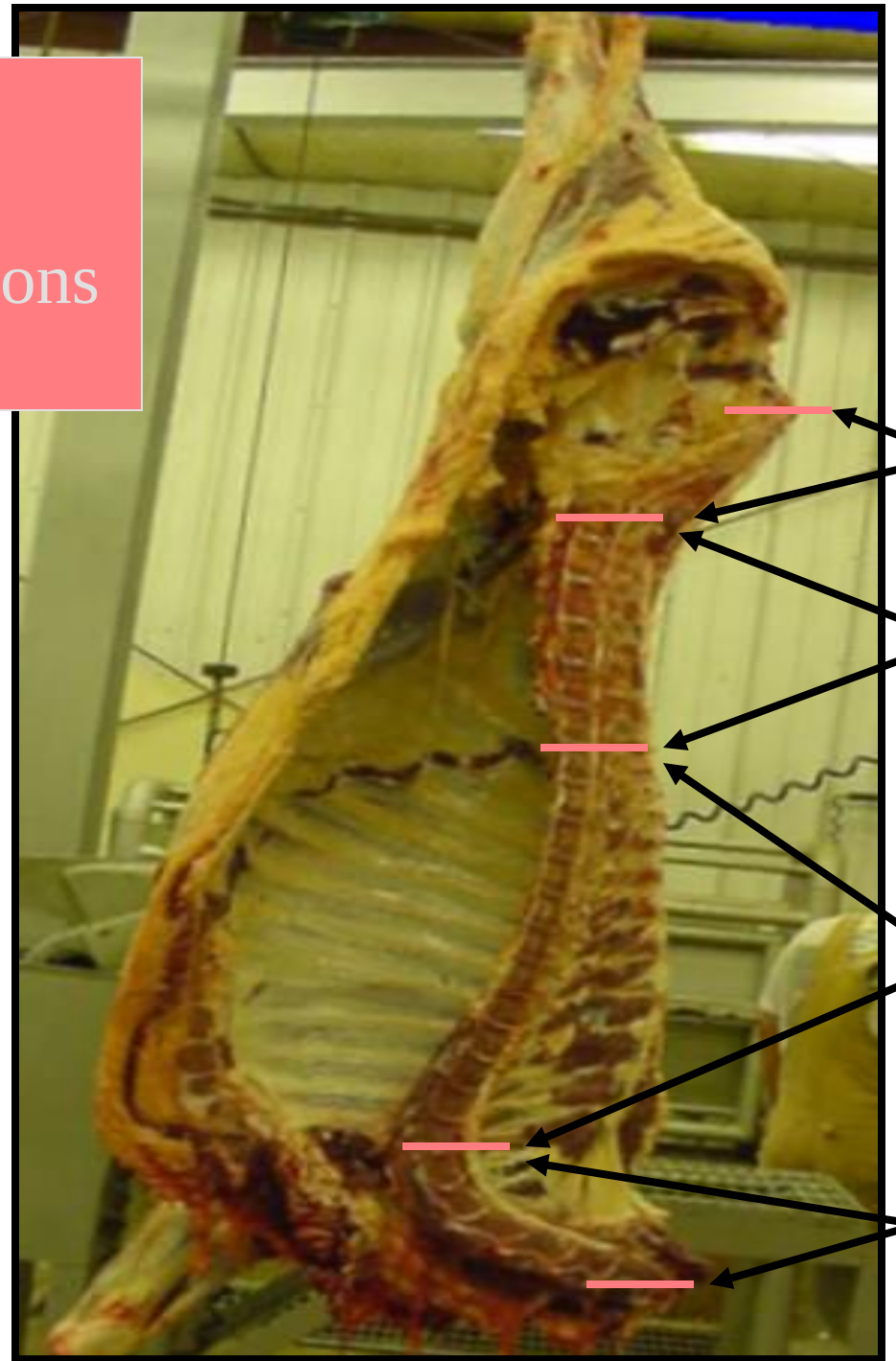

Trachea

Splitting the carcass down the vertebral column allows for more rapid chilling and easier handling

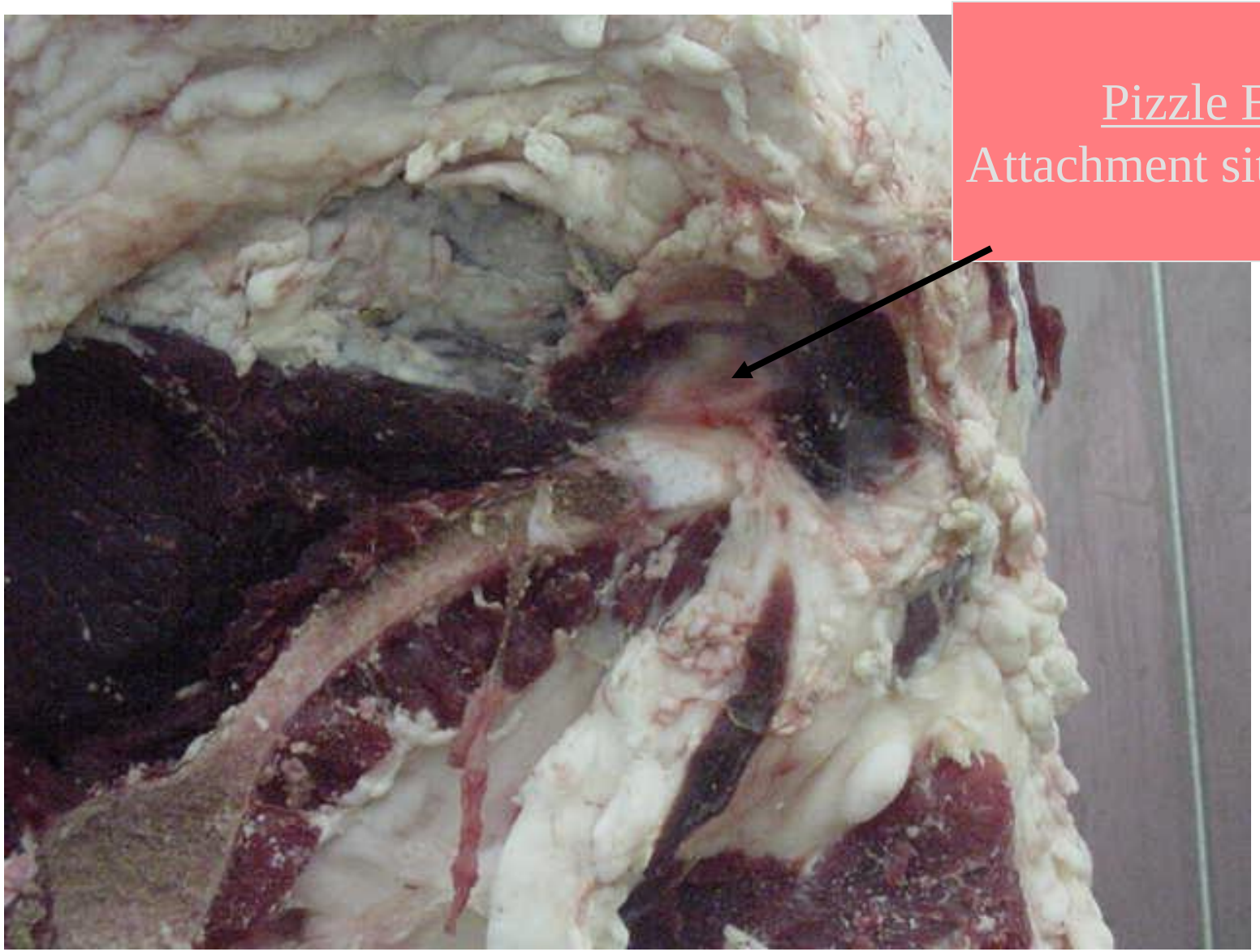
Can you identify the four vertebral regions?



The four vertebral regions



Washing the carcass to remove contamination

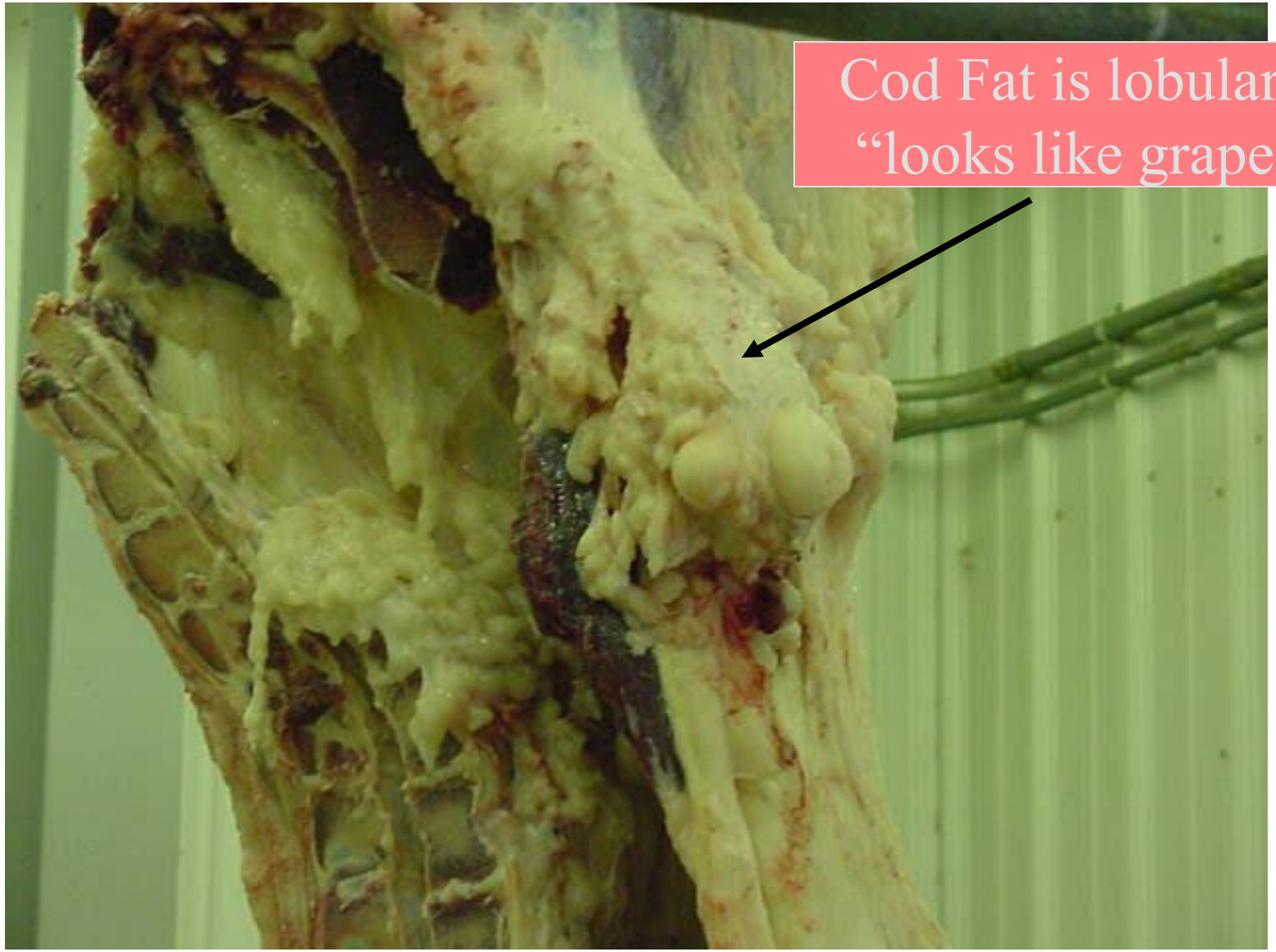


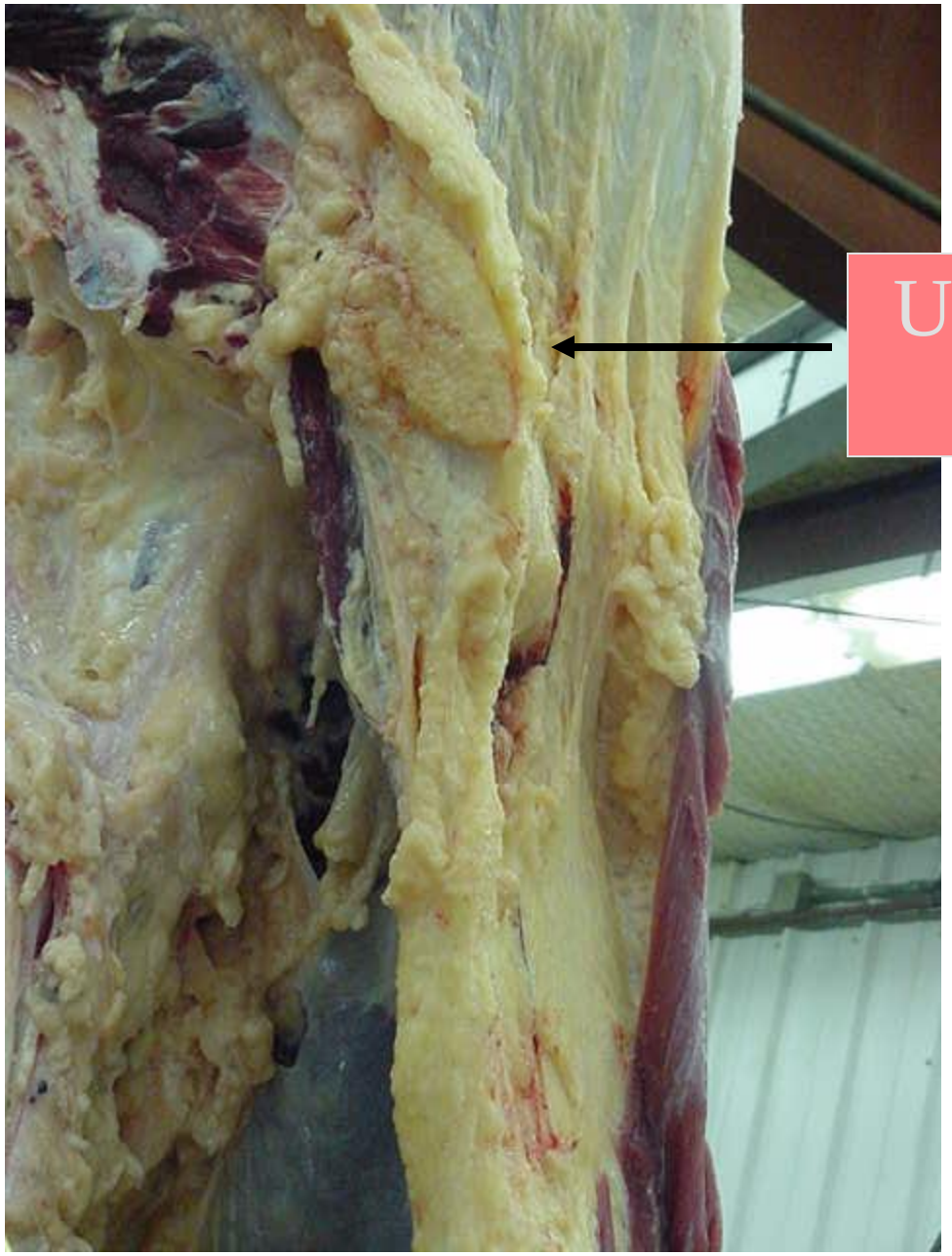
Pizzle Eye:
Attachment site of penis

Gracilis Muscles

Heifer:
Bean-shaped

Steer:
Diamond-shaped


Cod Fat is lobular…
“looks like grapes”

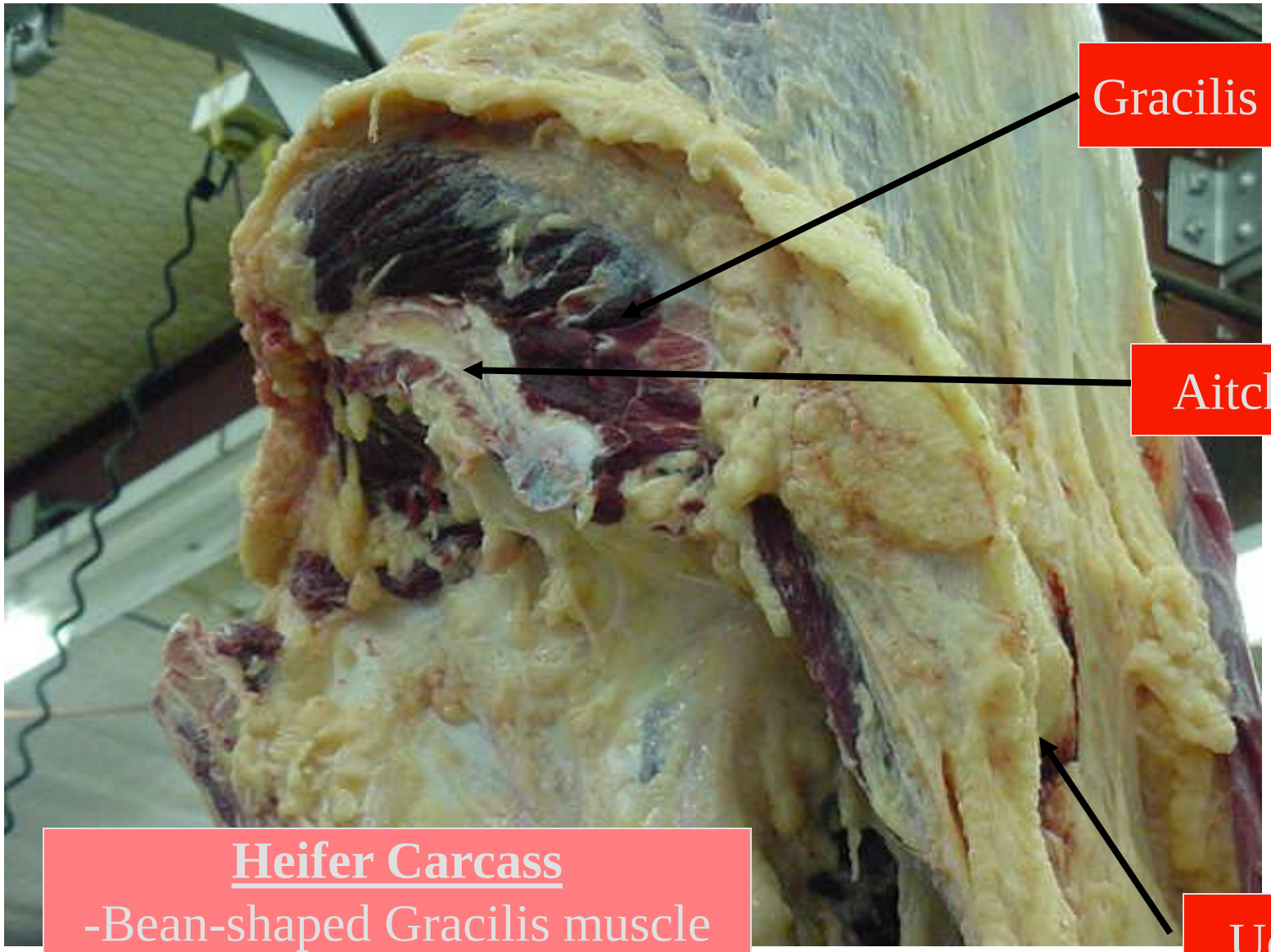

Udder fat is smooth

Cod Fat vs. Udder Fat

Cod

Udder

Can you identify the sex of this carcass?



Heifer Carcass

-Bean-shaped Gracilis muscle

-Flat aitch bone

-Udder fat

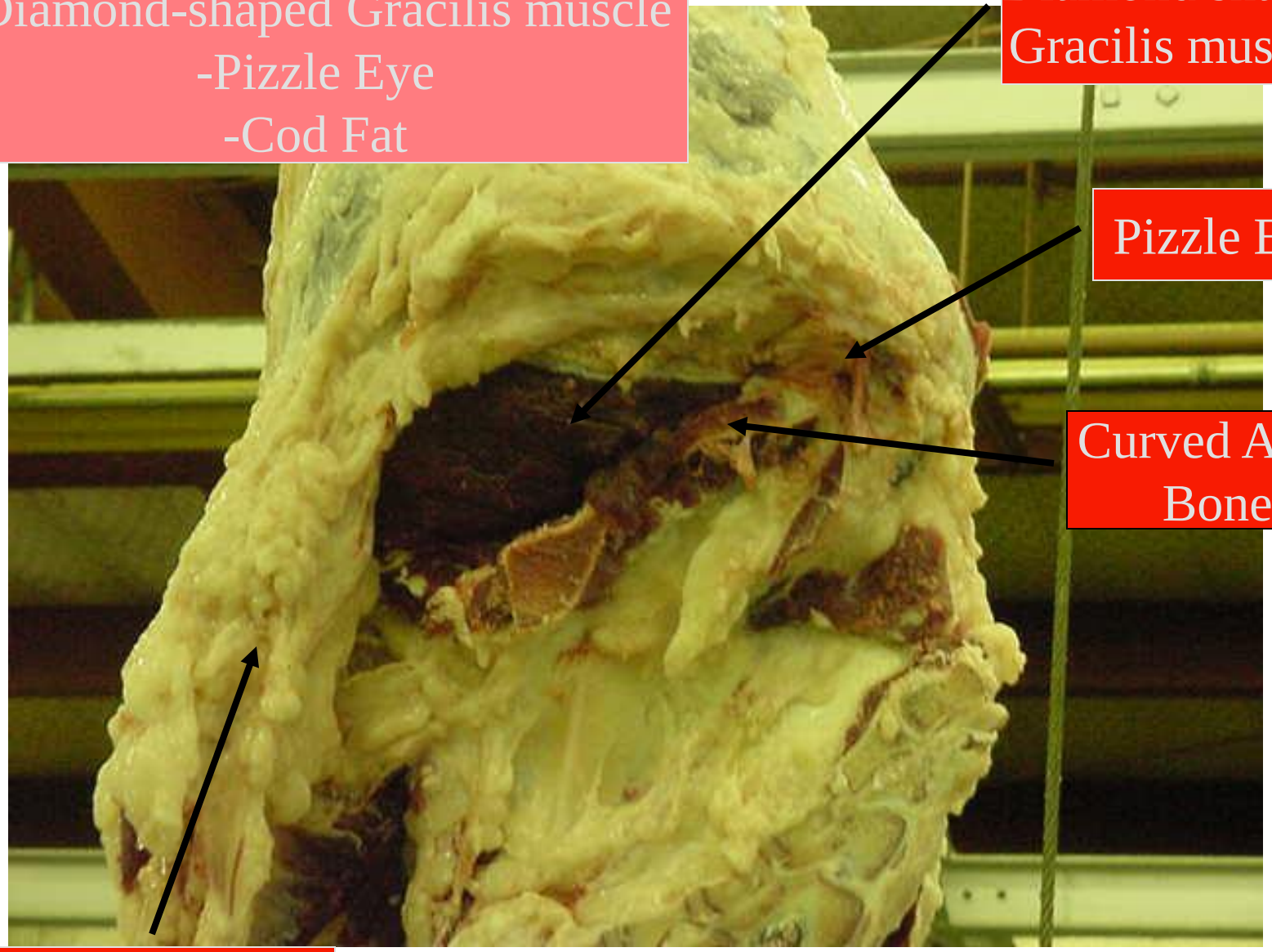
Can you identify the sex of this carcass?

Steer Carcass

-Diamond-shaped Gracilis muscle

-Pizzle Eye

-Cod Fat



Diamond shaped Gracilis muscle

Pizzle Eye

Curved Aitch Bone

Lobular Cod Fat

“HALAL SLAUGHTER”

ARI WIBOWO, Ph.D.

SCHOOL OF ANIMAL SCIENCE (MEAT SCIENCE)

2021

Traditional halal slaughter and other forms of religious slaughter are still an issue of debate. Opposing arguments related to pre-slaughter handling, stress and pain associated with restraint, whether the incision is painful or not, and the onset of unconsciousness have been put forward, but no consensus has been achieved

In Decades The Halal Slaughtering Without Pre-stunning Is Still Debatable Amongst Religious Society, Meat Scientists, Governments And Non-government Organizations Who Focus On Animal Welfare (Aghwan Et Al., 2016)

HALAL

- The Arabic word *Halal* has a possible English translations; including permissible, lawful, allowed, authorized, approved, sanctioned and trusworthy.
- Traditional Halal Slaughter is a Muslim method of slaughtering of animals based on islamic laws drawn from the Quran and Hadits and supervised by local Islamic Authorities (HAS, 1993; JAKIM 2011).
- According to this method, the animal intended for slaughter should be alive and sound at the time of salughtering.
- God's name must be mentioned while cutting or bleeding from a cut made

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Industrial halal meat production and animal welfare: A review

CrossMark

M.M. Farouk [a,*], K.M. Pufpaff [b], M. Amir [c]

[a] AgResearch Limited, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand
[b] Islamic Food and Nutrition Council of America (IFANCA), 777 Busse Hwy, Park Ridge, IL 60068, USA
[c] The Federation of Islamic Associations of New Zealand (FIANZ), 7-11 Queens Drive, PO Box 14155, Wellington, New Zealand

- Halal meat production must attempts to balance four points of view:
  - the scientific approach to animal welfare;
  - the ethic based approach to animal welfare:
  - Islamic dietary laws; and
  - the Islamic ethic about the role of animals in the world.

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Table 1
Islamic perspectives on non-human animal welfare issues and terminologies.

Welfare attribute	Islamic perspective on non-human animals	Sources/reference
Origin	They are all created by God.	Quran 24:45; 42:29
Sentience	There is no direct mention of sentience in the Islamic primary sources. However, Islamic scholars by analogy agree animals are sentient beings.	Masri (1993)
Emotions	Non-human animals have emotions.	Sunan Abu Dawud 5268; Sunan Ibn Majah 3163, 3686
Communication	Non-human animals are capable of communication and do communicate with their own kind and even with humans.	Quran 27:16, 18; 16:18; several Hadiths cited by Masri (1989)
Soul	There is no direct mention of non-human animal soul in the Quran or hadith. Islamic scholars by analogy reached a conclusion that non-human animals possess souls/spirit of God, which keeps them alive and they die when it departs from their body. Refer to references for human soul.	Quran 3:169; 6:93; 23:12–14; 32:11; 89:27–30; Saheeh Bukhari 546; An-Nawawi 4; Sunan Ibn Majah 2306; Masri (1993); Folz (2006)
Community	Non-human animals form and live in communities with their own kind.	Quran 6:38; Saheeh Muslim 556
Rights	Non-human animals have a right to be treated with kindness, respect and consideration; to be fed, watered and sheltered; not to be scared, overworked, overburden, disfigured or be forced to do what is not natural for their kind or be used frivolously or incited to fight. When they are to be slaughtered for food, it should be done humanely and with consideration.	Quran 7:73; 11:64; 26:155–156; 54:27–31; Hadith Saheeh al-Bukhari 3140, 3467, 5195, 6009, 6512; Saheeh Muslim, 1957, 1958, 2217, 2242, 2244, 4723; Sunan An-Nasa'I, 4445; Sunan At-Tirmidhi 1480; Abu Dawood 2532, 2567, 2826; Sunan Ibn Majah 3163, 3686; Masri (1989)
Worship/spirituality	Non-human animals worship God.	Quran 17:44; 24:41; 22:18; 19:93–95
Purpose	Non-human animals were created by God for several purposes including to be slaughtered humanely for meat and to be used for transportation and other honourable purposes by humans.	Quran 16:5,80; 22:34,36; 23:21; 36:71; 40:79; Sahih Muslim 4810

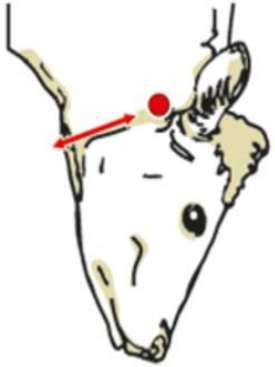
Slaughtering Process of Beef Cattle

SLAUGHTER METHODS

RITUAL SLAUGHTER

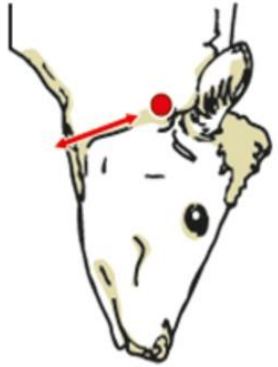
Cattle are conscious before their throats are slit and blood drained

Jewish Kosher method



- A certified butcher or **shochet** makes a transverse cut throughout all tissues and blood vessels in the neck using a special sharp knife **(the hallaf)**
- Parts of the animal forbidden for food such as blood and the sciatic nerve are removed
- The slaughtered animal is hung upside down to allow the blood to drain

Muslim Halal method

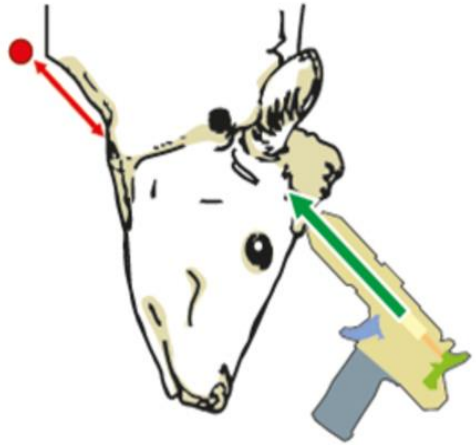


- Placed in the **direction of Mecca**, the animal must be awake at the time of slaughter
- A Muslim butcher **makes a quick and deep incision with a sharp knife at the animal throat and says "bismillah"** (in God's name)
- **The animal is then left to bleed to death**

Source: idé

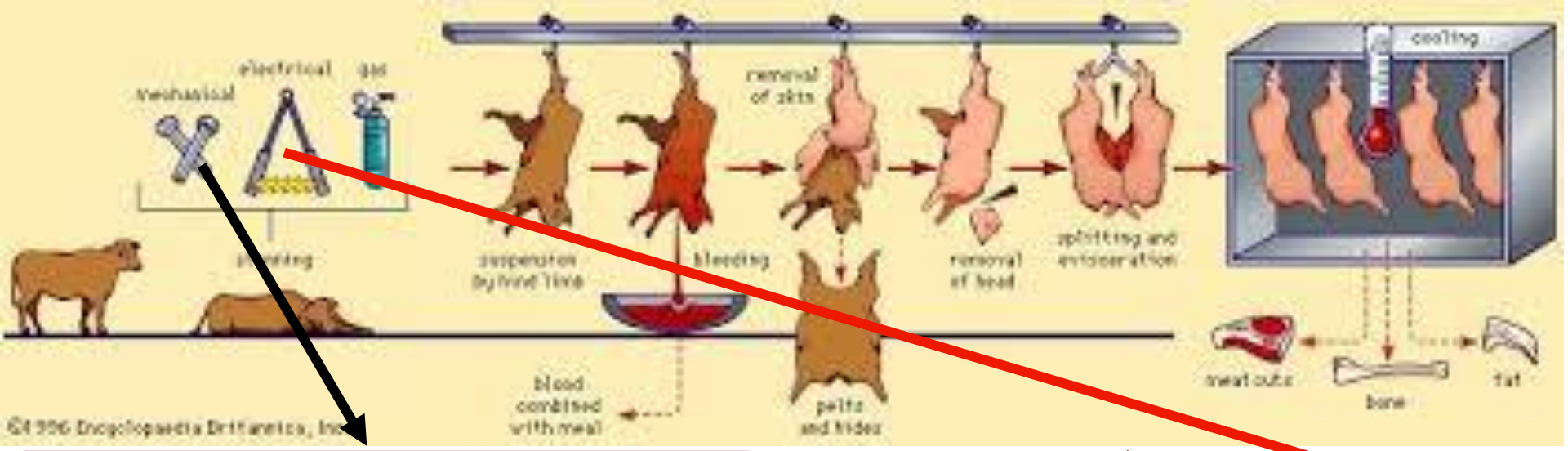
NON-RELIGIOUS METHOD

The animal is stunned first



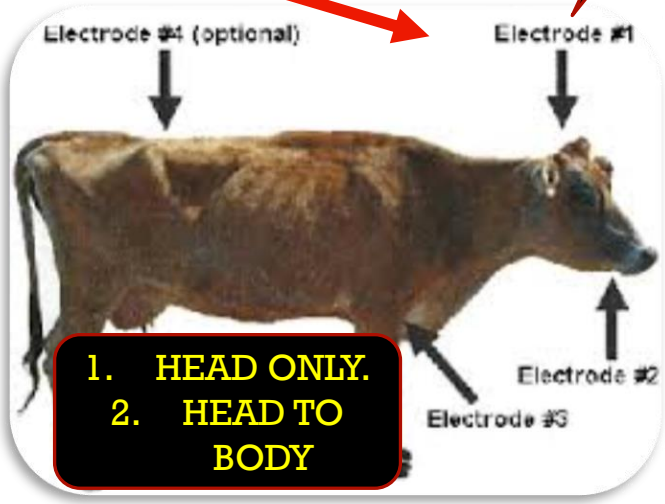
- Electronarcosis (anesthesia by electric current) is applied before killing the animal
- **The animal is bled to death by cutting its neck or sticking its chest**

idé REUTERS



MECHANICAL STUNNING

ELECTRICAL STUNNING



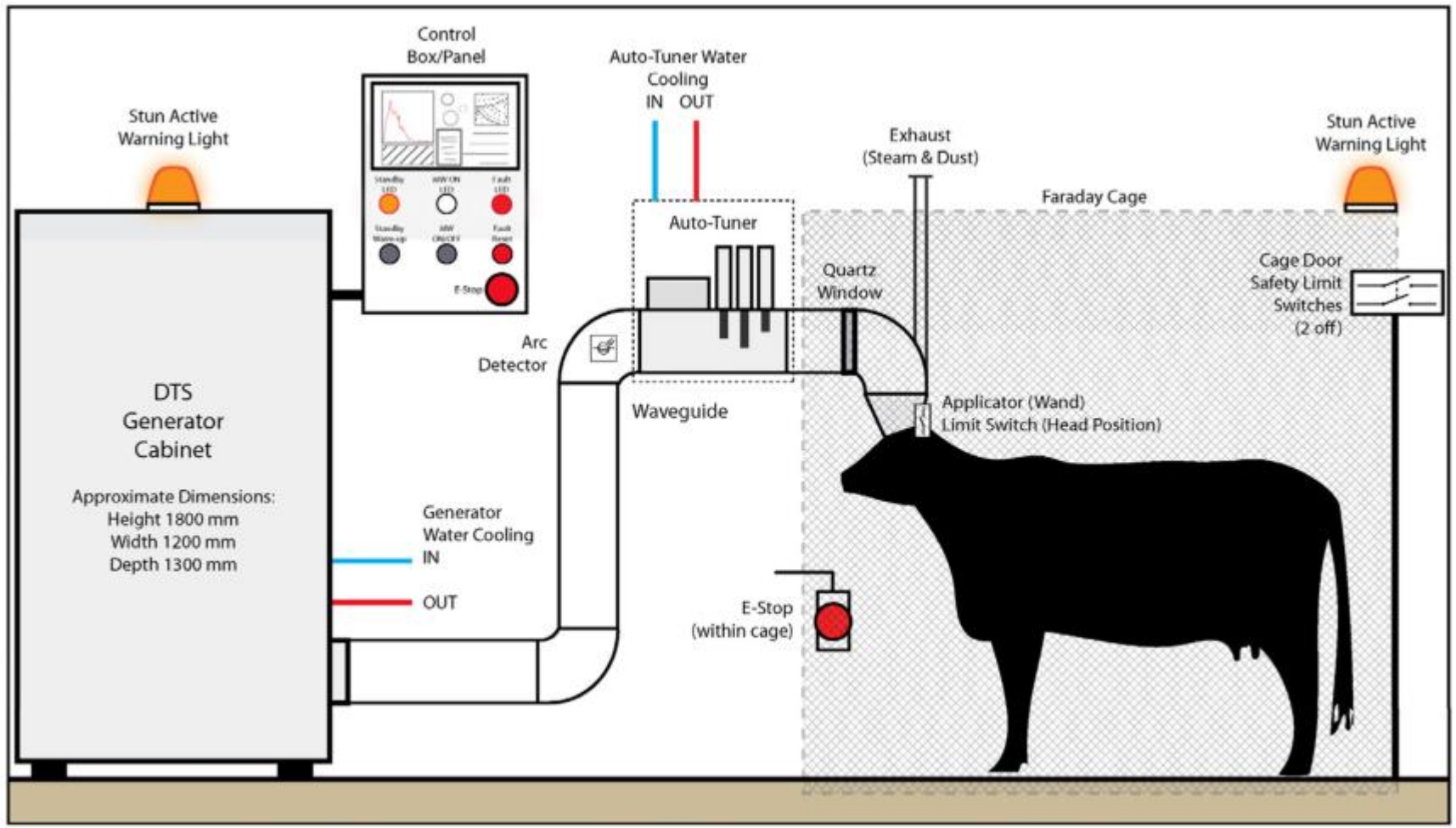
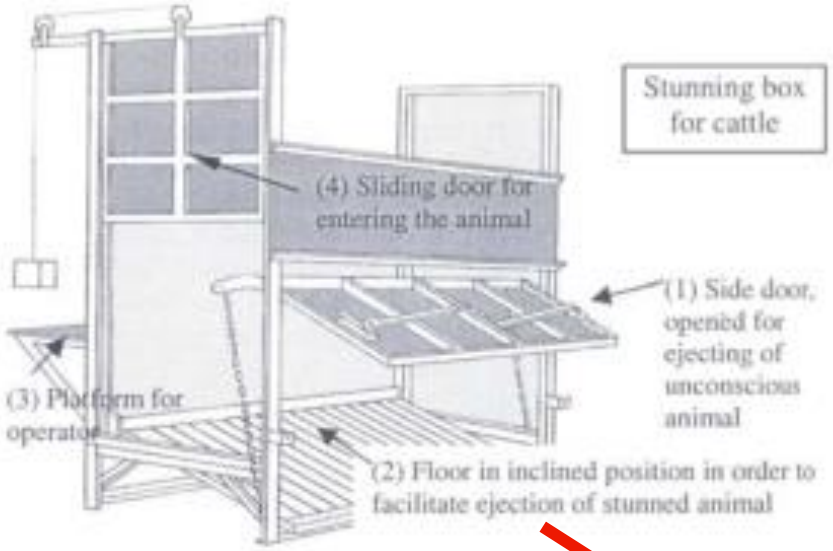


Fig. 2. Novel method of fully recoverable stun in development by a cross-disciplinary team in Australia. The 'Diathermic Syncope®' uses electromagnetic energy to effect a reversible stun (Small et al., 2015).



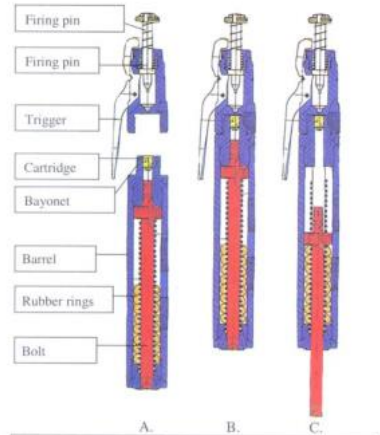
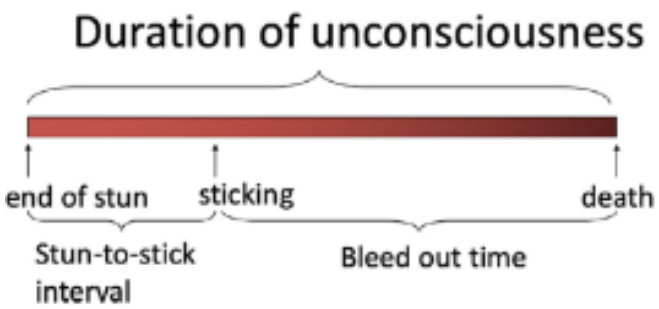


Fig. 67: How the captive bolt pistol operates



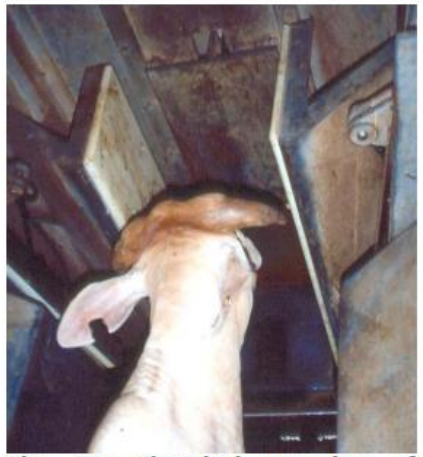


Fig. 70: Electrical stunning of cattle: The photo shows an animal about to enter a neck restrainer; once the animal is restrained, electrodes from a stunning device are placed on the nose and heart. This is an accepted Halal method used in a Jakarta abattoir.

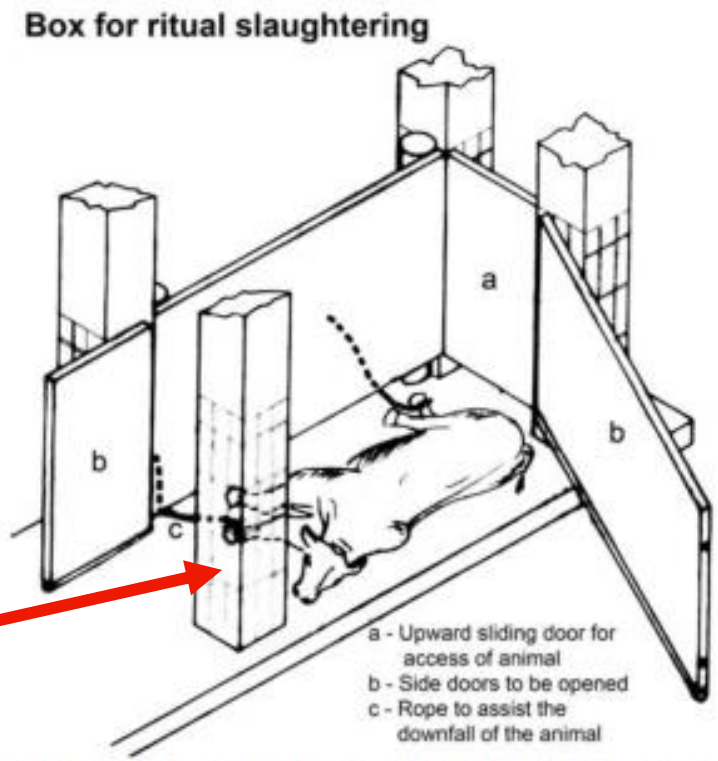


Fig. 73: Bovine restraining box: A rope is attached to the left fore and hind feet and pulled from the opposite side, under the wall of the box; the opposite wall (b) is closed during bringing down the animal.

Comparison of Halal slaughter with captive bolt stunning and neck cutting in cattle: exsanguination and quality parameters

MH Anil[*†], *T Yesildere*[‡], *H Aksu*[‡], *E Matur*[‡], *JL McKinstry*[†], *HR Weaver*[†], *O Erdogan*[‡], *S Hughes*[†] *and C Mason*[§]

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Estimated total blood weight (kg)

$$\frac{\text{volume (ml)} \times \text{specific gravity}}{1000}$$

Whereby the volume of blood can be determined by 57 ml kg^{-1} body weight and specific gravity of cattle blood is 1.052.

From here the estimated percentage blood loss for each animal was calculated using the equation:

Loss of estimated total blood weight(%)

$$\frac{\text{Total Blood Loss} \times 100}{\text{Estimated Total Blood Weight}}$$

Table 1 Comparison of variable measurements made on cattle following different slaughter methods.

Variable	No stunning mean ± SE	Captive bolt stunning mean ± SE	Assuming equal variances ©	t	df	Significance
Live weight (kg)	363.5 ± 5.7	355.3 ± 12.2	No	0.61	16	ns
Carcass weight (kg)	194.8 ± 3.2	188.0 ± 6.7	No	0.93	17	ns
Hide weight (kg)	31.23 ± 0.83	31.54 ± 0.97	Yes	-0.24	24	ns
Organ weight (kg)	11.57 ± 0.26	11.68 ± 0.30	Yes	-0.27	24	ns
PCV (%)	40.9 ± 0.90	40.0 ± 1.39	Yes	0.56	24	ns
pH (45 min)	7.01 ± 0.03	7.06 ± 0.03	Yes	-1.08	24	ns
pH (24 h)	6.17 ± 0.04	6.20 ± 0.05	Yes	-0.44	24	ns
Colour	4.91 ± 0.12	4.80 ± 0.17	Yes	0.55	24	ns

df — degrees of freedom; Significance — level of significance
ns — Not significant at the 0.05 level of significance
© — *F*-test two-sample for variances carried out to determine which *t*-test to use

Table 2 Table of means from two-sample *t*-tests.

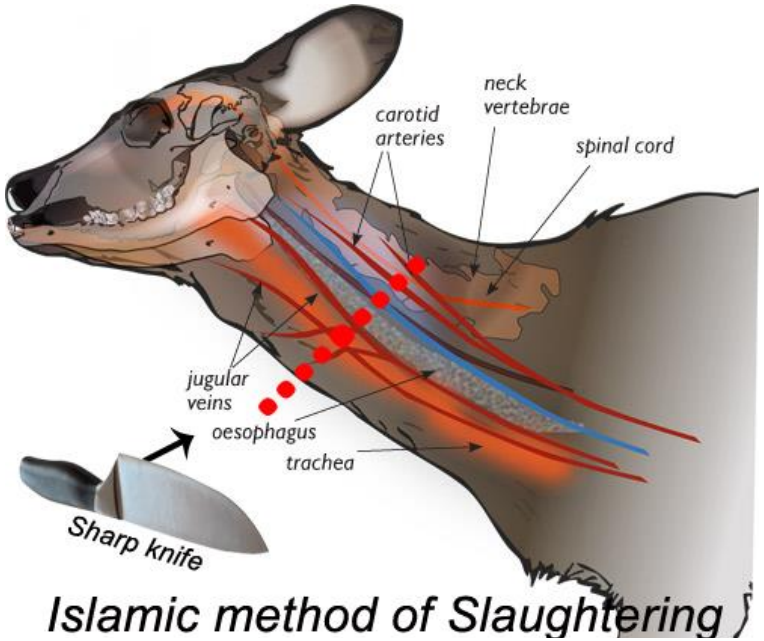
Variable	No stunning mean ± SE	Captive bolt stunning mean ± SE	Assuming equal variances ©	t	df	Significance
Total blood loss(kg)	10.85 ± 0.35	10.89 ± 0.69	No	-0.05	16	ns
Live weight (kg)	363.5 ± 5.63	355.3 ± 12.34	No	0.61	16	ns
Estimated total blood weight(kg)	21.80 ± 0.34	21.31 ± 0.74	No	0.61	16	ns
Estimated % blood loss	49.92 ± 1.63	51.70 ± 3.49	No	-0.46	16	ns
Blood loss as a % of live weight	2.99 ± 0.1	3.10 ± 0.21	No	-0.46	16	ns

df — degrees of freedom; Significance — level of significance
ns — Not significant at the 0.05 level of significance
© — *F*-test two-sample for variances carried out to determine which *t*-test to use

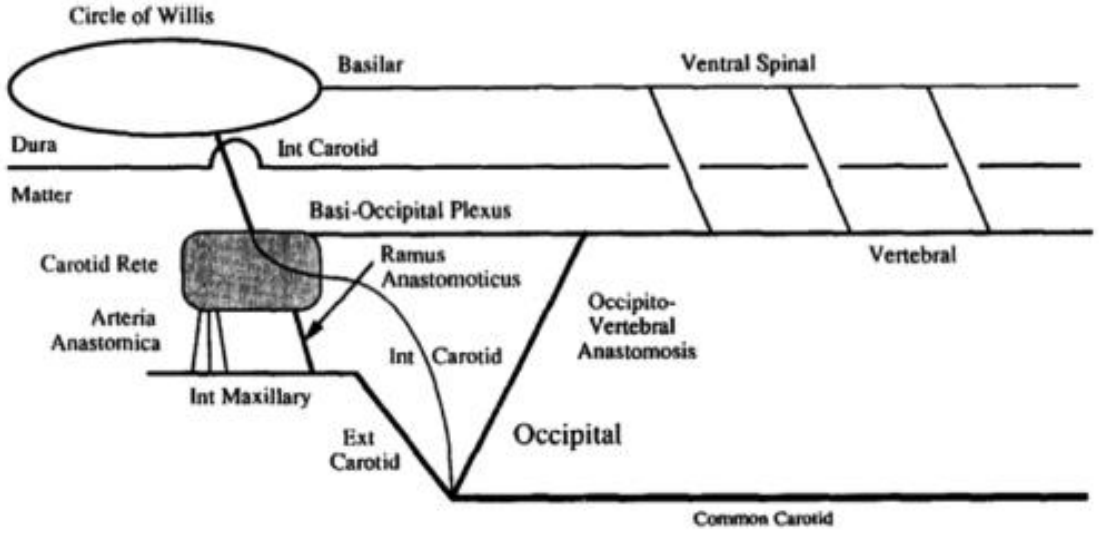
Table 3 The average rate of blood loss in cattle following different slaughter methods.

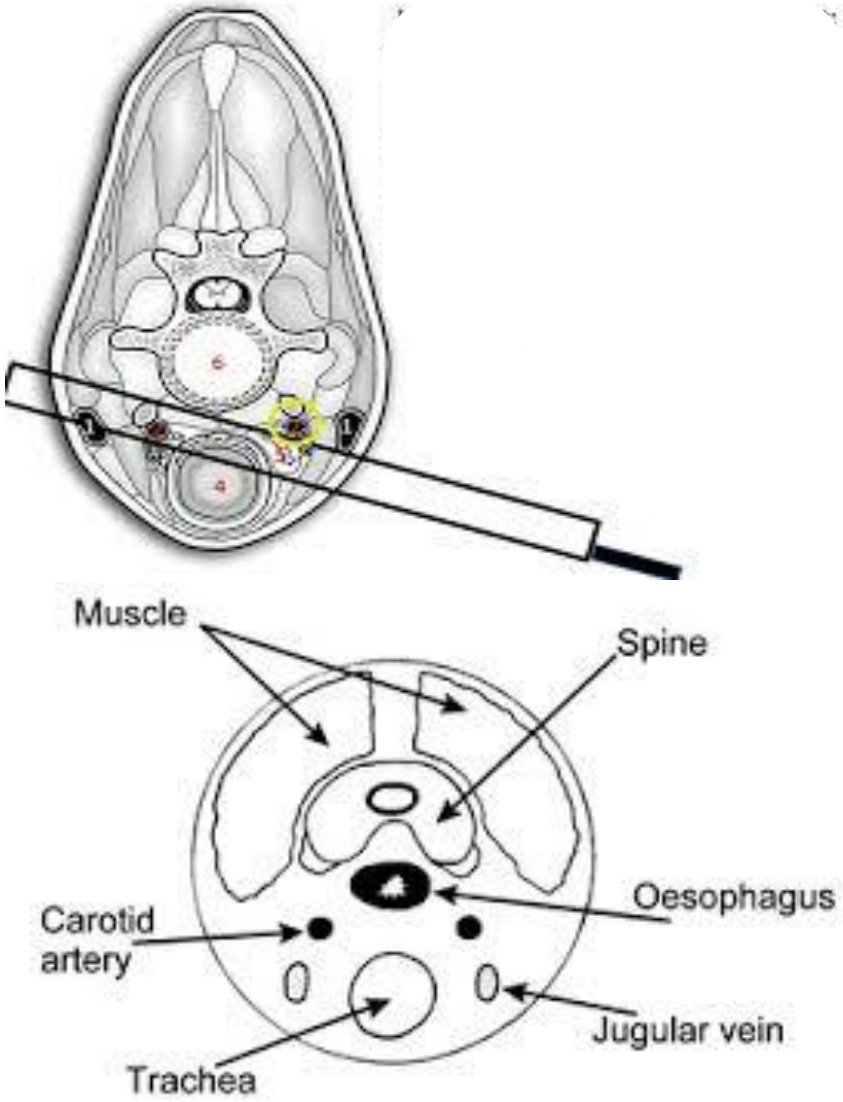
	No stunning mean ± SE	Captive bolt stunning mean ± SE	Assuming equal variances ©	t	df	Significance
Time to 25% blood loss (s)	17.3 ± 2.4	10.6 ± 1.5	Yes	2.29	13	*
Time to 50% blood loss (s)	37.5 ± 2.8	35.8 ± 3.7	Yes	0.36	18	ns
Time to 75% blood loss (s)	68.0 ± 4.5	67.6 ± 2.9	Yes	0.08	18	ns
Time to 90% blood loss (s)	94.4 ± 4.9	94.0 ± 2.0	No	0.08	11	ns

Slaughtering



Islamic method of Slaughtering





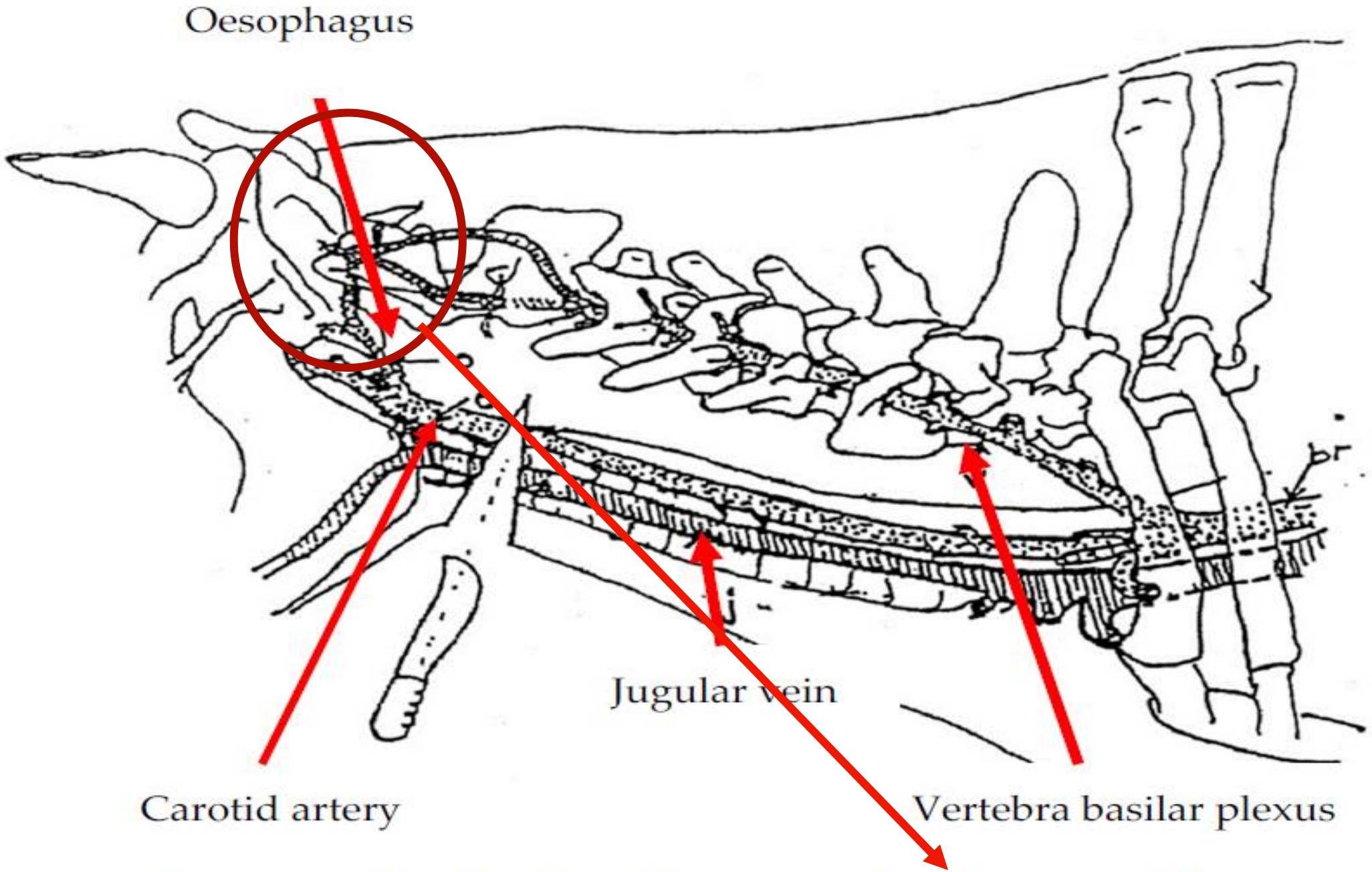


Figure 1. Anatomical position of the neck cut at the C1 vertebrae [35].

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Effect of neck cut position on time to collapse in halal slaughtered cattle without stunning

Troy J. Gibson *, Nikolaos Dadios, Neville G. Gregory

Department of Production and Population Health, Royal Veterinary College, Hawkshead Lane, Hatfield AL9 7TA, United Kingdom

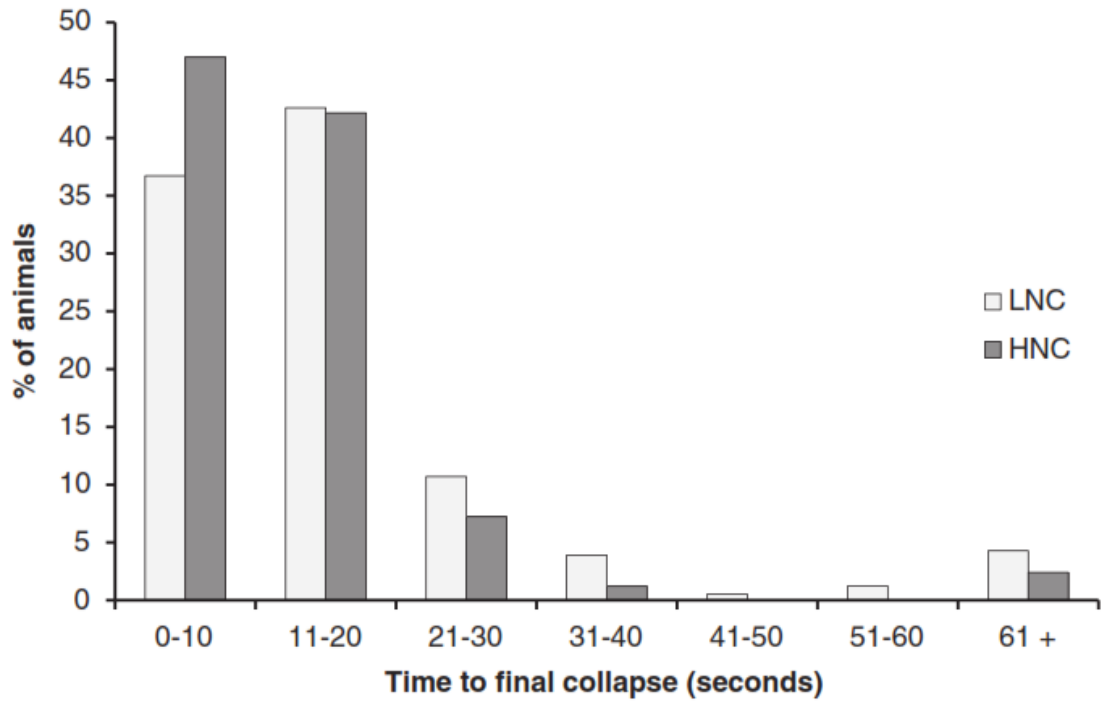


Fig. 1. Distribution (%) of cattle in LNC (light grey) and HNC (dark grey) groups according to time to final collapse following slaughter without stunning.

Table 29: Time to loss of brain function in cattle (means and/ or ranges (s) (from von Holleben et al., 2010)

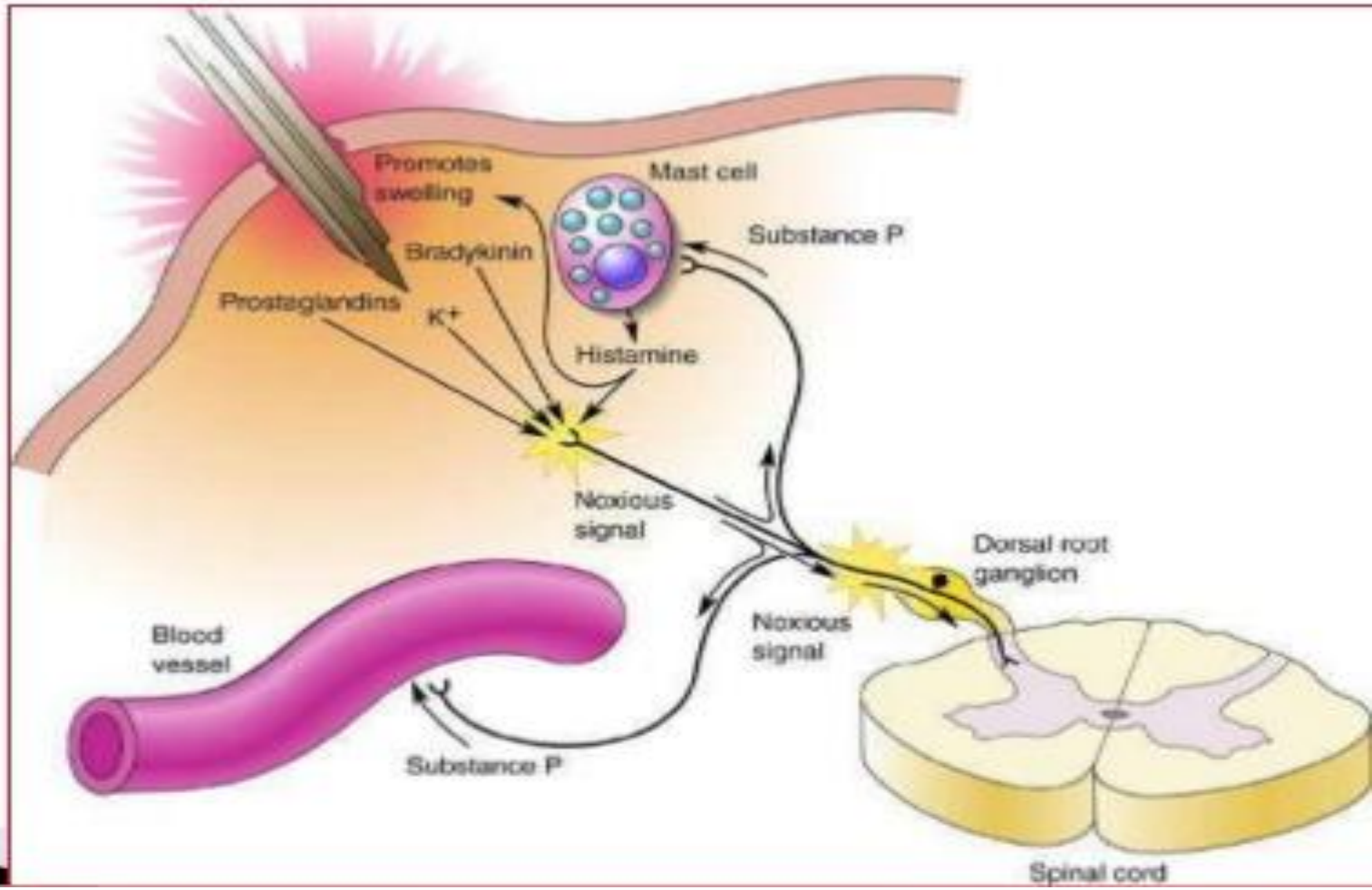
Cattle category (age, weight)	Number of animals	Parameter for loss of consciousness, used in the respective study	Time post cut to appearance of indicators for loss of consciousness (mean, range)	Source
Calves (1 week old)	8	EEG*[2] amplitudes not consistent with sensibility Periodic resurgence of possible sensibility Isoelectric EEG	34s (1 animal), 65-85s (7 animals) 123–323s 132–326s	Blackmore and Newhook (1982)
Calves (40–60 kg)	10	Relevant EEG changes*[1] Isoelectric EEG	10s (up to 18s, 24s)*[1] 23s	Schulze et al. (1978)
Calves (30–40 kg)	8	Loss of VEPs *[2] Flat ECoG*[2]	17s (12–23s) 23s (14–28s)	Gregory and Wotton (1984)
Calf (6 weeks old)	1	EEG amplitudes not consistent with sensibility	79s	Devine et al. (1986)
Calves (4–8 weeks old)	6	ECoG analysis (power content and frequency)	10s	Bager et al. (1992)
Cattle (170 kg), shechita	4	ECoG isoelectric	10.8s (8.7–12.8s)	Kallweit et al. (1989), Daly et al. (1988)
Cows (436 kg), shechita	8	Start of HALF*[2] Duration of HALF ECoG < 10μV Loss of SEPs*[2] Loss of VEPs*[2]	7.5s (5–13s) 28s (9–85s) 72s (19–113s) 77s (32–126s) 55s (20–102s)	
Calves/Bull	4	Loss of ability to stand/loss of coordinated attempts to rise (only animals with satisfactory cut and no occlusion)	7 days old (2 calves with (severed exteriorised vessels): 16-40s/30-47s 7 days old (1 calf): 5s/41s 13 months old (1 Bull): 3s (fractured leg)/20s	Blackmore (1984)
Adult cattle	174	Time to collapse	19.5s (maximum 265s)	Gregory et al. (2010)

*[1]: The original report and data of the project (Hazem et al., 1977) revealed that, though the authors concluded loss of consciousness being highly probable in calves after 10 s, they recorded unchanged EEG until 18 s after the cut, and in one animal, which had to be recut because of obviously low bleeding, the EEG showed only very small changes until 24 s after the first cut.

*[2]: HALF: high amplitude low frequency waves; VEPs: visual evoked potentials; SEPs: somatosensory evoked potentials; EEG: electroencephalogram; ECoG: electrocorticogram.

Nociceptors

- Nociceptors are special receptors that respond only to **noxious** stimuli and generate nerve impulses which the brain interprets as "pain"
- Free nerve endings
- Tissue damage



animals

MDPI

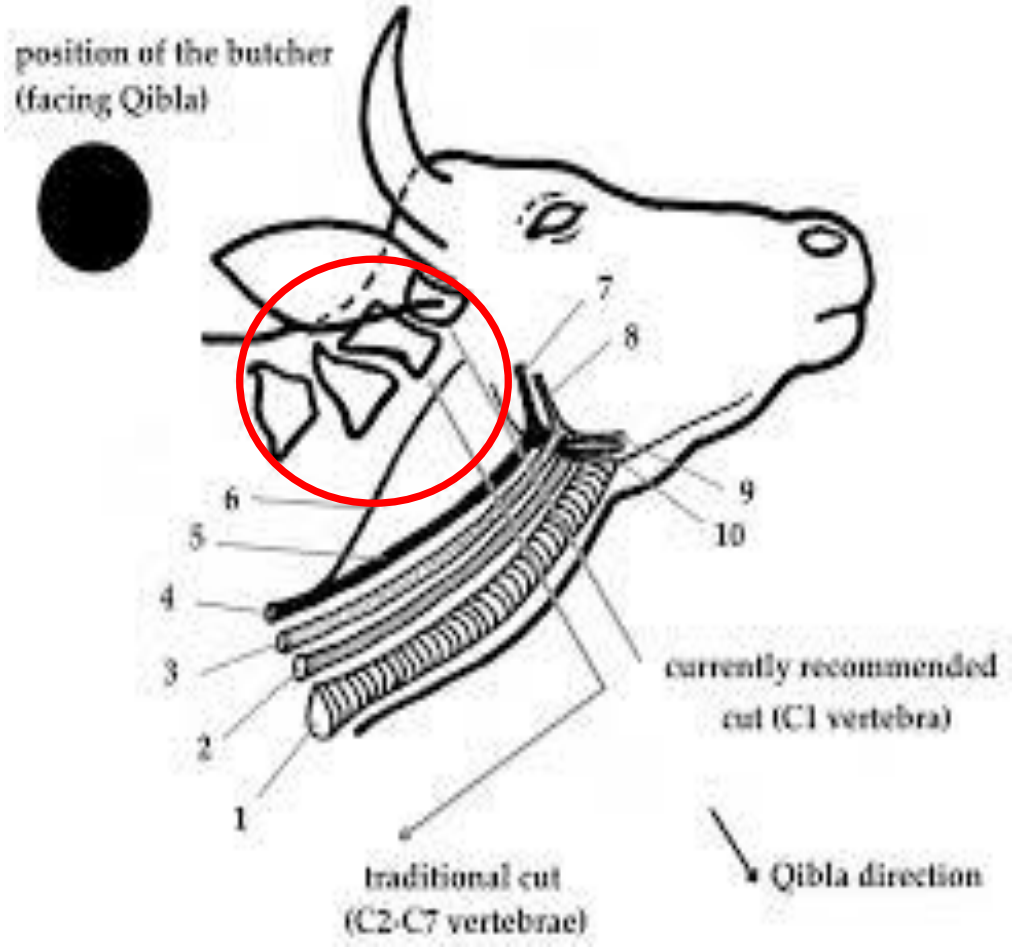
Article

Evaluation of the Occurrence of False Aneurysms During Halal Slaughtering and Consequences on the Animal's State of Consciousness

Giancarlo Bozzo [1], Elisabetta Bonerba [1], Roberta Barrasso [1,*], Rocco Roma [2], Francesco Luposella [3], Nicola Zizzo [1] and Giuseppina Tantillo [4]

Table 1. Percentage of false aneurysm (FA) presence and their resolution.

Observations	Operator C4	Operator C2	Operator C1
Total number of animals	400	400	400
Total number of FA	41	29	29
Percentage of FA out of the total number of animals	10.25%	7.25%	7.25%

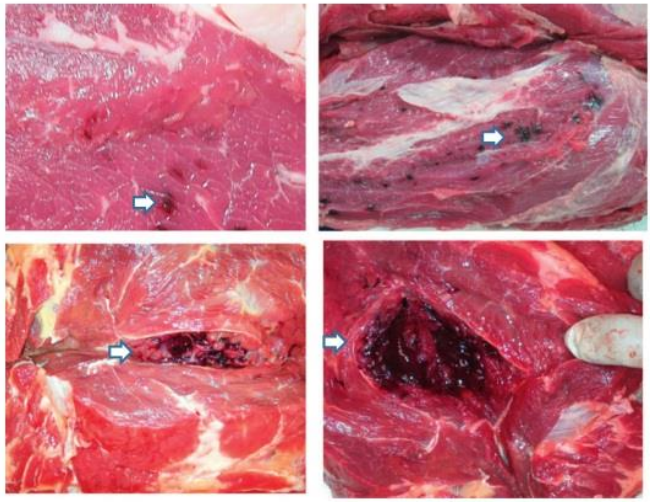


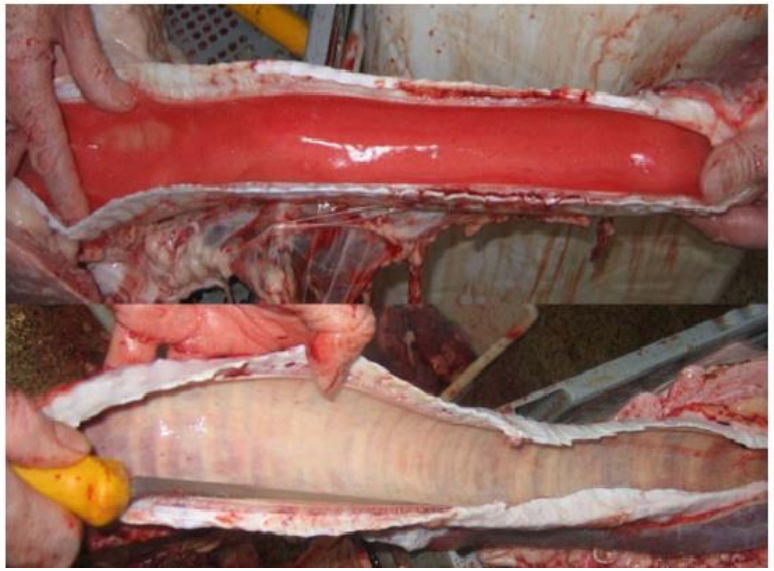
Slaughtering indiocators

.

- **There is no kicking (*Hind Quarter)*.**
- **There is no blood lining in trachea.**
- **(*Absence of corneal reflex*)**
- **No Bruised on meat/ carcass**

BLOOD SPLASH IN MEAT





TRACHEA

Ways of improving welfare of animals during handling and transportation

- To improve animal welfare during transport, it becomes necessary to comprehend the attitudes and activities of those involved in handling and transporting of animals.
- The aforementioned hadits, as reported, emphasize the welfare of animals and reveal how animals should be handled and managed
- From the Islamic point of view, The prophet (PBUH) in a hadith stated that:

'It is a great sin for a man to imprison animals that are in his power' (Sahih Muslim[1]).

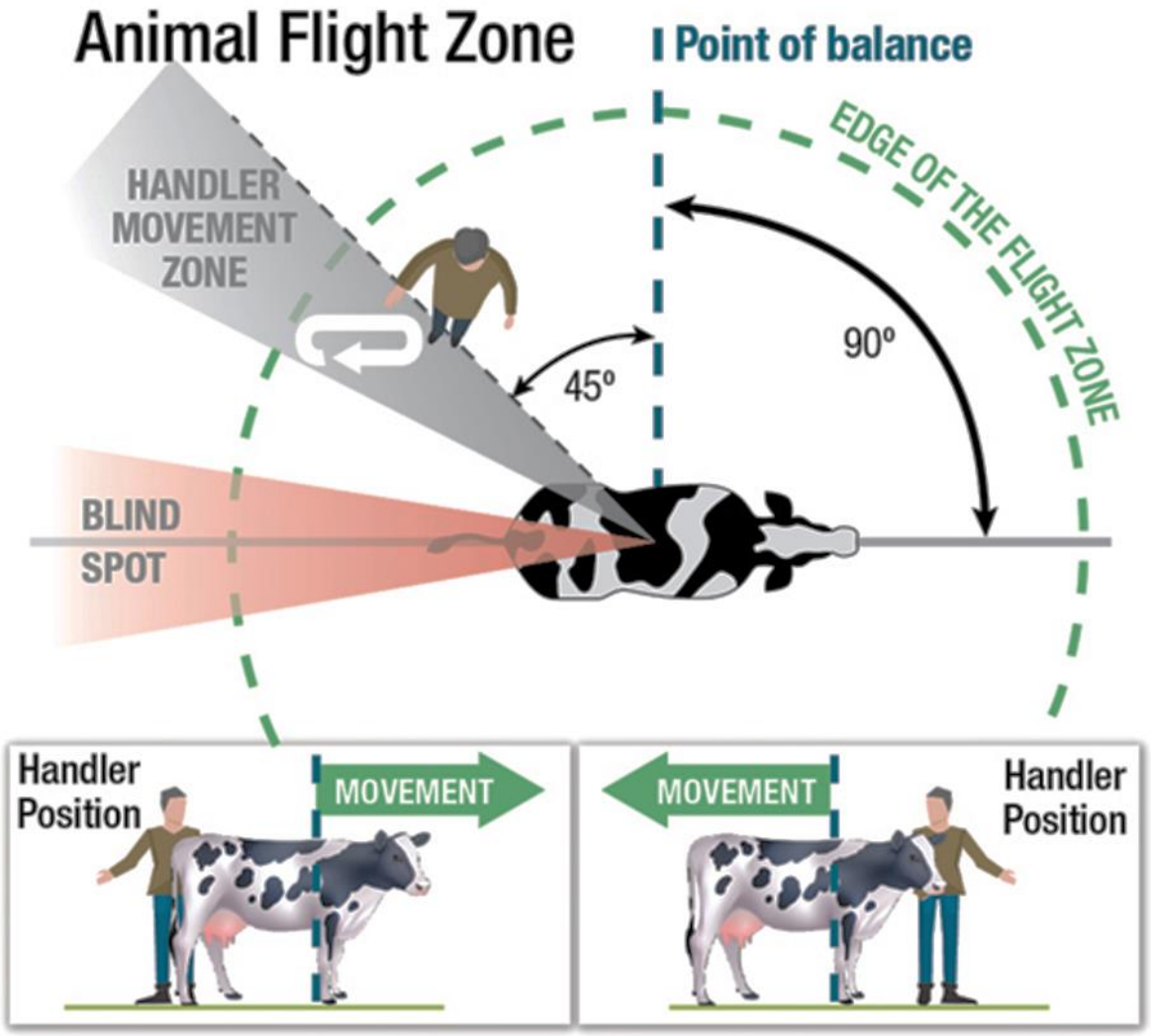
'A good deed done to an animal is commendable as a good deed done to a human being while an act of unkindness to an animal is as bad as an act of cruelty to a human being' (Abu Dawud and At-Tirmidhi).

'Fear Allah in these silent animals, and ride them while they are suitable to be ridden, and let free when they need to rest' (Abu Dawud).

Pre-Slaughter Handling

- The manner whereas livestock are mustered, yarded, handled, transported, restrained, slaughtered, and exanguinated can affect their welfare and final meat quality (Farouk et al., 2014).
- The handling of animals for slaughter is composed of a series of procedures that are quite uncommon and therefore stressful for them (Peres et al., 2014). Moreover, handling the animals during pre-slaughter and is the main aspect can influence the quality of meat and meat products.
- The pre-slaughter handling consists of the animals both on the farm and during the transport (loading/displacement/landing), at lairage, and finally on their way to be stunned and slaughtered.

Flight zone


Animal Flight Zone
Point of balance
EDGE OF THE FLIGHT ZONE
HANDLER MOVEMENT ZONE
45º
90º
BLIND SPOT
Handler Position
MOVEMENT
MOVEMENT
Handler Position

binocular vision

clear vision up to the shoulder

reduced vision behind the shoulder

blind spot behind the animal

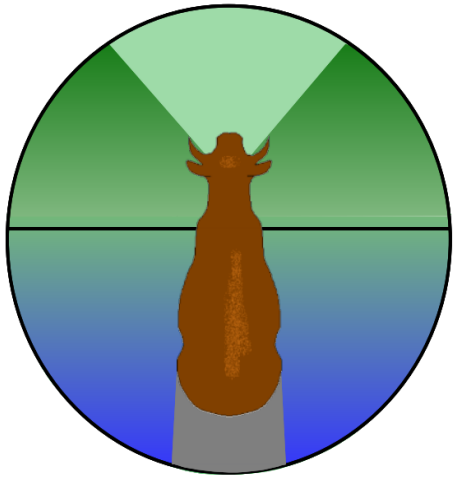
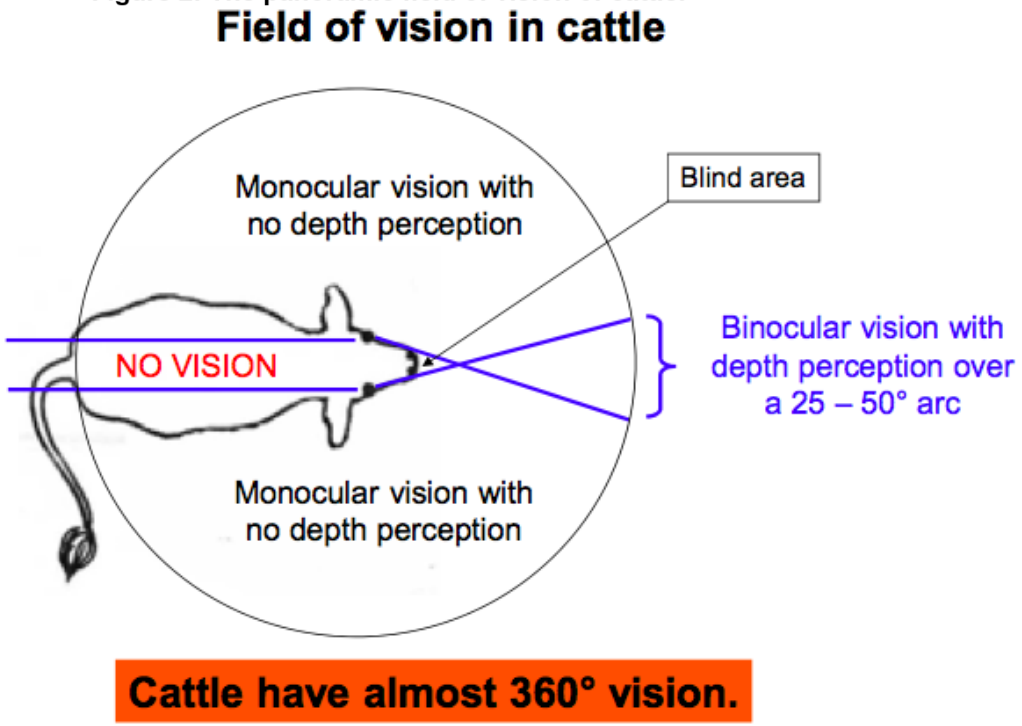
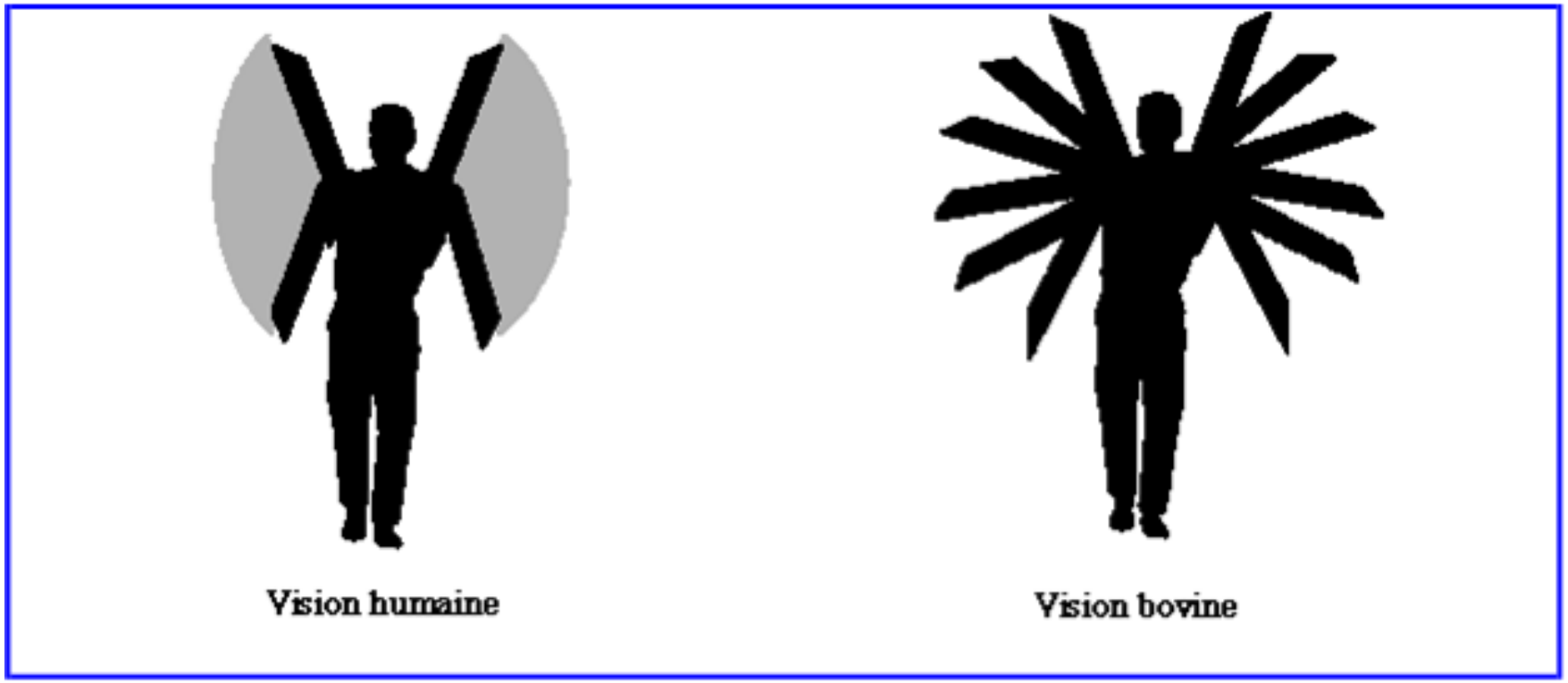


Figure 2: The panoramic field of vision of cattle.

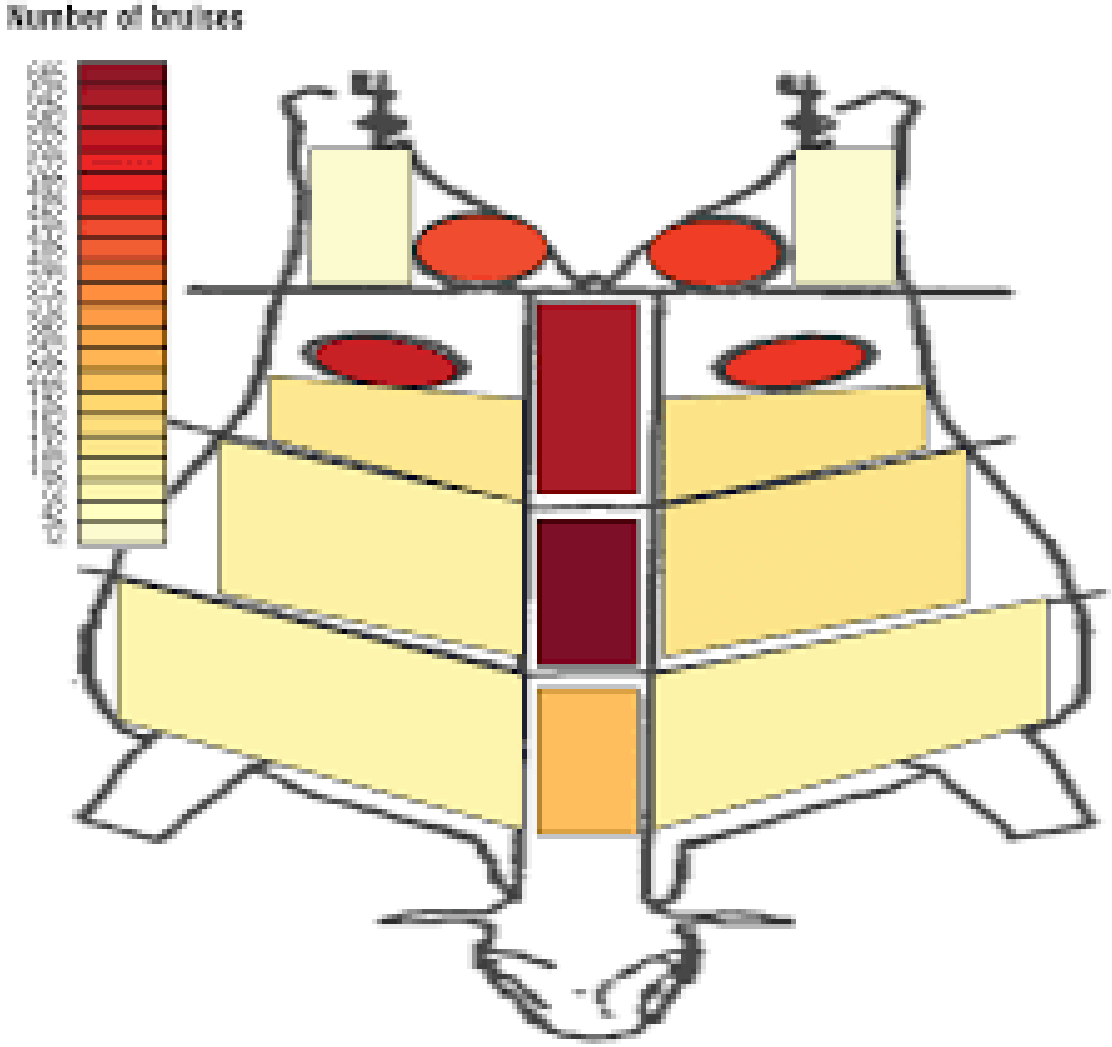


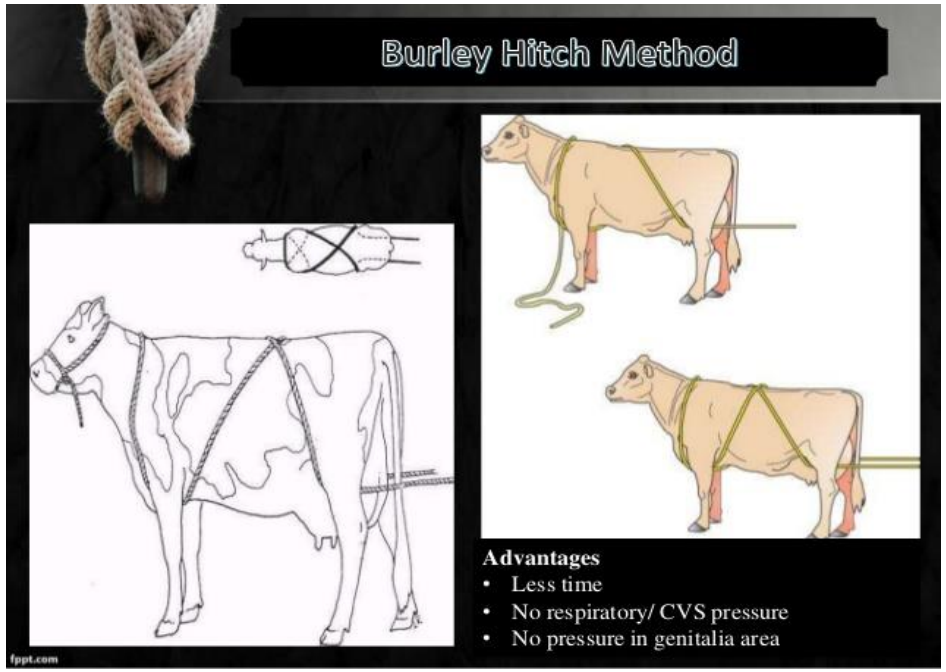
1. Vertical vision of cattle is limited to about 60 degrees.
2. An animal must lower its head to focus on the ground. Therefore, it is advisable to give cattle time to put their heads down to judge flooring during handling.
3. Cattle may balk less in handling facilities that are uniform in color.

Perception of movements in humans and cattle.

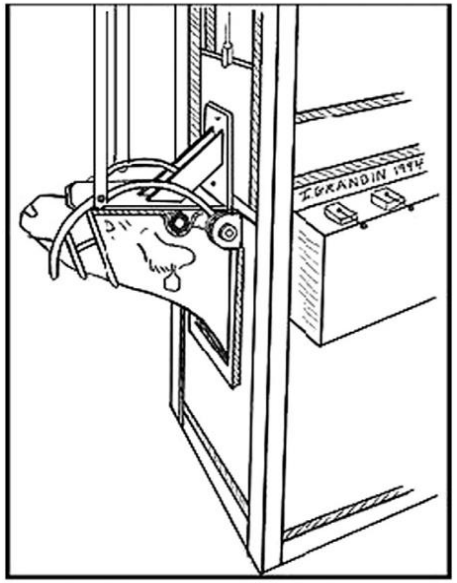


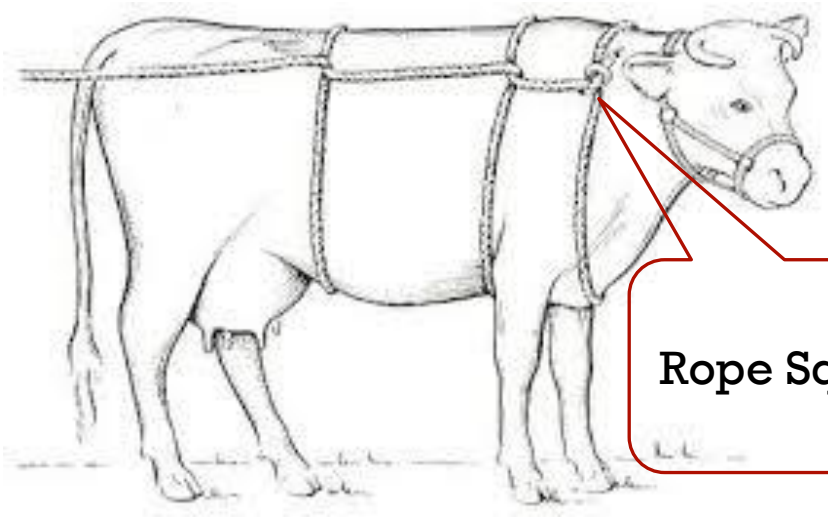
Bruising counts by body location, all plants



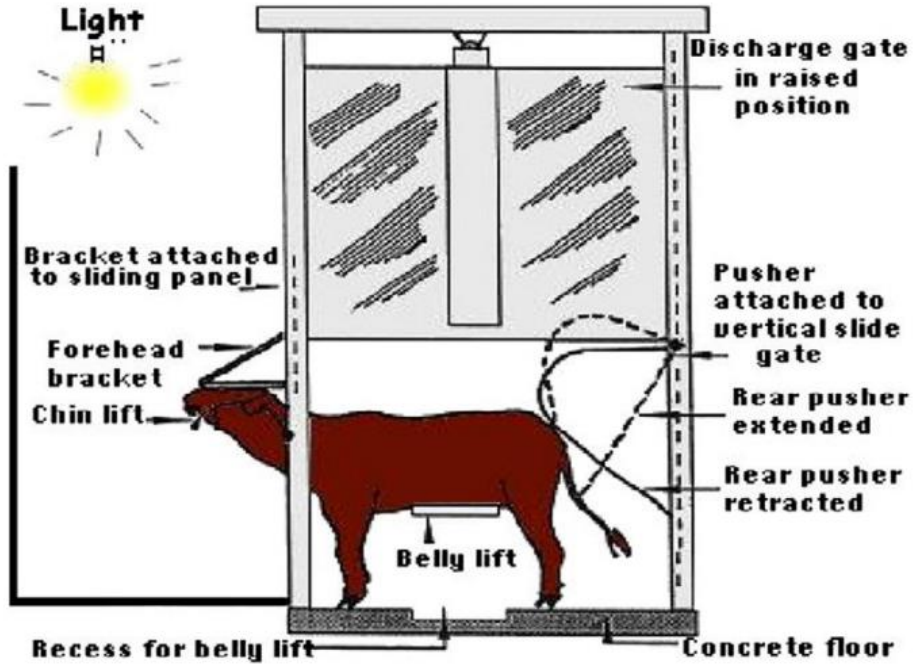


Manual VS Automation





Rope Squeeze



Side view of a modified American Society for the Prevention of Cruelty to Animals (ASPCA) pen (Source: Grandin & Regenstein, 1994).

The pre-slaughter handling practice on traditional slaughter house in Thasala district showed poor of animal handling start from lairage area until overthrow practice to the animals before slaughter.

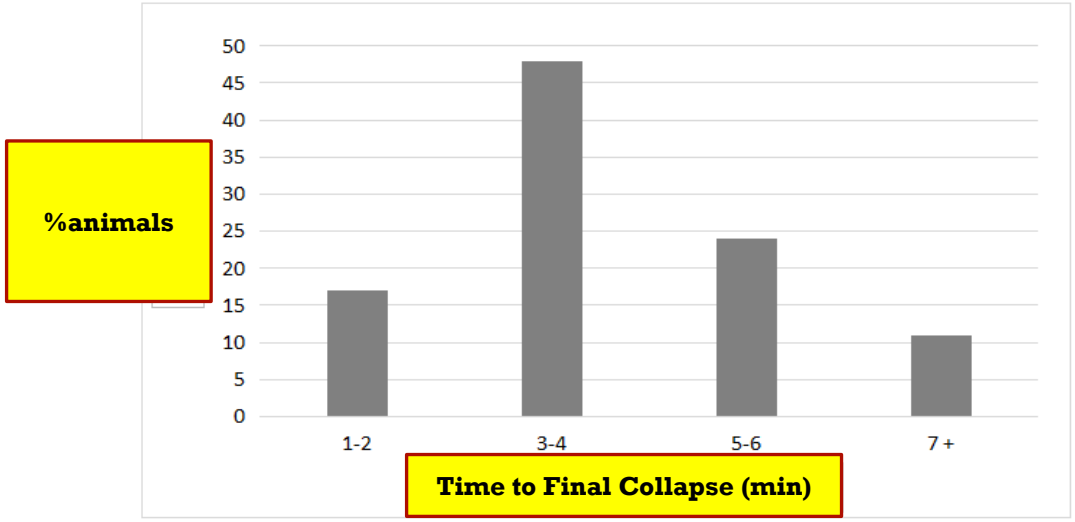
Variables	Abattoir (A) (n=6)	Abattoir (B) (n= 4)	Abattoir (C) (n=8)
Slips	3	2	4
Falls	1	0	2
Reversing	3	3	5
Jumps	1	1	1
Aggresion	4	2	4
Vocalizing	4	3	5

The animal welfare indicators were shown for slips and reversing was happened more than 50 - 62.5% cases

From three traditional Halal slaughter houses had shown more than 60% beef cattle undergone vocalizing due to poor practice animal handling, start from loading, unloading, lairage/barnyard, and slaughtering area (slaughtering/sticking process.

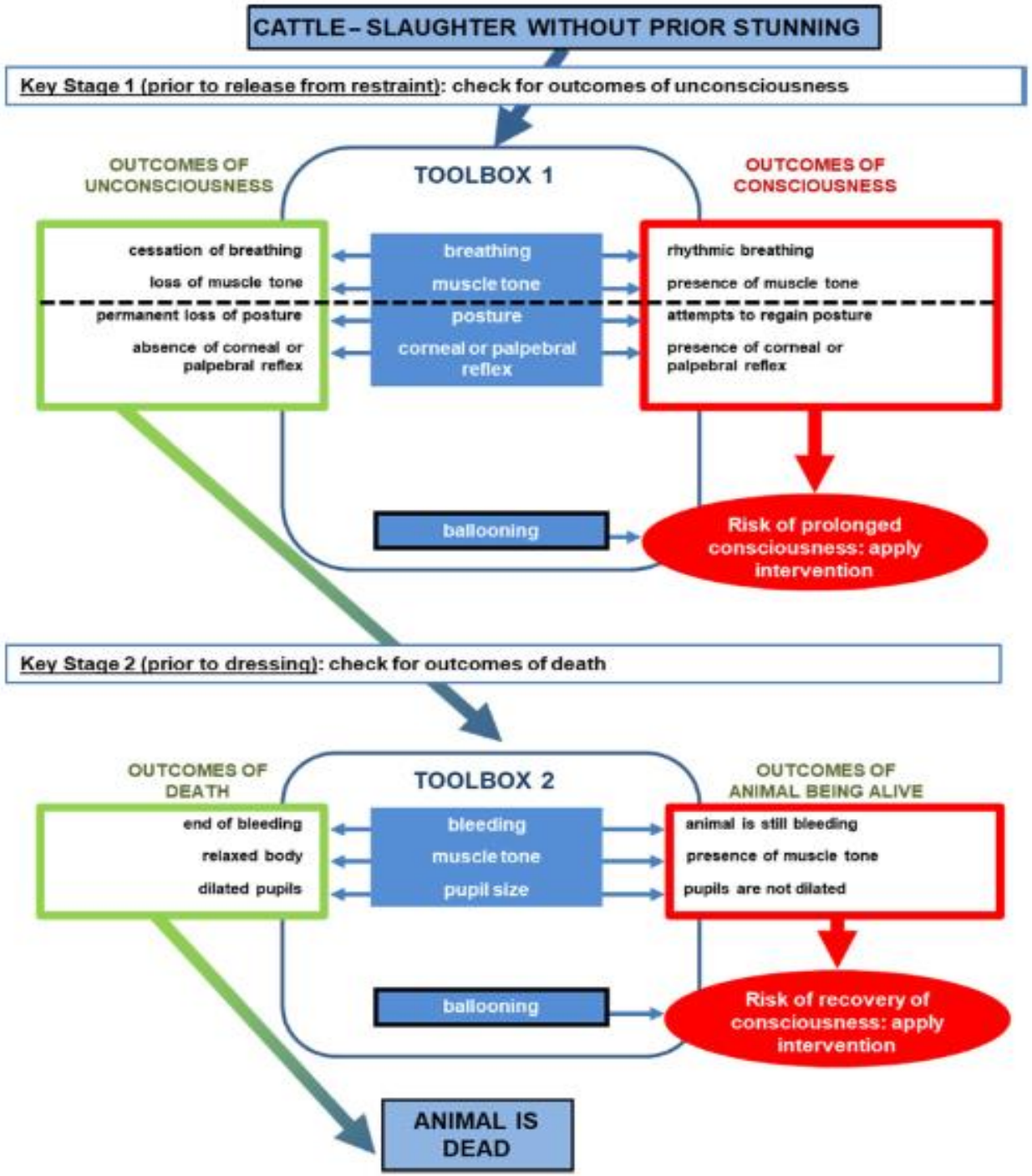
Characteristics of Thai native beef slaughtered by traditional Halal method

The Impact of Pre-Slaughter and Slaughter Procedure on Animal Welfare and Behavior Changes in Cattle at Local Abattoir in Samarinda-Indonesia 2020-2021



Indicators of consciousness and unconsciousness	Percentage
did not show signs of sensibility	2,8
eye corneal reflex	1,4
reflex to straighten the head and / or body	57,0
voice	69,0
rhythmic breathing	21,1
tail movement	82,4

A total 142 Bali cattle were observed and slaughtered at an abattoir in Samarinda-indonesia



EFSA Journal

SCIENTIFIC OPINION

ADOPTED: 24 September 2020

doi: 10.2903/j.efsa.2020.6275

Welfare of cattle at slaughter

EFSA Panel on Animal Health and Welfare (AHAW),
Søren Saxmose Nielsen, Julio Alvarez, Dominique Joseph Bicout, Paolo Calistri, Klaus Depner, Julian Ashley Drewe, Bruno Garin-Bastuji, Jose Luis Gonzales Rojas, Christian Gortázar Schmidt, Virginie Michel, Miguel Ángel Miranda Chueca, Helen Clare Roberts, Liisa Helena Sihvonen, Hans Spoolder, Karl Stahl, Antonio Velarde, Arvo Viltrop, Denise Candiani, Yves Van der Stede and Christoph Winckler

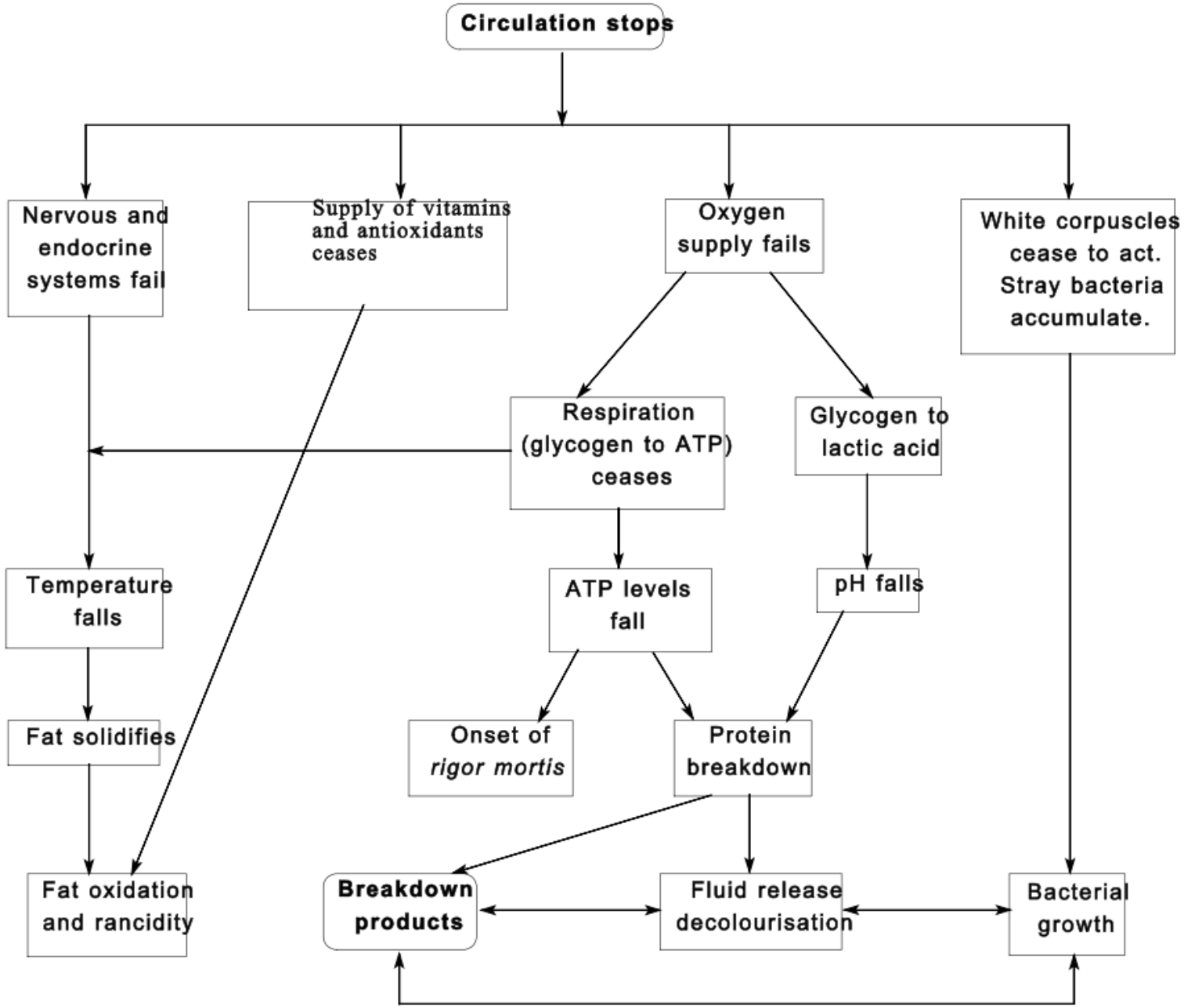
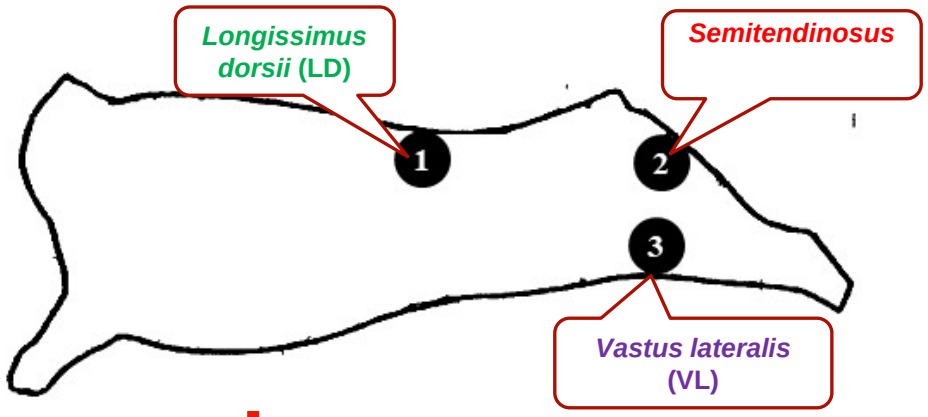


Figure 2 - The changes in meat after slaughter

9 SAMPLES FROM 3 beef cattle (3 PARTS OF RETAIL CUTS)



1. It was packed using tray and PE plastics
2. Stored at 5°C (chilled storage) for 7 days.

- At 3 h, 24 h, 48 h, d 3, d 5, and d 7 post-mortem, physicochemical analyses including pH, expressible drip, cooking loss, hardness and color were performed.
- The other lots of samples were chilled storage for 21 h at 5 °C to achieve the total 24 h post-mortem and physicochemical parameters were analyzed again. The chemical compositions including moisture, protein, fat, ash, zinc, iron, myoglobin content, myoglobin redox, TBARS were determined at d 0, 24 h 48 h, d 3, d 5, and d 7 post-mortem. Samples were kept on ice during preparation and analysis.

PHYSICOCHEMICAL PROPERTIES

Attributes	*Semitendinosus*	*Longissimus dorsi*	*Vastus lateralis*
pH $_{(3\ h)}$	6.83±0.57^{b}	6.26±0.57^{a}	6.93±0.20^{b}
pH $_{(24\ h)}$	5.83±0.57^{a}	5.83±0.20^{a}	6.40±0.20^{b}
Expressible drip $_{(3\ h)}$ **(%)**	8.03±1.91^{b}	9.74±3.72^{a}	7.45±3.51^{c}
Expressible drip $_{(24\ h)}$ **(%)**	16.57±4.35^{b}	17.62±1.40^{c}	15.50±1.75^{a}
Cooking loss $_{(3\ h)}$ **(%)**	11.50±5.91^{b}	12.70±2.28^{c}	8.68±1.62^{a}
Cooking loss $_{(24\ h)}$ **(%)**	16.64±1.15^{b}	17.90±1.52^{c}	15.89±0.67^{a}
Hardness $_{(3\ h)}$ **(N)**	10.24±4.09^{b}	7.37±3.67^{a}	10.45±3.98^{b}
Hardness $_{(24\ h)}$ **(N)**	9.45±2.59^{b}	7.35±1.57^{a}	9.50±2.59^{b}

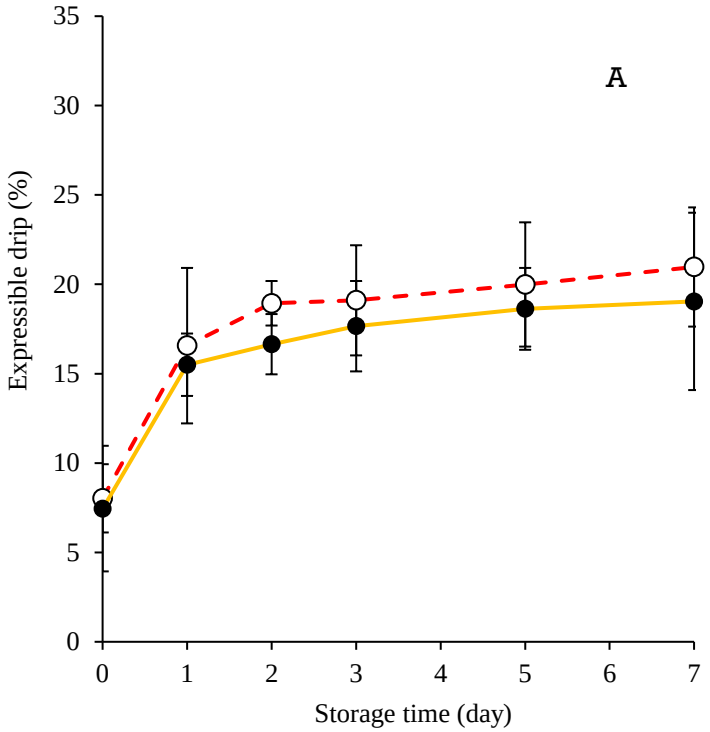
Table. pH, expressible drip, cooking loss and hardness of three beef cuts, *Semitendinosus*, *Longissimus dorsi* and *Vastus lateralis*, slaughtered by traditional Halal method

Color of three beef cuts

Color	Semitendinosus	Longissimus dorsi	Vastus lateralis
Color (3 h)			
L*	27.64±0.73^{c}	24.11±1.94^{a}	26.10±1.49^{b}
a*	7.07±1.24^{b}	5.74±0.96^{a}	5.66±0.84^{a}
b*	6.63±0.73^{c}	3.73±0.69^{a}	5.26±0.78^{b}
Color (24 h)			
L*	25.50±1.34^{b}	24.11±1.36^{a}	27.13±1.67^{c}
a*	10.29±1.24^{a}	9.50±0.96^{a}	10.90±0.84^{a}
b*	11.66±0.73^{b}	9.21±0.69^{a}	9.10±0.78^{a}

EXPERIMENT 4

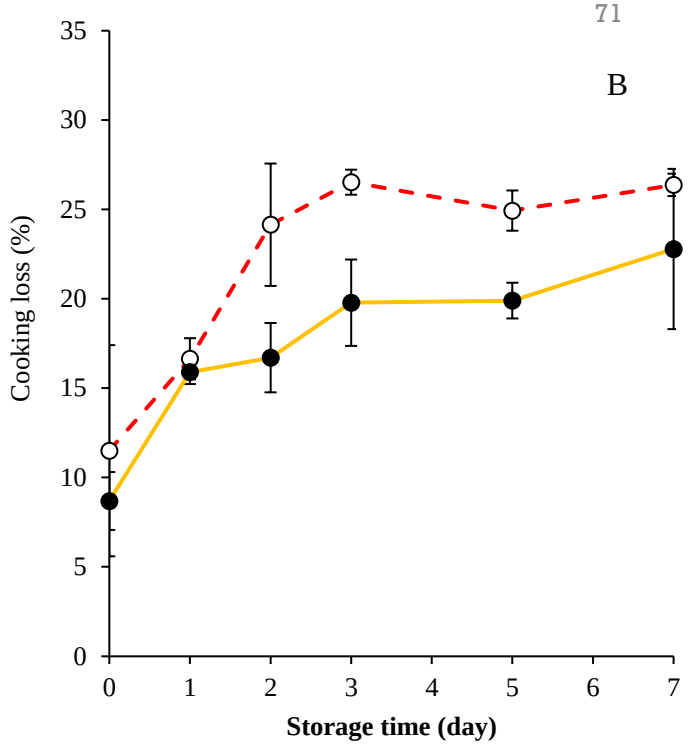
Changes in expressible drip and cooking loss



DRIP LOSS

- There were no significantly different on percentage of expressible drip between ST and VAL at the beginning of chilled storage ($P > 0.05$).
- ST tended to give high percentage of expressible drip numerically compared to VAL.

COOKING LOSS

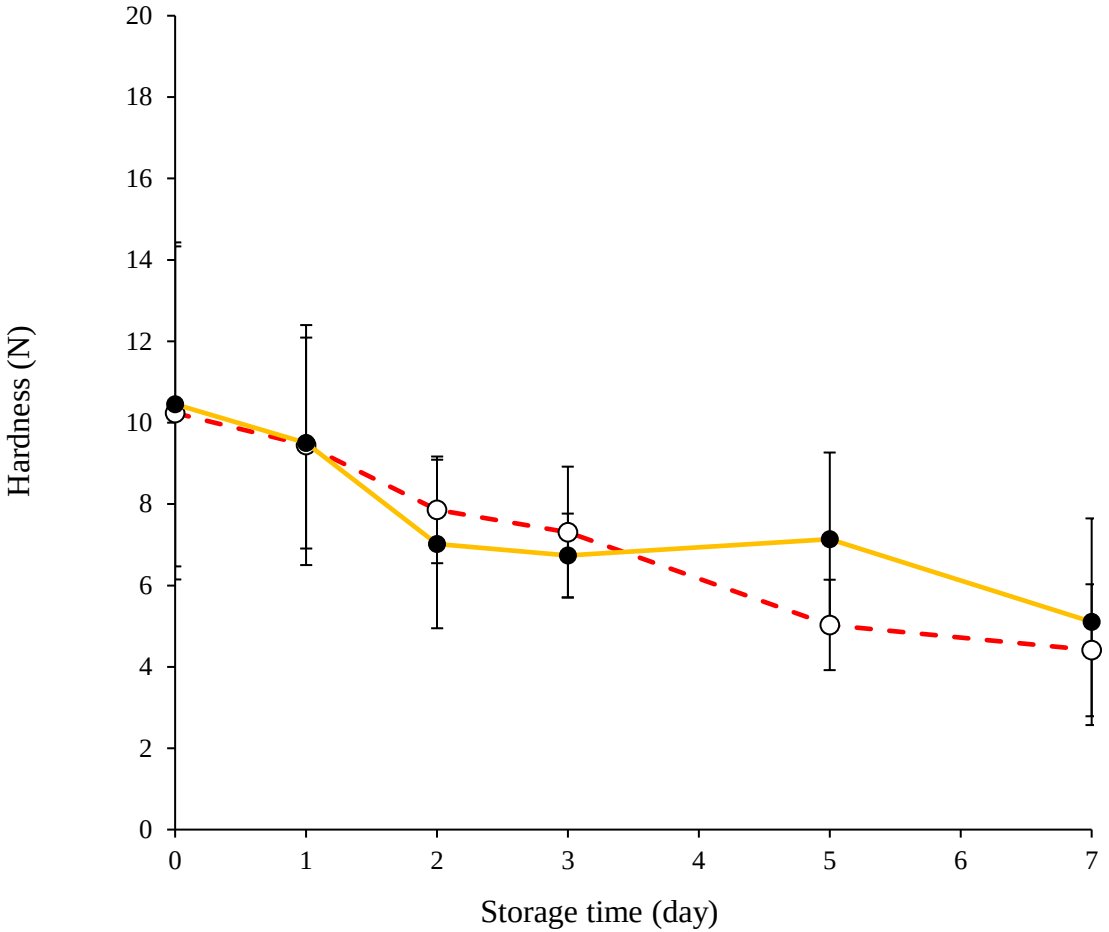


- There was not significantly different in cooking loss between ST and VAL during chilled storage at day 0 and day 1 ($P > 0.05$). However, the differences were found markedly from day 2 until the end of storage ($P < 0.05$)

Changes in expressible drip (A) and cooking loss (B) of ST (○) and VAL (●) from Thai native cattle during chilled storage. Bars represent the standard deviation from triplicate determinations.

EXPERIMENT 4

Changes in hardness



Changes in hardness of ST (○) and VAL (●) from Thai native cattle during chilled storage. Bars represent the standard deviation from triplicate determinations.

- There were not any differences statistically on hardness between two beef cuts during 7 days of storage ($P > 0.05$) and hardness of both cuts tended to decrease throughout the storage.
- After 7 days, hardness of VAL and ST decreased by approximately 51 and 57% when compared to day 0.
- Decreases of hardness values in both cuts may probably due to the proteolytic enzyme system and ultimate pH

OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

Critical Factors Affecting the Quality of the Longissimus Lumborum from Native Thai Cattle (*Bos indicus*)

Ari Wibowo[1*], Suhardi[1], Khoiru Indana[1], Krishna Purnawan Chandra[1], Manat Chaijan[2], Zuraida Hanum[3]

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Abstract | Colour is one of the important parameters determining the purchasing decision of consumer and it's also become a challenging errand for the meat industry. The colour of meat itself is administered by the concentration and redox stage of myoglobin which that myoglobin underwent denaturation and oxidation in the presence of external triggers such as pH and temperature. Hence this study aimed to investigate the effect of chilled storage on the physicochemical changes and oxidative deterioration of *Longissimus lumborum* and their interrelationships between these traits from native Thai cattle. Physicochemical changes and oxidative deterioration of the *Longissimus lumborum* from native Thai cattle (n=3 female, 36 months, live wt. 350 kg) during storage at 5°C from day 0 to 7 was investigated. Muscle pH decreased (6.26±0.05 to 5.53±0.32) and expressible drip increased (9.74 to 20.66) during storage and were highly correlated (R^2 = 0.97). Autooxidation of oxymyoglobin followed a first-order kinetic model as steaks became more discolored as the redness index (a*/b*) decreased over time (1.55±0.12 to 1.02±0.05). Lipid oxidation increased during storage, where the thiobarbituric acid reactive substances (TBARS) (0.98±0.02 to 1.25±0.01) and it was correlated with percentage metmyoglobin (R^2 = 0.91). *Longissimus lumborum* from native Thai cattle developed PSE-like meat as it became paler (greater L* values) soft and exudative (greater values for expressible drip and cooking losses). Values for muscle hardness gradually declined during storage, indicating a greater tenderness after 7 days of aging. Therefore, it can be concluded that these data indicate that the meat from native Thai cattle improved by controlling the critical factors (muscle pH, expressible drip, cooling losses, meat color, and color stability) during rigor development and post-mortem storage.

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Citation | Wibowo A, Suhardi, Indana K, Chandra KP, Chaijan M, Hanum Z (2021). Critical factors affecting the quality of the longissimus lumborum from native thai cattle (*bos indicus*). Adv. Anim. Vet. Sci. 9(8): xx-xx.
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ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331

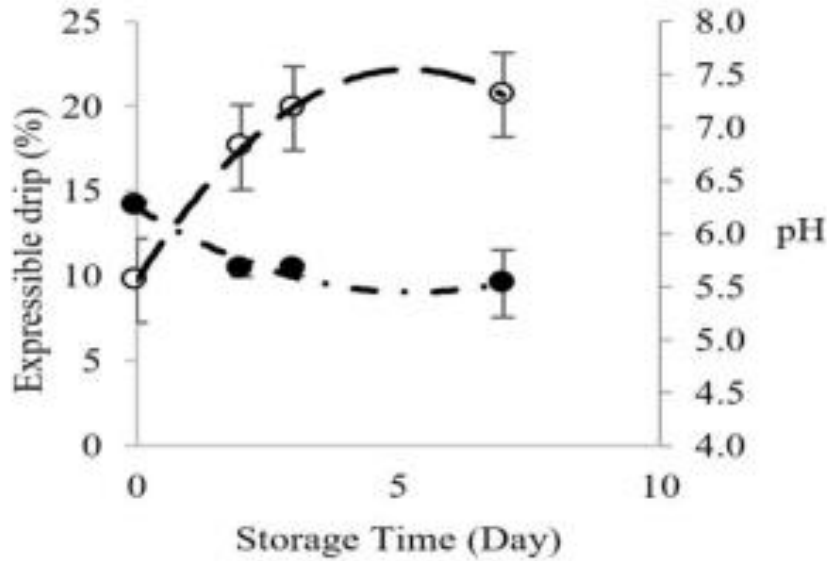


Figure 1: Changes inexpressible drip (○) and pH () of *Longissimus lumborum* from Thai native cattle during chilled storage (15 °C). Bars indicate standard deviation from triplicate determinations. Pearson Product-Moment Correlation between the two parameters is 0.9695.

TABLE 14.1 Water Distribution in Muscles of Live Animals (pH ~ 7) and Meat (pH 5.3–5.8). All Values Are Approximate

	Water (%)	
	Muscle	Meat
Protein-bound water	1	1
Intramyofibrillar	80	75
Extramyofibrillar	15	10
Extracellular water	5	15

Reproduced and adapted from Honikel, K.O., 2009. Moisture and water-holding capacity. In Nollet, L.M.L., Toldra, F. (Eds.), Handbook of Muscle Foods Analysis, CRC Press, Boca Raton, Florida.

In muscle prone to the PSE condition, the high temperatures (HTs) shortly after slaughter (35–42°C) and the low pH, caused by rapid glycolysis, lead to myosin denaturation along with early membrane destruction. When the myosin head denatures, it shrinks from 19 to 17 nm causing a shrinkage in the myofibrillar lattice in addition to the shrinkage due to the low pH (Offer and

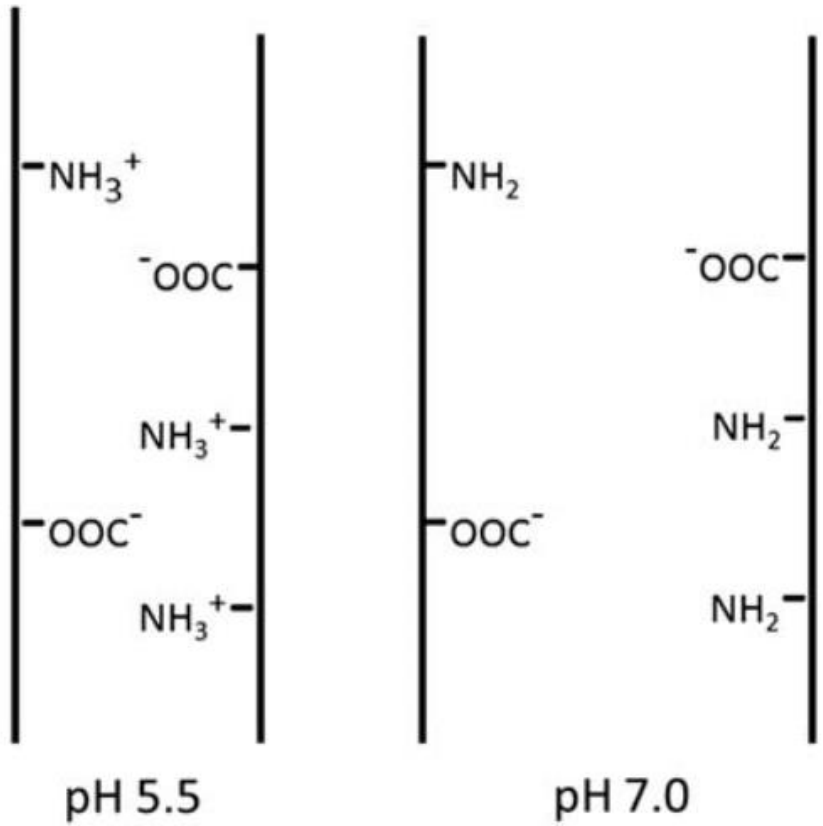


FIGURE 14.1 Schematic of protein shrinkage by changes in pH from muscle (pH 7) to meat (pH 5.5). Owing to the increase of positive charges of side chains (–NH2 → –NH3+) the meat proteins approach the isoelectric point of 5.0–5.2 (see Fig. 14.2). The structure shrinks due to the attraction of the opposite electric charges of the side chains and it leaves less space for water molecules in between. *Reproduced from Honikel, K.O., 2009. Moisture and water-holding capacity. In: Nollet, L.M.L., Toldra, F. (Eds.), Handbook of Muscle Foods Analysis, CRC Press, Boca Raton, Florida.*

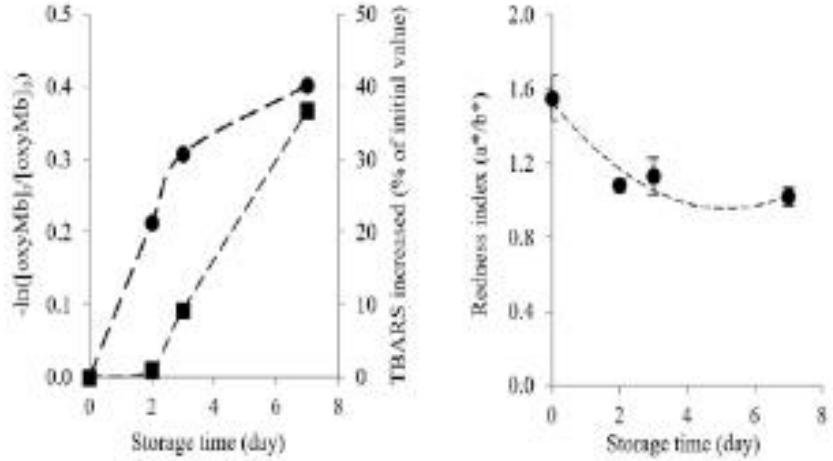


Figure 2: Changes in oxymyoglobin autooxidation rate () and percentage of TBARS increased (■) (a) and changes in redness index (b) of *Longissimus lumborum* from Thai native cattle during chilled storage. Bars indicate standard deviation from triplicate determinations. Pearson Product Moment Correlation between the redness index and autooxidation of oxymyoglobin is 0.8516.

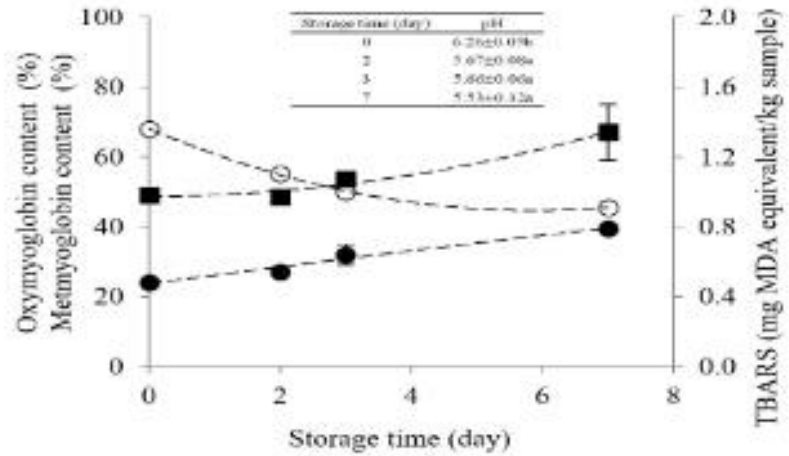


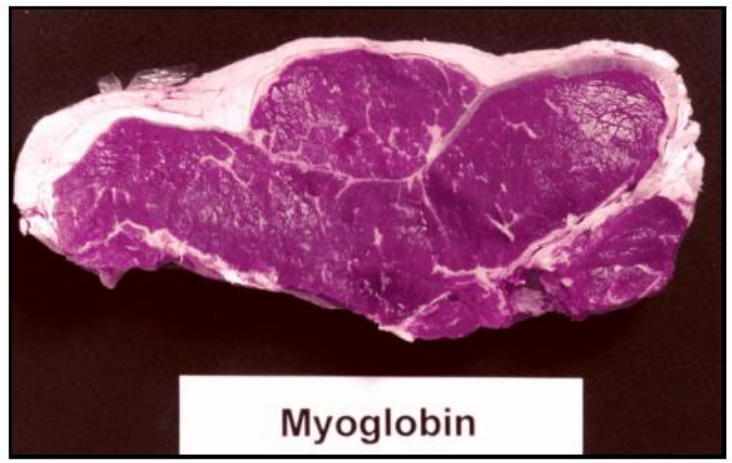
Figure 3: Changes in oxymyoglobin content (○), metmyoglobin content (), and TBARS (■) of *Longissimus lumborum* from Thai native cattle during chilled storage. Bars indicate standard deviation from triplicate determinations. Pearson Product Moment Correlation between the formation of metmyoglobin and TBARS content is 0.9144.

Basic Meat Color

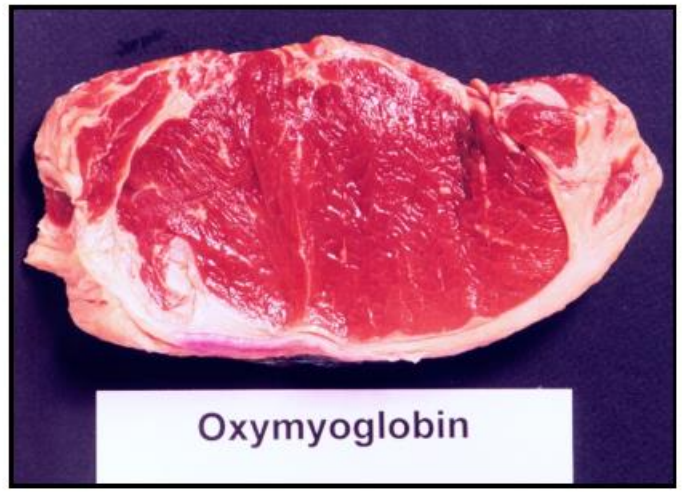
The first impression consumers have of any meat product is its color and thus color is of utmost importance. The color of meat may vary from the deep purplish-red of freshly cut beef to the light gray of faded cured pork. Fortunately, the color of meat can be controlled if the many factors that influence it are understood.

Fresh and cured meat color both depend on myoglobin, but are considerably different from each other in terms of how they are formed and their overall stability.

Myoglobin is a water-soluble protein that stores oxygen for aerobic metabolism in the muscle. It consists of a protein portion and a nonprotein porphyrin ring with a central iron atom. The iron atom is an important player in meat color. The defining factors of meat color are the oxidation (chemical) state of the iron and which compounds (oxygen, water or nitric oxide) are attached to the iron portion of the molecule.

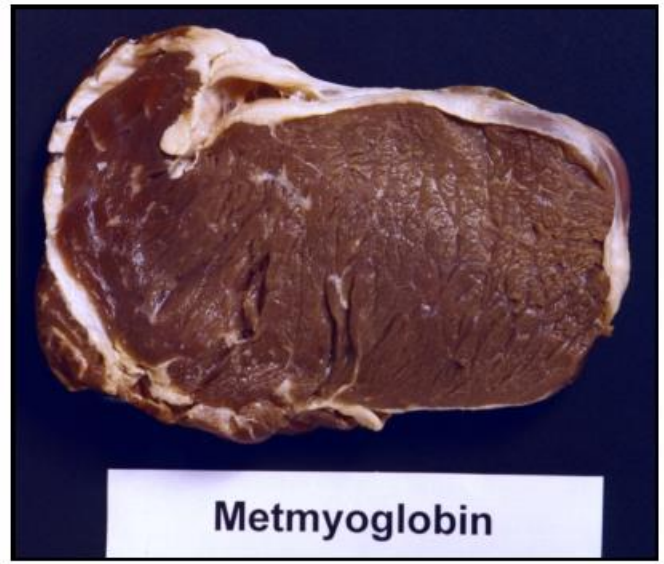


Fresh cut meat surface. The meat pigment is myoglobin.



Striploin steaks allowed to bloom to oxymyoglobin.

Myoglobin and oxymyoglobin have the capacity to lose an electron (called oxidation) which turns the pigment to a brown color and yields metmyoglobin. Thus, myoglobin can change from a dark purple color to a bright red color simply from oxygenation or to a brown color by losing electrons. The pigments myoglobin, oxymyoglobin and metmyoglobin can be changed from one to the other, depending on the conditions at which the meat is stored. After cooking, a brown pigment called denatured metmyoglobin is formed, which normally cannot be changed to form another pigment.



Striploin steak that has been stored and metmyoglobin has formed

Oxymyoglobin, commonly known as the fresh meat color, is the most desirable color for fresh meats. Maintaining this color requires that the meat surface be free from any contamination which would cause a chemical reaction resulting in the formation of the brown pigment metmyoglobin. Also, oxygen must be available at a sufficient concentration in order to combine with the myoglobin to form oxymyoglobin. This reaction is reversible and dependent on the availability of oxygen, active enzymes and reducing compounds in the muscle.

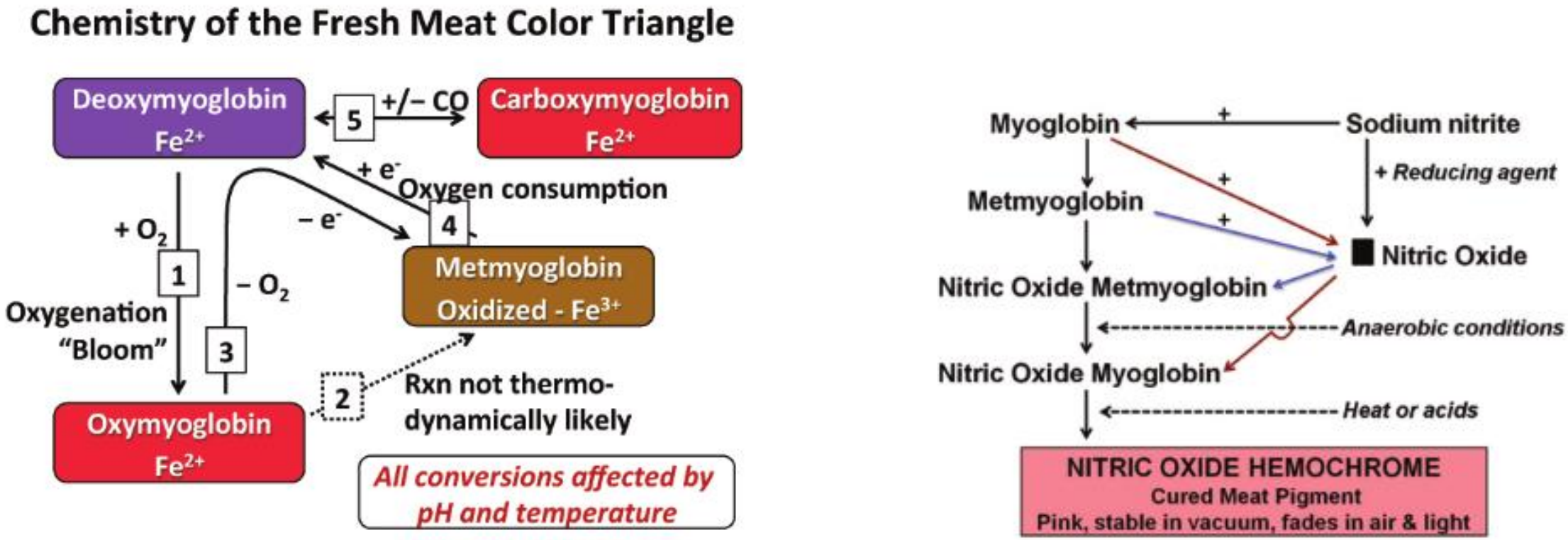
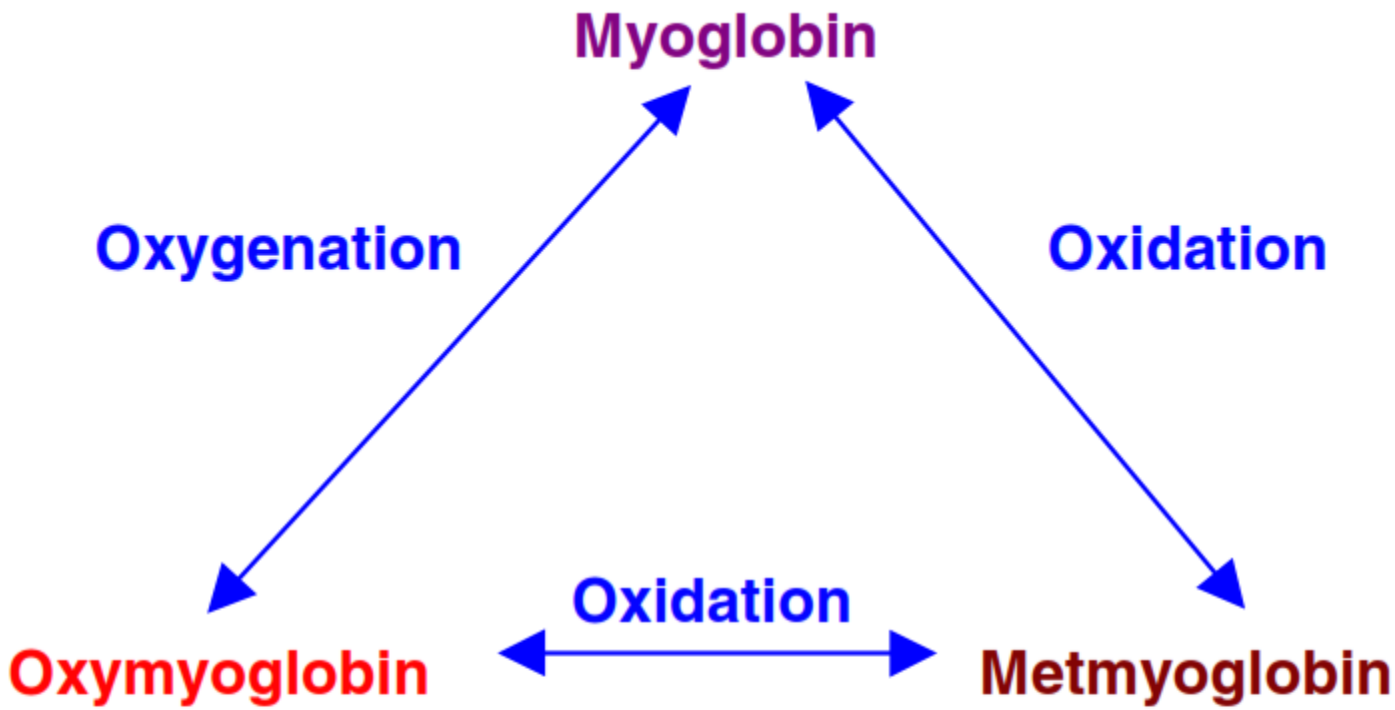
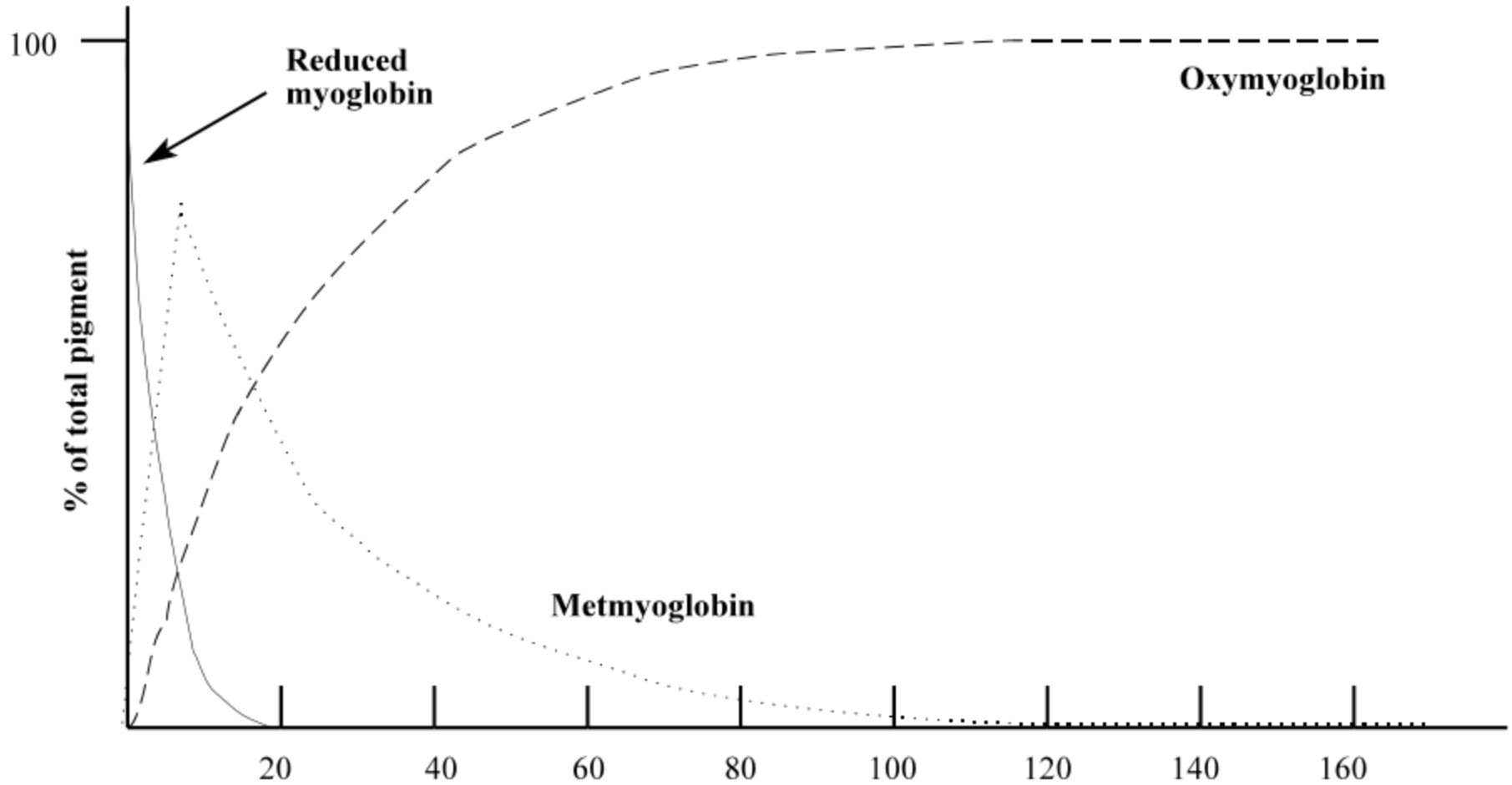


Figure 2.1. Schematic of the interconversions of myoglobin redox forms in fresh meat.
Courtesy of Drs. M. C. Hunt, Kansas State University and D. P. Cornforth, Utah State University.



Interconversion of meat pigments. Myoglobin when oxygenated is bright red in color and called oxymyoglobin. Both myoglobin and oxymyoglobin can lose an electron (oxidize) to form metmyoglobin


100
Reduced
myoglobin
Oxymyoglobin
% of total pigment
Metmyoglobin
20
40
60
80
100
120
140
160

BEEF:
Example of how meat colour is affected by ultimate pH

Effect of ultimate meat pH on the color of beef. Picture supplied by Arie Grafhuis, MIRINZ Food Research

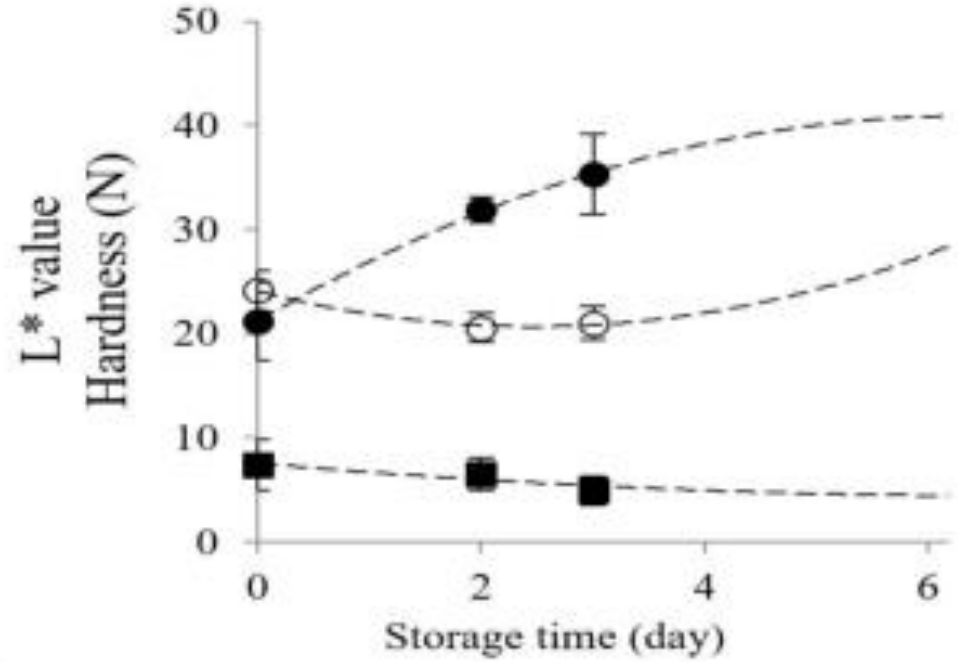


Figure 4: Changes in L* value (○), hardness (■), and cooking loss () of *Longissimus lumborum* from Thai native cattle during chilled storage. Bars indicate standard deviation from triplicate determinations.

Use of the knives and science slaughter

- The effectiveness of slaughtering and exsanguinations however have been a source of concern in that in some of cases occlusions can impede in bleed out rate and delay loss of consciousness (Wong and Ashton, 2015; Anil et al., 2006; Gregory et al., 2009).
- A saharp knife must be used to slaughter an animal to allow a quick flow of blood, and immediate loss of consciousness.

'Certainly, Allah has decreed proficiency in all things. Thus, …if you perform slaughter (zabh), perform it well (painlessly). Let each one of you sharpen his knife/blade and let him minimizes suffering his slaughters (zabiha die painlessly/peacefully)' (Awan, 2012).

animals

MDPI

Article

Effects of Slaughter Knife Sharpness on Blood Biochemical and Electroencephalogram Changes in Cattle

Jurhamid Columbres Imlan [1,2], Ubedullah Kaka [1,3], Yong-Meng Goh [1,4], Zulkifli Idrus [1,5], Elmutaz Atta Awad [1,6], Ahmed Abubakar Abubakar [1], Tanbir Ahmad [5,7], Hassan N. Quaza Nizamuddin [8] and Awis Qurni Sazili [1,5,9,*]

ANAGO Score		Relative Force Required to Cut
10.0	=	no force required
9.7	=	a tenth of the force required
9.5	=	less than a fifth of the force
9.0	=	less than half the force
8.5	=	two-thirds of the force
8.0	=	1 x force
7.5	=	a third more force
7.0	=	four-fifths more force, nearly twice as much
6.5	=	two and a half times as much force
6.0	=	more than three times as much force
5.5	=	four times as much force
5.0	=	nearly five and a half times as much force
4.5	=	seven times as much force
4.0	=	more than nine times as much force
3.5	=	13 times as much force
3.0	=	18 times as much force
2.0	=	42 times as much force

Table 2. Differences in the blood's biochemical parameters in cattle subjected to different knife sharpness.

Parameter	Treatment	Sampling Period			
		Pre-slaughter	Post-slaughter	*p*-value	Trt * Period
Glucose (mmol/l)	Sharp	5.21 ± 0.10 ^{a,x}	5.23 ± 0.16 ^{a,x}	0.9193	0.1387
	Commercial sharp	4.44 ± 0.05 ^{b,y}	4.83 ± 0.13 ^{a,x}	0.0167	
	p-value	<0.0001	0.0747		
Creatine kinase (U/l)	Sharp	448.20 ± 87.73 ^{a,x}	449.60 ± 94.49 ^{a,y}	0.9915	0.1636
	Commercial sharp	538.10 ± 74.31 ^{b,x}	753.30 ± 21.39 ^{a,x}	0.0123	
	p-value	0.4445	0.0057		
Lactate Dehydrogenase (U/l)	Sharp	1021.40 ± 18.68 ^{b,y}	1137.90 ± 47.86 ^{a,y}	0.0359	0.0578
	Commercial sharp	1639.70 ± 152.55 ^{b,x}	2122.60 ± 95.03 ^{a,x}	0.0151	
	p-value	.0008	<0.0001		

Table 3. Changes in catecholamine parameters in cattle subjected to different knife sharpness.

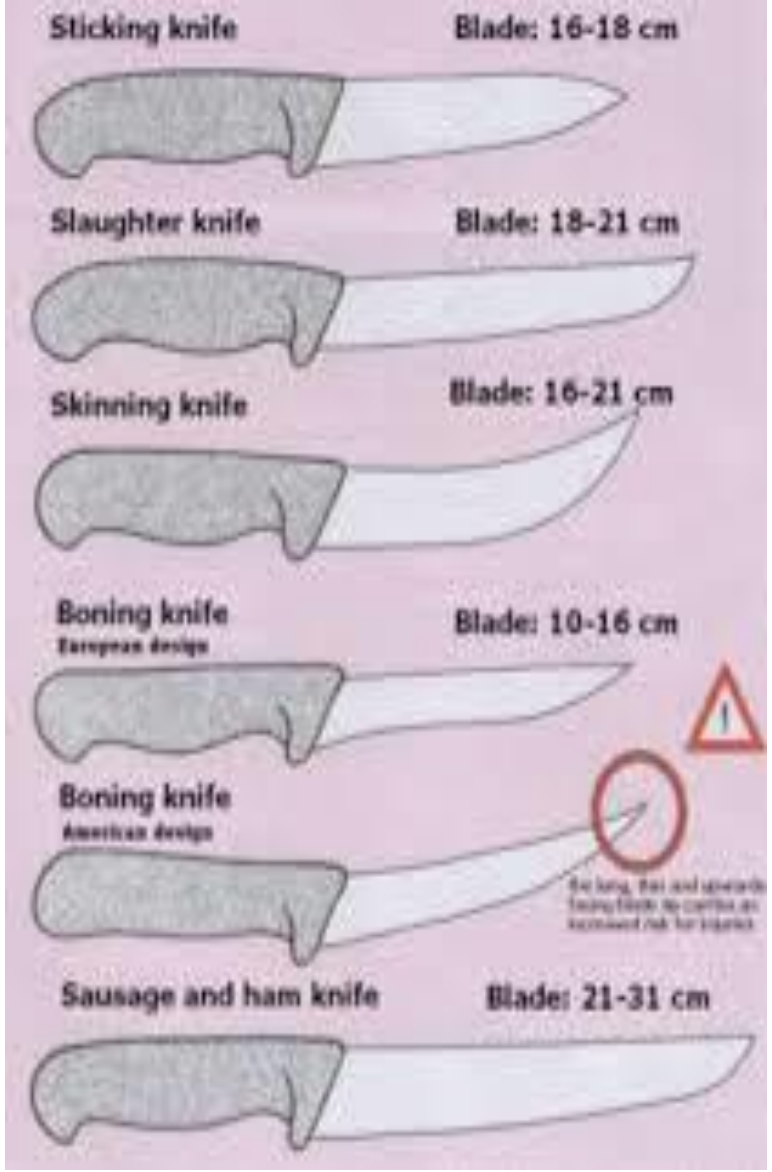
Parameter	Treatment	Sampling Period			
		Pre-slaughter	Post-slaughter	*p*-value	Trt * Period
Adrenaline (pg/mL)	Sharp	$728.01 \pm 1.51^{b,x}$	$1053.96 \pm 17.97^{a,y}$	<0.0001	<0.0001
	Commercial sharp	$732.78 \pm 2.69^{b,x}$	$1222.09 \pm 14.77^{a,x}$	<0.0001	
	p-value	0.1535	<0.0001		
Noradrenaline (pg/mL)	Sharp	$435.07 \pm 3.12^{a,x}$	$438.17 \pm 6.77^{a,y}$	0.6871	0.2974
	Commercial sharp	$459.54 \pm 12.5^{a,x}$	$482.37 \pm 11.24^{a,x}$	0.2057	
	p-value	0.0881	0.0072		

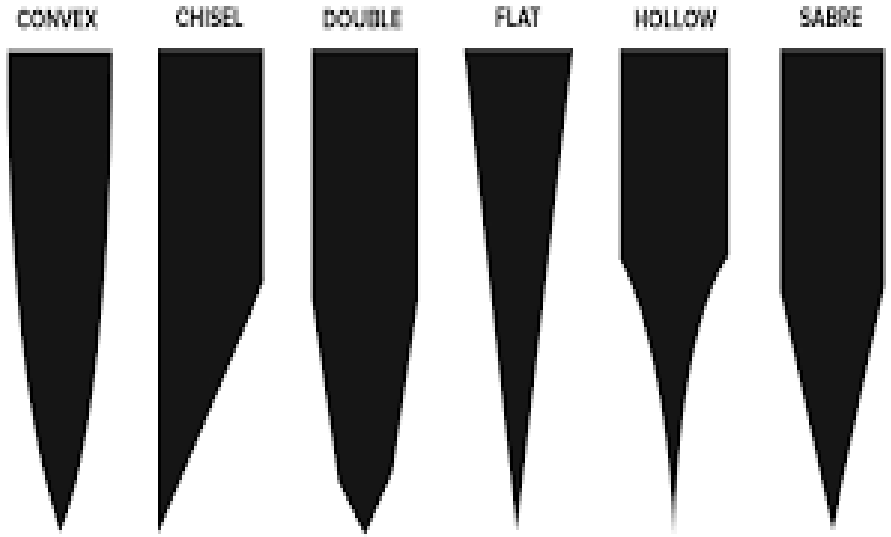
^{a,b} Means within the same row with different superscripts are significantly different at $p < 0.05$; ^{x,y} Means within the same column with different superscripts are significantly different at $p < 0.05$.

Deboning knife

Slaughtering knife

skinning knife





SHAPES OF BLADE

Knife handling

Figure 7 - Work Sharp electric belt sharpener used for testing

Figure 9 - Belt sharpened results showing 2.5 point drop in sharpness score after 60 cuts

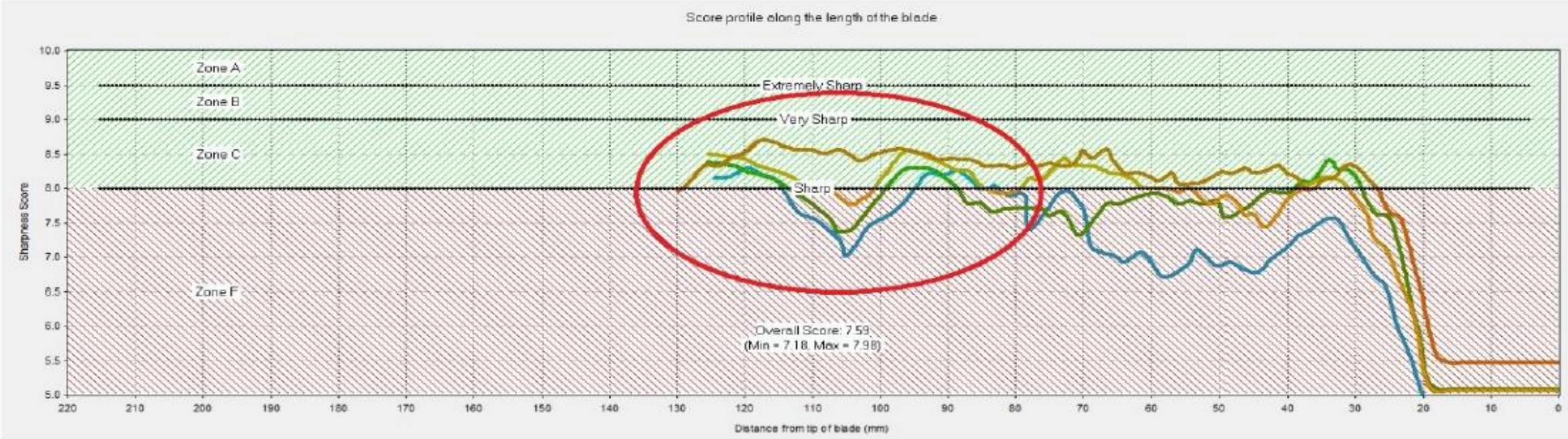
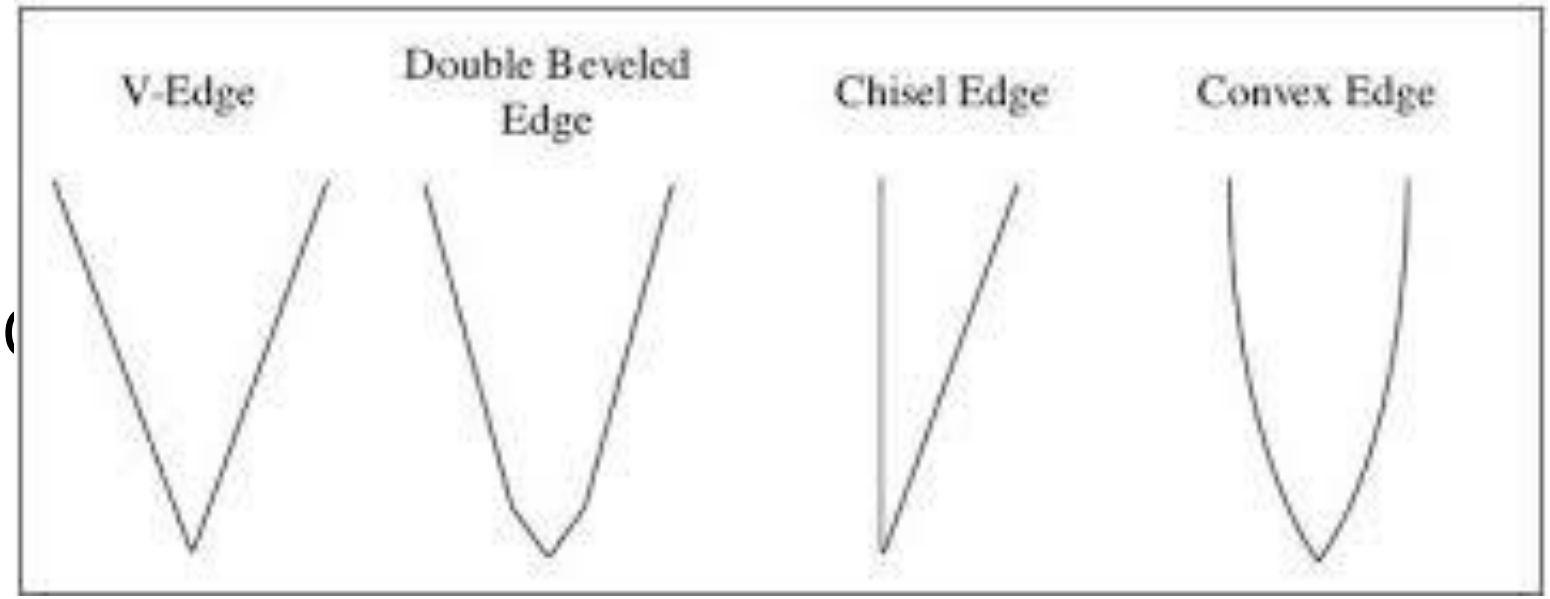


Figure 8 - Stone sharpened tests show a drop of 1.5 in the sharpness score after 90 cuts

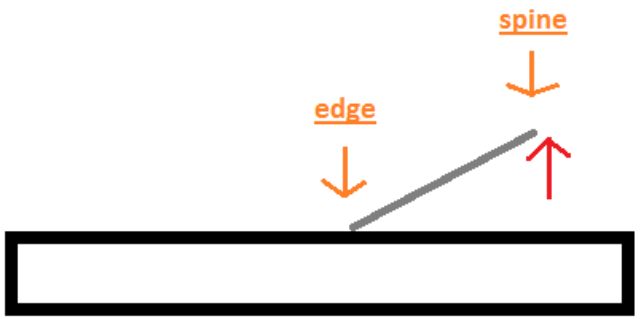
Bevel



sharpening stone

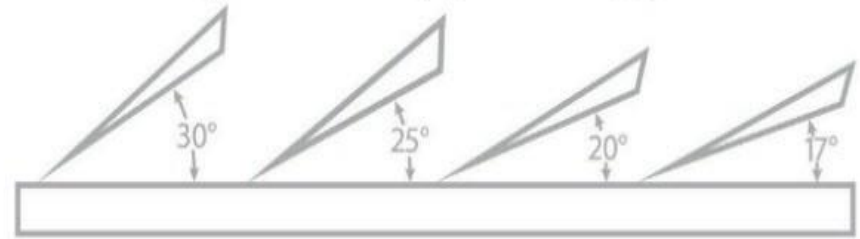
knife

angle in centimetres



if i wanted a scary sharp edge on my knife how many centimetres should i lift the spine of the blade off the stone?

Lansky Sharpening Angles

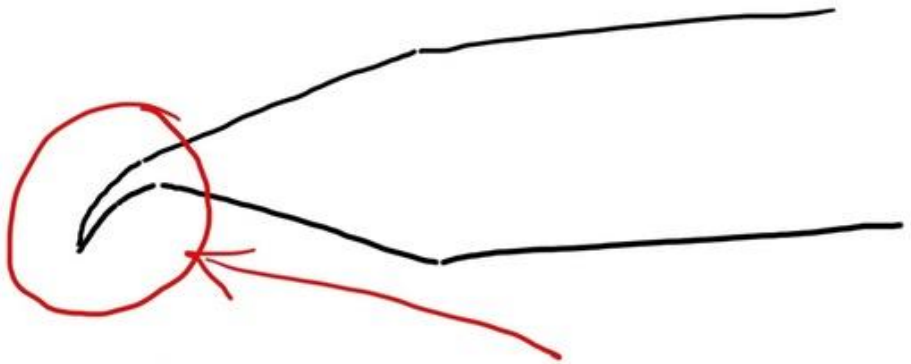


30° Recommended for heavy duty use.

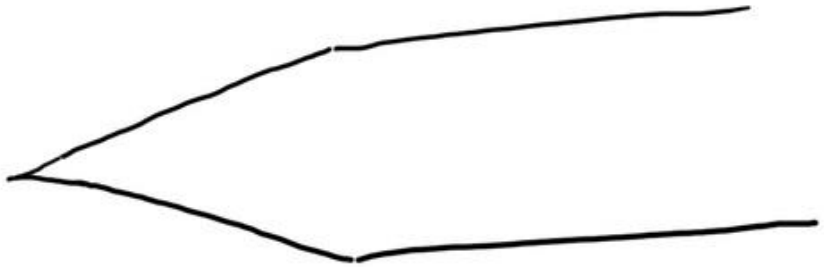
25° Ideal for hunting and outdoor knives.

20° Provides an excellent edge for kitchen cutlery.

17° A severe angle recommended for fillet knives, razor blades or similar tools.



Cross section of a cutting edge after use,
note the roll over where the comparatively
weak fine edge is out of alignment making it less effective.

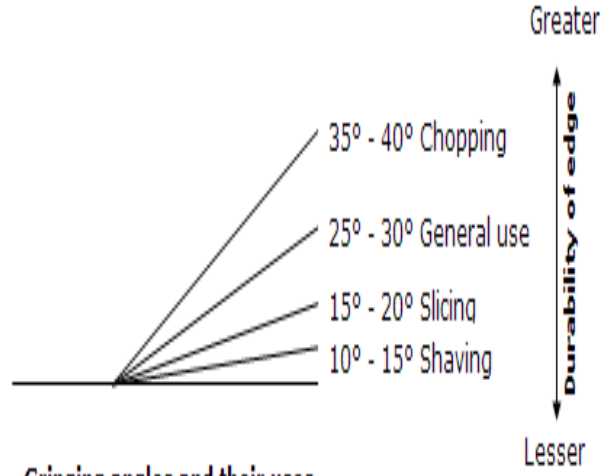


After honing the cutting edge is realigned for maximum sharpness.

FEATURES

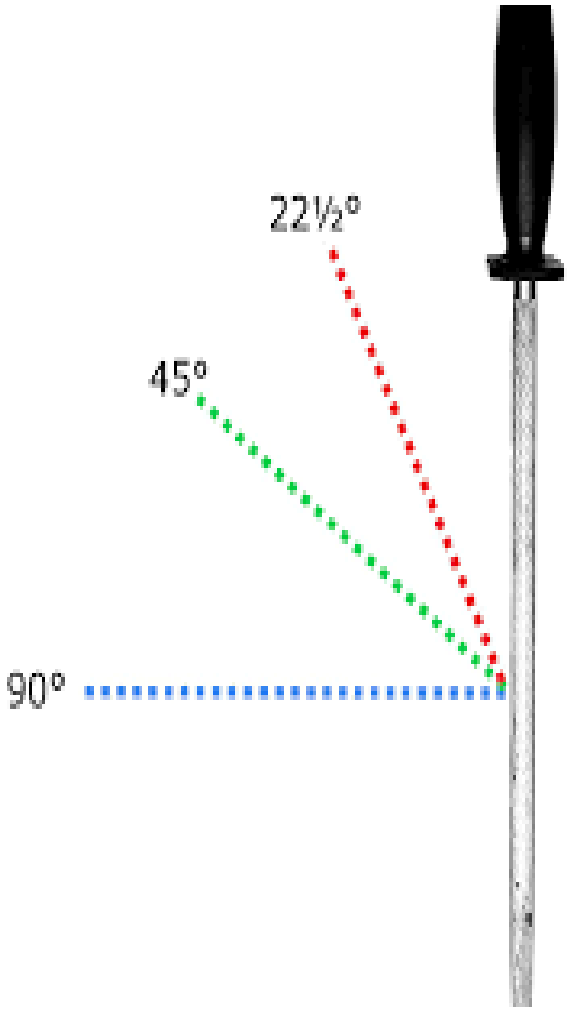
SP™ 1000/6000

Two Side 1000/6000 Whetstone	✓
Provides Excellent Cutting Performance	✓
Sharpens Dull Knives Quickly	✓
Sharpening Angle Guide	✓
Hand Crafted Non-Slip Bamboo Base	✓
eBook Guide	✓
Sharpening Oil - Not Needed	✓
Quality Inspected	✓



Gringing angles and their uses

Fig. 3. Top to bottom, left to right: Photographs of steps involved in sharpening a knife from coarse grinding to steeling, and two versions of Anago Ltd. devices for quantitatively testing knife sharpness.

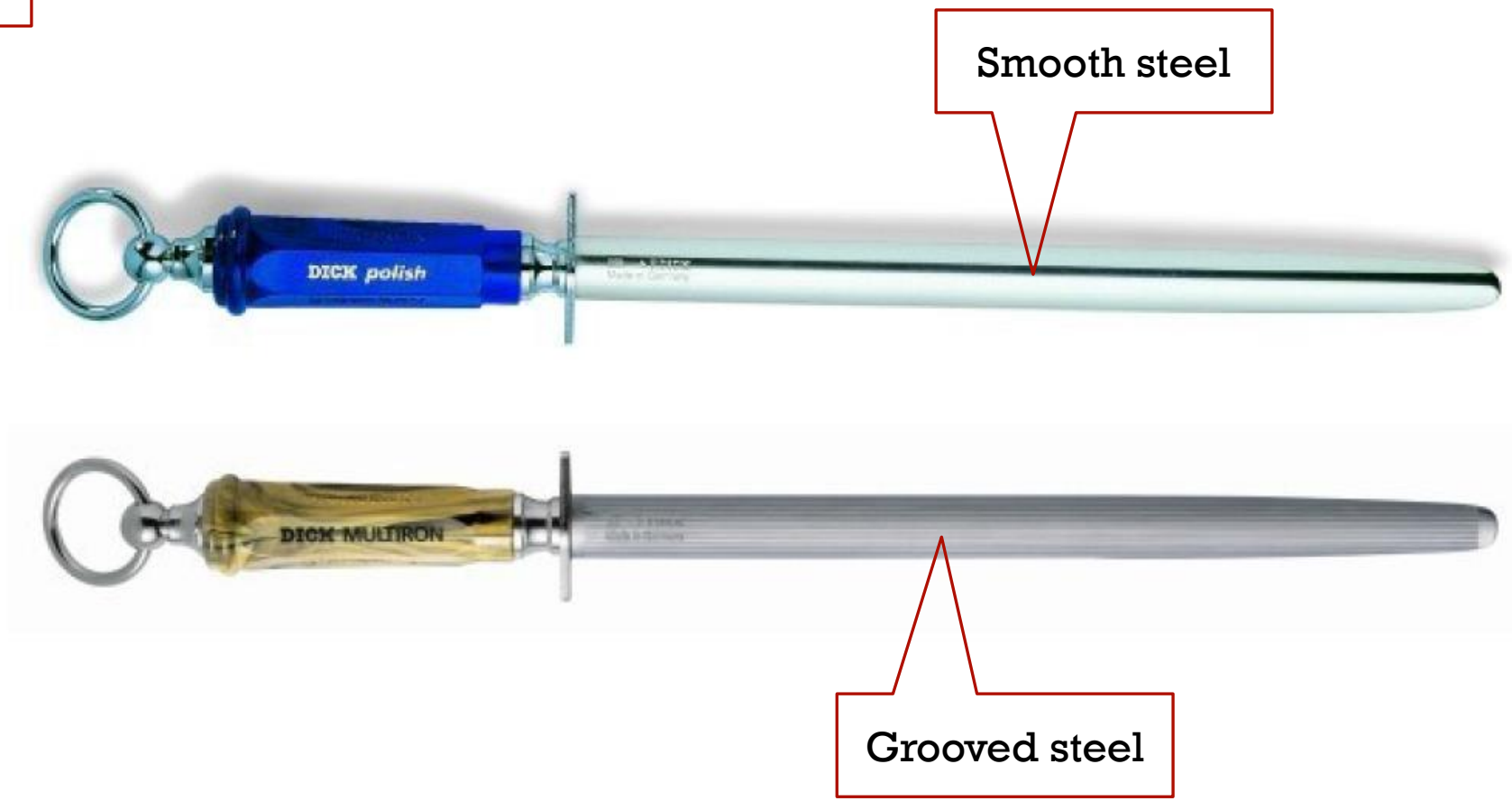


Straightening the Edge by Steeling

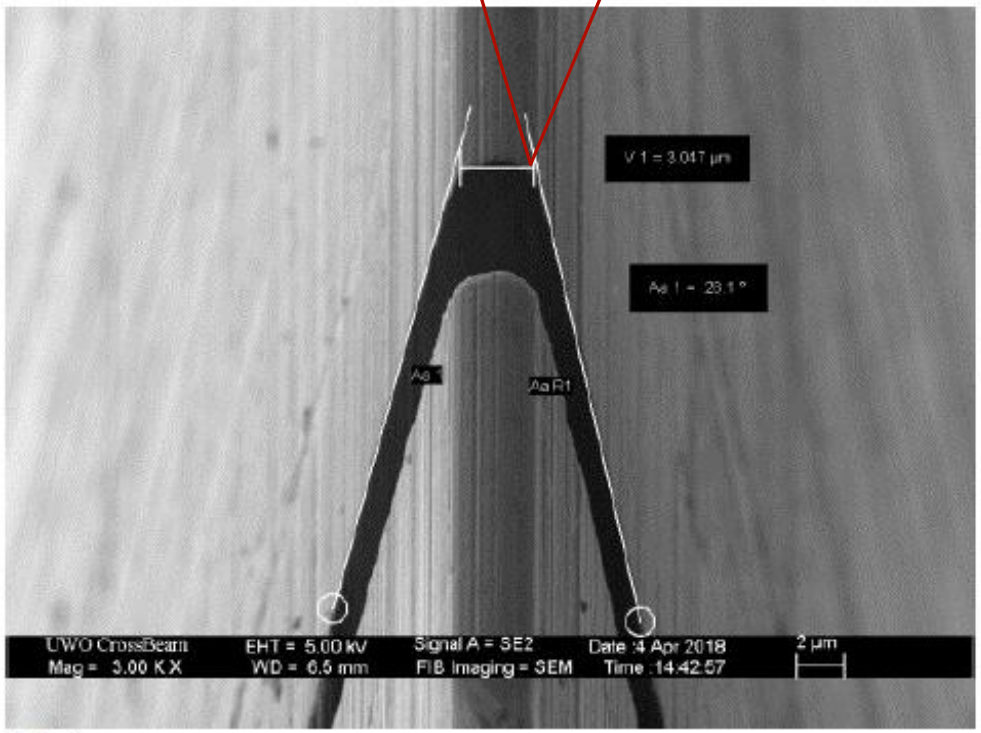
Before Steeling:
Rolled Edge

After Steeling
Straightened Edge

Steel

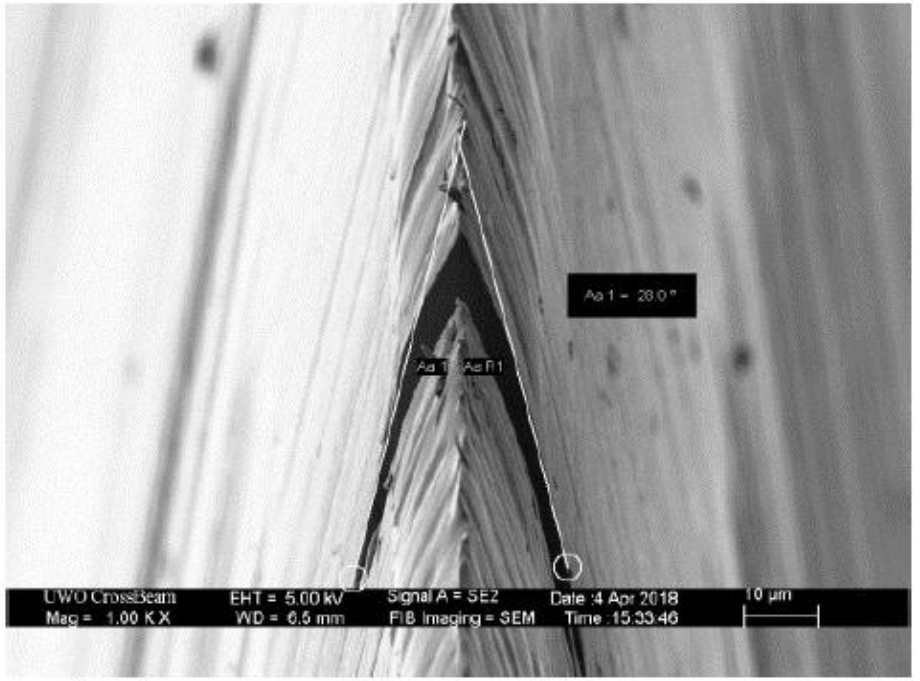


Blunt/dull

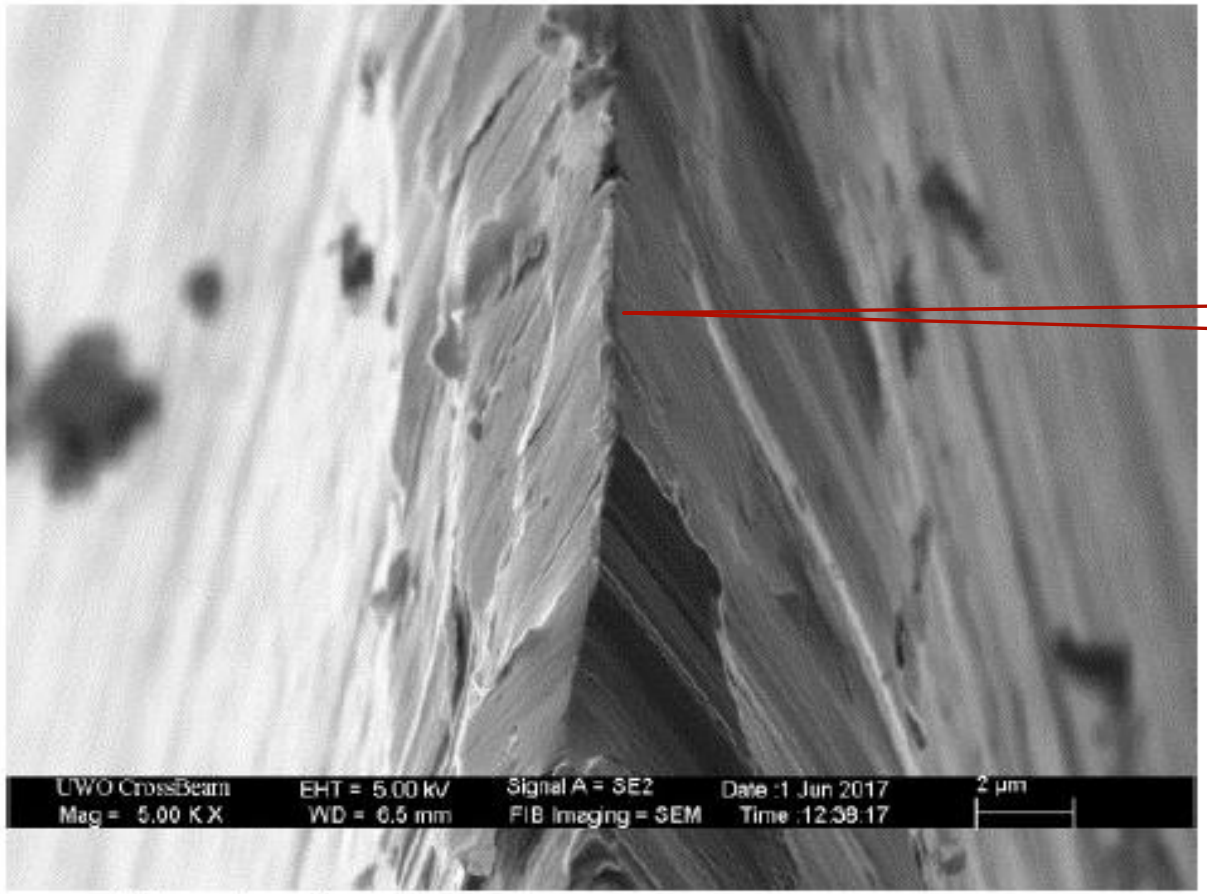


Dull edge

(Smooth steel)



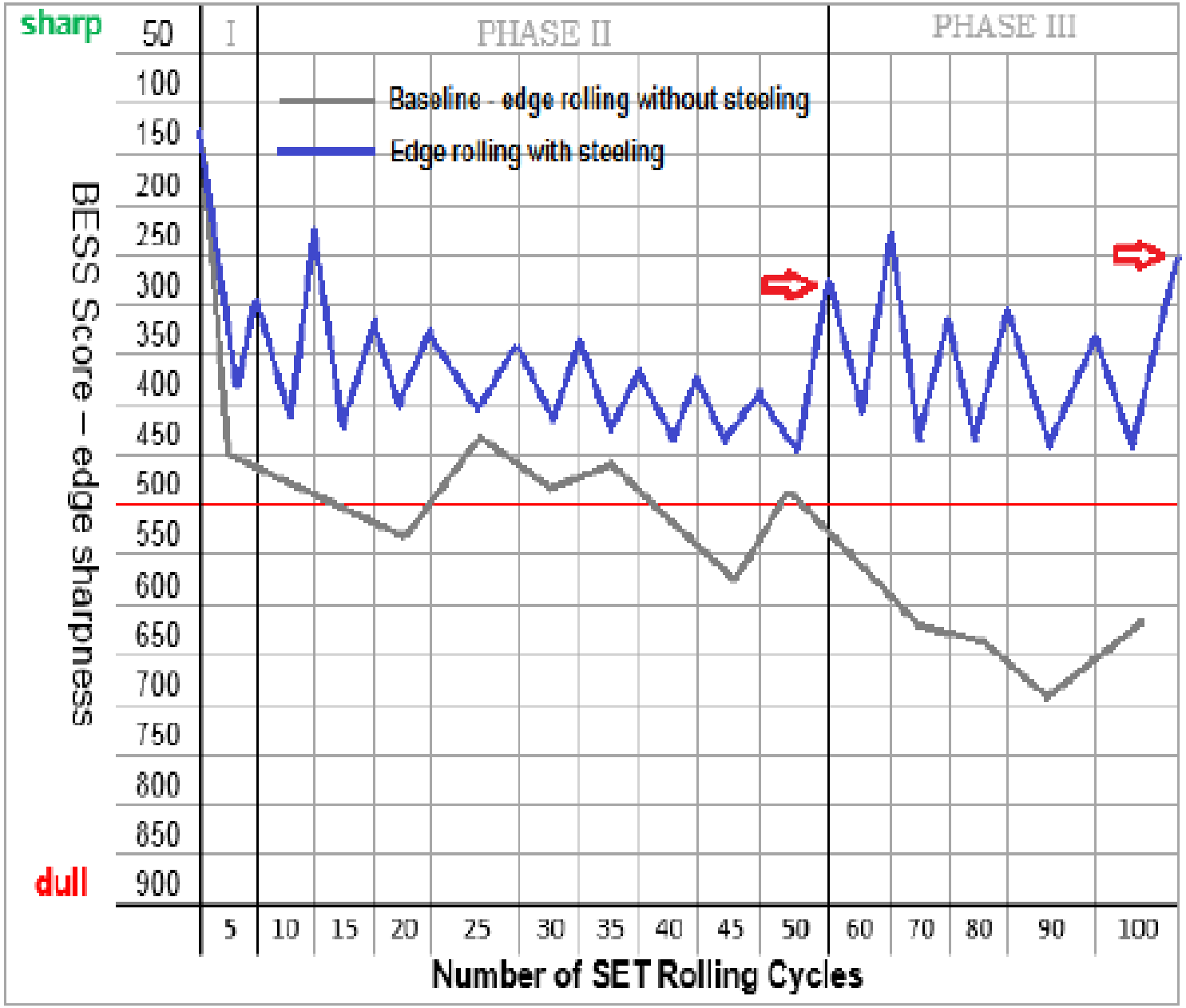
Smooth steeling



(Grooved steel)

Grooved (abrasive) steeling

SWIBO 5.8404.16	HRC 57-58	
GIESSER 2515 wwl 15	HRC 56-57	
VICTORINOX 5.6603.15	HRC 55-56	



The Measurement of Knife Sharpness and the Impact of Sharpening Technique on Edge Durability

Joshua Mulder & Jonathan Scott

School of Engineering, University of Waikato, Hamilton

cuts	stone		belt	
	score	drop	score	drop
0	8.5		9	
30	7.75	-0.75	6.9	-2.1
60	7.4	-1.1	6.5	-2.5
90	7	-1.5	-	-

Broad level	Detailed level	Score
Unsatisfactory	Needs improvement	<8.00
Satisfactory	Sharp	8.00-8.99
	Very sharp	9.00-9.49
	Extremely sharp	>9.50

Thank you (Kop Khun Khrub)