

Global Perspectives on Halal Slaughter: A Critical Review of Animal Welfare, Meat Quality, Islamic Ethics and Regulatory Divergence

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ABSTRACT

Halal meat now moves through supply chains that cross religious, scientific and legal boundaries, and the method of slaughter sits where these boundaries meet. This review synthesizes evidence published mainly between 2013 and 2026 on halal slaughter with and without stunning, covering bleeding efficiency, stress physiology, meat quality, Islamic ethics, consumer knowledge and regulation. Peer-reviewed studies from Scopus, Web of Science, PubMed and ScienceDirect were combined with standards, fatwas and court decisions and analyzed in five themes. In halal-slaughtered cattle, blood loss rose from 3.55% of live weight after 5 min of bleeding to 3.99% after 15 min, and longer bleeding gave a more compact myofibrillar structure and firmer meat without changing pH or color. Head-only reversible electrical stunning did not reduce blood loss in lambs or goats, whereas head-to-back stunning in goats lowered bleeding efficiency and reduced oxidative and microbial stability. Field data from Indonesian abattoirs and Eid al-Adha sacrifices locate the largest welfare risks before and around the cut: roping and casting, blunt knives and delayed loss of consciousness, with 57% of Bali cattle moving or trying to stand after the neck cut. Islamic sources place welfare inside the *halalan tayyiban* requirement, yet surveys show that many Muslim consumers believe certification covers farm practices it does not address. Regulatory positions range from mandatory pre-cut stunning in several European jurisdictions, upheld by the Court of Justice of the European Union in 2020 and the European Court of Human Rights in 2024, to conditional acceptance of reversible stunning in Indonesia, Malaysia and the Gulf states and rejection in Pakistan. The stunning debate has drawn attention away from controllable points such as restraint, knife sharpness, cut position and slaughterer competence. Harmonization is more likely to come from shared, measurable welfare outcomes that religious authorities can verify than from agreement on stunning alone.

Keywords: *Animal welfare, Bleeding efficiency, Halal certification, Halal slaughter, Halalan tayyiban, Meat quality, Stunning*

INTRODUCTION

Demand for halal meat has grown with the Muslim population and with non-Muslim consumers who link the halal label to hygiene and careful handling. Market analysts valued the global halal meat market at USD 810.4 billion in 2022 and projected USD 1.66 trillion by 2031, while Asia holds about 59% of the wider halal market and Europe 21% (Straits Research 2023; Rahman et al. 2024). Indonesia made halal certification mandatory through Law No. 33 of 2014 on Halal Product Assurance, which placed ruminant and poultry abattoirs inside a state-regulated assurance system (Republic of Indonesia 2014; BSN 2016, 2018). At this scale a single procedural failure at slaughter can compromise religious validity, animal welfare and carcass value at the same time.

Halal slaughter is a multidisciplinary problem. The neck cut that makes an animal permissible under Islamic law also decides how fast the brain loses its blood supply, how much blood leaves the carcass, which stress metabolites reach the muscle and whether the product may enter a market that requires or forbids stunning (Farouk 2013; Aghwan and Regenstein 2019). Meat scientists, veterinarians, jurists and trade regulators have each studied part of this chain with different vocabularies and different standards of proof. Veterinary science measures insensibility with electroencephalography (EEG) and brainstem reflexes, whereas Islamic jurisprudence asks whether the animal had stable life (*hayah mustaqirrah*) at the moment of the cut and whether blood flowed freely (Nakyinsige et al. 2013; MUI 2009).

The scientific questions center on exsanguination and stress. Residual blood feeds spoilage bacteria and its heme iron catalyzes lipid oxidation, so poor bleeding can shorten shelf life (Sabow et al. 2016b). Pre-slaughter stress depletes muscle glycogen and alters plasma glucose, lactate dehydrogenase (LDH),

creatine kinase (CK) and cortisol; these changes carry through to pH decline, color and water-holding capacity (Sullivan et al. 2022; Bouzraa et al. 2023). Recent work has moved from bulk blood loss to muscle ultrastructure, using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR) to show how bleeding time changes fiber packing and protein conformation in beef (Öztekin and Candoğan 2025).

The ethical debate has concentrated on pre-slaughter stunning. EFSA (2020) identified the interval between the neck cut and loss of consciousness in cattle slaughtered without stunning as a source of pain, fear and distress, and many European welfare scientists regard stunning as the main safeguard. Muslim scholars who reject stunning worry that it may kill or injure the animal before the cut and impede bleeding; those who accept it require that the stun be reversible and leave no permanent injury (MUI 2009; Fuseini et al. 2017; Sazili et al. 2023). Chao (2022) argued that stunning is often presented as the moral technology of slaughter, although the concept of welfare it serves rests on value assumptions that are themselves debated.

Regulation has split along the same line. Council Regulation (EC) No 1099/2009 requires stunning but allows a derogation for religious rites and lets member states adopt stricter rules (European Union 2009). The Flemish and Walloon regions of Belgium used that option to require at least reversible stunning, and both the Court of Justice of the European Union and the European Court of Human Rights upheld the bans (CJEU 2020; ECtHR 2024). Malaysia, Indonesia and the Gulf Cooperation Council states accept stunning on condition that the animal is alive at the cut, whereas authorities in Pakistan do not permit it (MUI 2009; GSO 2015; DSM 2019; Rahman et al. 2024). Exporters therefore work with several incompatible rulebooks at once.

Earlier reviews examined halal meat from the side of industrial practice (Farouk 2013; Farouk et al. 2016), bleeding and handling (Aghwan et al. 2016), stunning compliance (Sazili et al. 2023), current methods (Fuseini et al. 2022) or ethics and sustainability (Rahman et al. 2024). Three gaps remain. Field evidence from tropical systems, where much halal meat comes from small municipal abattoirs and from community sacrifice during Eid al-Adha, is rarely read beside controlled experiments (Wibowo et al. 2022a, 2024). Consumer studies are seldom compared with the regulatory texts that define what certification covers. The stunning question has also absorbed attention that could have gone to restraint, knife sharpness and slaughterer competence. This review therefore asks five questions: (1) how slaughter method and bleeding affect meat quality and safety; (2) what the evidence shows about stunned and non-stunned slaughter in terms of welfare, stress and religious acceptance; (3) how the *halalan tayyiban* principle relates to animal welfare science; (4) what consumers know and expect of halal certification; and (5) how regulations differ and what blocks harmonization. From the answers we derive an integrated framework and a research agenda.

MATERIALS AND METHODS

Review approach

This article is a critical narrative review. It does not attempt an exhaustive count of the literature; it selects the studies that answer the five review questions and weighs them against each other. A meta-analysis was not attempted because stunning parameters, species, sampling times and outcome units differed too much between studies to pool effect sizes.

Sources of literature

Peer-reviewed articles were located in Scopus, Web of Science, PubMed and ScienceDirect using combinations of the terms halal slaughter, Islamic slaughter, religious slaughter, animal welfare, stunning, bleeding, exsanguination, meat quality, certification, regulation, consumer and halalan tayyiban. Google Scholar, the Indonesian Garuda and SINTA portals and the reference lists of recent reviews were used to find regional field studies. Standards, fatwas, statutes and court decisions were taken from the issuing bodies. The review concentrates on work published from 2013 to 2026; older studies were kept only when later work treats them as reference points, for example the audit criteria of Grandin (2010).

Selection and synthesis

Sources were retained when they reported data or analysis on halal or religious slaughter in relation to welfare, stress physiology, bleeding, meat quality, microbial or oxidative stability, consumer perception, ethics or regulation. Opinion pieces without sources and studies of non-religious slaughter with no comparison to halal practice were not used. Grey literature was admitted only for market figures and one consumer survey that has no peer-reviewed equivalent, and these sources are identified as such in the text.

The evidence was organized into five themes: (T1) bleeding, physiology and meat quality; (T2) stunning and non-stunning; (T3) Islamic ethics and welfare science; (T4) consumer knowledge and trust; and (T5) regulation and harmonization. Within each theme, controlled experiments with validated indicators such as EEG were given more weight than observational reports, and conflicting results were examined for differences in species, stunning parameters and sampling time before a conclusion was drawn.

RESULTS AND DISCUSSION

Characteristics of the evidence

The included sources fall into three groups. Controlled experiments, mainly from Malaysia, the United Kingdom, India, Spain, Korea and Turkey, compared slaughter or stunning methods in poultry, goats, sheep and cattle. Field observations from Indonesia, Nigeria and Ecuador described handling and slaughter under routine conditions. Legal, religious and consumer studies formed the third group. Cattle are under-represented in stunning experiments compared with poultry and small ruminants, although cattle show the longest and most variable times to collapse after a neck cut (Gibson et al. 2015; EFSA 2020) and dominate the value of the halal red meat trade. Figure 1 arranges the five themes as a chain in which slaughter practice shapes welfare, welfare shapes meat quality, and quality and welfare together shape consumer trust and regulation, all within the normative frame of Islamic ethics.

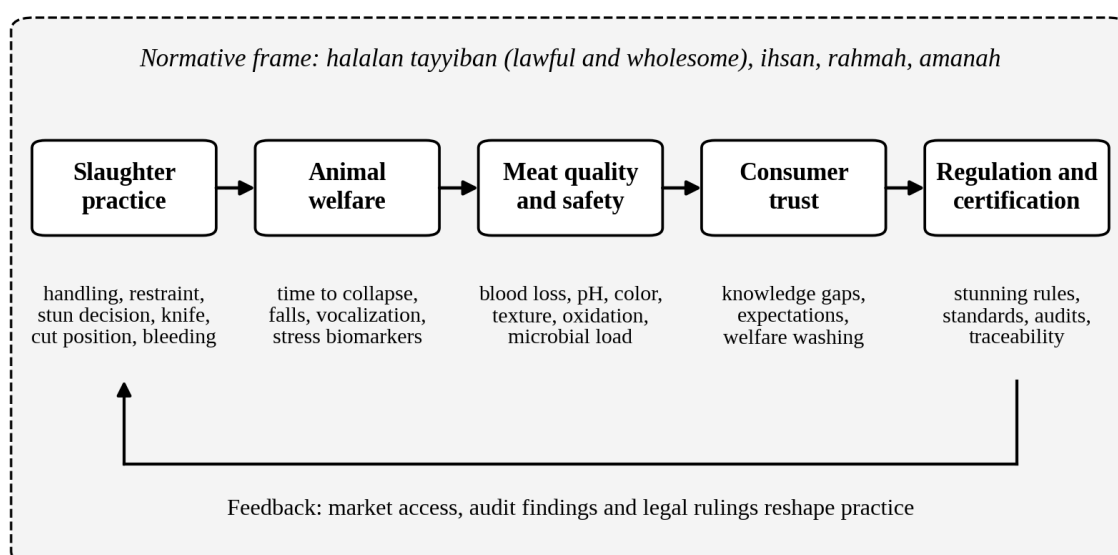


Figure 1. Conceptual framework linking halal slaughter practice, animal welfare, meat quality, consumer trust and regulation.

Theme 1: Bleeding efficiency, physiology and meat quality

Öztekin and Candoğan (2025) provide the most detailed recent test of bleeding time in cattle. Brangus cattle slaughtered by the halal method were left to bleed for 5, 10 or 15 min. Blood loss rose from 3.55% to 3.68% and 3.99% of live weight, and only the 15-min group differed significantly (Figure 2A). Proximate composition, pH, water activity and CIE L^* , a^* and b^* values did not differ between treatments. Hardness did change, from about 48.9 N at 5 min to 84.7 N at 15 min. SEM images of the 5-min samples showed wide interfibrillar spaces, while fibers in the 10- and 15-min samples were compact and ordered. FTIR spectra shifted in the amide I and amide II region ($1540\text{--}1655\text{ cm}^{-1}$), consistent with changes in protein secondary structure, and bands assigned to phosphate groups and nucleic acids were stronger in the longer bleeding groups.

Plasma glucose and LDH in the collected blood peaked at 10 min and fell at 15 min, while total protein and urea declined as bleeding went on (Öztekin and Candoğan 2025). The authors linked the 10-min peak to acute stress and glycogen breakdown. Another reading is possible. Blood collected at different times after the cut comes from a failing circulation and from different vascular beds, so its composition may track hemodilution and tissue washout more than the stress state of the animal. Biomarkers taken at exsanguination also integrate transport, lairage and restraint, as studies in cattle and pigs show (Bouzraa

et al. 2023; Ogawa et al. 2024), which limits what they can say about the cut itself.

Three further cautions apply to the bleeding-time results. The absolute gain between 5 and 15 min was 0.44 percentage points of live weight, about 2.2 kg of blood in a 500 kg steer. Whether this changes shelf life was inferred, not measured. Firmer meat is not better meat for most consumers, so the claim that longer bleeding improves quality depends on which trait is valued. The authors attributed the softer texture at 5 min to retained blood and slower rigor development. Longer bleeding also delays dressing and chilling, so muscle temperature at rigor onset may have differed between groups; texture measured at one post-mortem time says little about tenderness after aging. A study that crosses bleeding time with chilling rate and aging period is needed before a 15-min rule enters standards.

The mechanism behind the link between bleeding and keeping quality is better established. Retained blood supplies nutrients to bacteria and hemoglobin catalyzes lipid and protein oxidation. In Boer crossbred goats, animals slaughtered without stunning or after low-frequency head-only or high-frequency head-to-back electrical stunning lost more blood and kept less residual hemoglobin than goats given low-frequency head-to-back stunning; the latter group also had higher thiobarbituric acid reactive substances on days 7 and 14 and higher bacterial counts after day 3 (Sabow et al. 2016b). What matters is not whether an animal is stunned but whether the stun stops the heart or provokes convulsions that interfere with drainage. Aghwan et al. (2016) reached a similar conclusion and treated efficient bleeding as the outcome of handling, restraint and cut quality taken together.

Breed and muscle can outweigh small differences in bleeding. Wibowo et al. (2019) characterized the chemical composition and physicochemical traits of retail cuts from Thai native cattle (*Bos indicus*) slaughtered by the traditional halal method, and Wibowo et al. (2022b) identified the factors that govern the quality of the *longissimus lumborum* in the same cattle. Such baseline data for tropical breeds are scarce, yet halal beef in Southeast Asia comes largely from *Bos indicus* and crossbred cattle whose muscle biochemistry differs from the European breeds used in most stunning trials. Table 1 summarizes the main experimental and field results.

Table 1. Selected experimental and field studies on halal slaughter, bleeding, meat quality and welfare

Study	Species (n)	Comparison	Main findings
Öztekin and Candoğan (2025)	Brangus cattle	Bleeding for 5, 10 or 15 min after halal cut	Blood loss 3.55, 3.68 and 3.99% LW; hardness about 48.9 to 84.7 N; pH, a_w and color unchanged; compact fibers at 10–15 min (SEM)
Sabow et al. (2016b)	Boer cross goats (32)	SWS vs LFHO, LFHB and HFHB electrical stunning	SWS, LFHO and HFHB lost more blood than LFHB; LFHB had higher TBARS on d 7 and 14 and higher bacterial counts after d 3
Khalid et al. (2015)	Lambs	Traditional halal vs pre-cut and post-cut head-only electrical stunning	Blood loss did not differ among methods
Bouzraa et al. (2023)	Beef cattle (52 blood samples)	Conventional, halal, halal with non-penetrative bolt, rotating box	Glucose, LDH, CK, cortisol and carcass microbial counts differed by method
Govindaiah et al. (2023)	Slow-growing broilers (100)	Halal without stunning vs electrical stunning	Stunned birds: lower post-mortem pH, higher a^* , lower MFI and bleeding efficiency; overall quality not impaired
Alam et al. (2024)	Broilers	Electrical, 80% CO ₂ , 98% N ₂ and halal without stunning	CO ₂ : low pH and WHC; electrical: pale, hemorrhagic breast meat; N ₂ proposed as an alternative
Gibson et al. (2015)	Cattle	Neck cut position, no stunning	Cut position altered time to collapse; a high cut gave faster collapse
Imlan et al. (2020)	Cattle	Sharp vs blunt knife	Blunt knife produced larger blood biochemical and EEG changes
Wibowo et al. (2019)	Thai native cattle	Retail cuts after traditional halal slaughter	Baseline composition and physicochemical data for halal-slaughtered <i>Bos indicus</i> beef
Wibowo et al. (2022a, 2024)	Bali cattle (142; 115)	Municipal abattoir; Eid al-Adha sacrifice at nine mosques	6.3% falls before slaughter; 57% moved or tried to stand after the cut; 21.1% kept rhythmic breathing; roping and casting common

Note: LW, live weight; SWS, slaughter without stunning; LFHO, low-frequency head-only; LFHB, low-frequency head-to-back; HFHB, high-frequency head-to-back; TBARS, thiobarbituric acid reactive substances; MFI, myofibrillar fragmentation index; WHC, water-holding capacity.

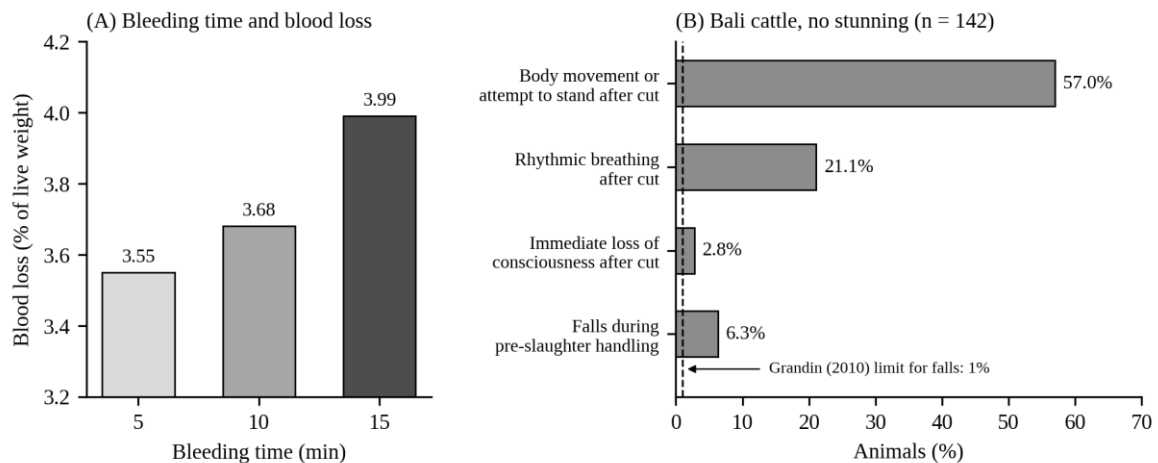


Figure 2. (A) Blood loss of halal-slaughtered Brangus cattle at three bleeding times, redrawn from Öztekin and Candoğan (2025). (B) Welfare indicators in 142 Bali cattle slaughtered without stunning at a municipal abattoir in Samarinda, redrawn from Wibowo et al. (2022a, 2024); the dashed line marks the 1% limit for falls proposed by Grandin (2010).

Theme 2: Stunning and non-stunning slaughter

The central welfare question is how long an animal can feel after the cut. In sheep and goats the carotid arteries carry most of the blood to the brain, and severing both leads to rapid collapse. In cattle the vertebral arteries run through the transverse foramina of the cervical vertebrae, escape the knife and keep supplying the brain through anastomoses with the occipital and epidural vessels (Figure 3). Occlusion of the cut carotid ends can slow the fall in brain perfusion further (Nakyinsige et al. 2013; EFSA 2020). Gibson et al. (2015) found that cut position changed the time to collapse in cattle slaughtered without stunning, with a cut close to the first cervical vertebra giving faster collapse. In goats, Sabow et al. (2016a) recorded EEG changes after the neck cut that they interpreted as a response to noxious stimulation.

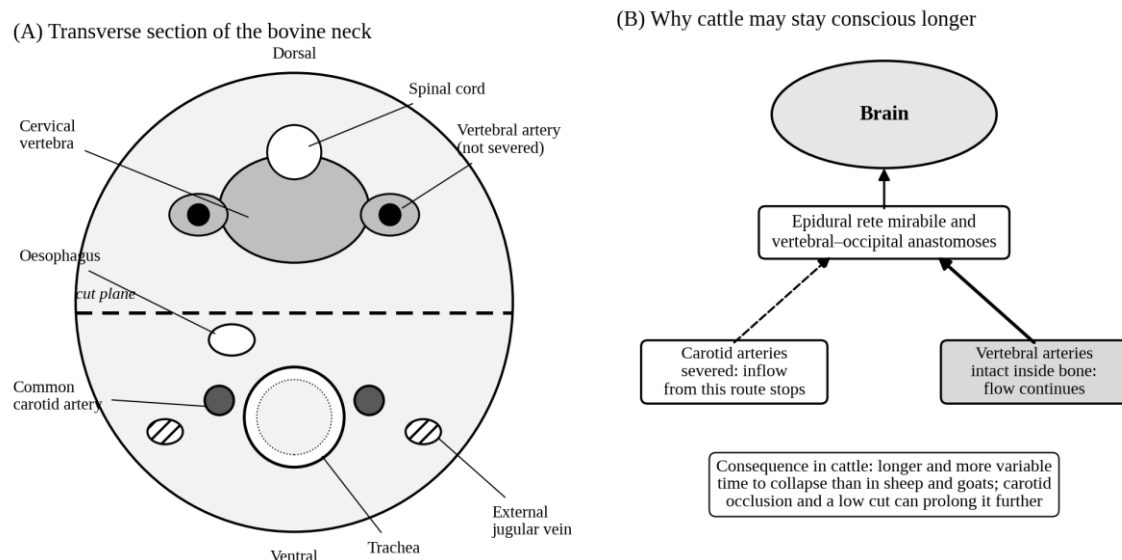


Figure 3. Schematic illustration (not to scale) of (A) the structures severed by the halal neck cut in cattle and (B) the collateral blood supply that can delay loss of consciousness. Structures ventral to the dashed cut plane are severed; the vertebral arteries are protected by bone.

Stress biomarkers give a less clear picture. Bouzraa et al. (2023) found that glucose, LDH, CK and cortisol differed among conventional slaughter, halal slaughter without stunning, halal slaughter with a non-penetrative captive bolt and slaughter in a rotating box, and they also examined skull damage from the bolt radiologically. In broilers, Govindaiah et al. (2023) detected no difference in glucose, LDH, CK or cortisol between stunned and non-stunned birds, although stunned birds had higher creatinine, total protein and triiodothyronine. Because samples are taken at exsanguination, both sets of values mix the effect of the cut

with everything that happened earlier.

Meat quality results depend on stunning parameters more than on the presence of stunning. Head-only electrical stunning did not reduce blood loss in lambs (Khalid et al. 2015) or goats (Sabow et al. 2016b). In broilers, electrical stunning lowered post-mortem pH and bleeding efficiency without impairing overall quality (Govindaiah et al. 2023), gas stunning reduced water-holding capacity and redness (Salwani et al. 2016), and CO₂ and electrical stunning caused low water-holding capacity and hemorrhagic breast meat respectively, while 98% N₂ performed better (Alam et al. 2024). Hayat et al. (2023) showed that the current and frequency of a water-bath stunner determine whether it stays compatible with halal requirements and how it affects eating quality, and comparisons of controlled-atmosphere and electrical stunning under commercial parameters continue to report differences in broiler meat (Riggs et al. 2023). The literature therefore supports neither a general claim that stunning spoils halal meat nor a general claim that it improves it (Table 2).

Table 2. Comparison of slaughter without stunning and slaughter after reversible pre-cut stunning

Aspect	Slaughter without stunning	Reversible pre-cut stunning	Sources
Onset of unconsciousness	Depends on cut quality and position; slower and more variable in cattle	Immediate when effective; risk of mis-stun or recovery before the cut	Gibson et al. 2015; EFSA 2020; Sazili et al. 2023
Pain at the cut	Possible until collapse; knife sharpness decisive	Cut made on an insensible animal if the stun works	Sabow et al. 2016a; Imlan et al. 2020; Kumar et al. 2023a
Stress biomarkers	Reflect handling, restraint and cut together	Also affected by handling into the stunning box and by convulsions	Bouzraa et al. 2023; Govindaiah et al. 2023
Blood loss	Reference level	Similar after head-only stunning; lower after head-to-back methods that stop the heart	Khalid et al. 2015; Sabow et al. 2016b
Meat quality	Normal pH decline; few stun-related hemorrhages	Parameter-dependent; high currents and some gases cause hemorrhages or low WHC	Salwani et al. 2016; Hayat et al. 2023; Alam et al. 2024
Religious acceptance	Accepted by all schools when performed correctly	Accepted by MUI, JAKIM and GSO if the animal is alive and uninjured at the cut; rejected by some authorities and many consumers	MUI 2009; GSO 2015; Fuseini et al. 2017; DSM 2019; Fuseini and Knowles 2020
Legal status	Permitted by derogation in the EU; banned in some European regions	Mandatory in several European jurisdictions	European Union 2009; CJEU 2020; ECtHR 2024

Religious acceptance turns on a different question from welfare. Welfare science judges a method by the probability and duration of pain; jurisprudence judges it by the state of the animal at the moment of the cut. MUI (2009) allows stunning if it causes only temporary unconsciousness, does not kill or permanently injure the animal and is done to ease slaughter as an act of *ihسان*. Fuseini et al. (2017) found that acceptance of stunning among UK Islamic scholars and halal consumers depended on confidence that the stun did not kill the animal, and a later survey in England found that most halal consumers preferred meat from animals slaughtered without stunning (Fuseini and Knowles 2020). Evidence that a stun is reversible under experimental conditions does not prove that each animal on a commercial line survives it. This operational uncertainty, more than disagreement about pain, keeps many scholars opposed, which is why post-cut stunning and verified reversibility checks are discussed as compromises (Sazili et al. 2023).

Pre-slaughter handling and slaughterer competence

Most comparisons of slaughter methods assume skilled slaughterers, sharp knives and calm animals. Field data show that these assumptions often fail. Wibowo et al. (2022a) observed 142 Bali cattle slaughtered without stunning at a municipal abattoir in Samarinda, East Kalimantan: 6.3% fell during pre-slaughter handling, only 2.8% (four animals) lost consciousness promptly after the cut, 57% moved or tried to stand, and 21.1% kept rhythmic breathing (Wibowo et al. 2022a, 2024; Figure 2B). Grandin (2010) proposed that no more than 1% of cattle should fall during handling in a well-managed plant, so the observed rate was more than six times that limit. During Eid al-Adha in 2023 the same group assessed 115 cattle at nine mosques in Samarinda and recorded roping and manual casting to bring animals down; the authors named insufficient knife sharpness as one reason for delayed loss of consciousness (Wibowo et al. 2024). Wibowo et al. (2023) extended this work with physiological stress measurements before and after slaughter at the Tanah Merah abattoir.

Knife sharpness is where jurisprudence and physiology agree most directly. The hadith narrated by Shaddad ibn Aws instructs the slaughterer to sharpen the blade and spare the animal suffering, and

experiments in cattle found that a blunt knife produced larger biochemical and EEG changes than a sharp one (Imlan et al. 2020; Kumar et al. 2023a). Training for slaughterers in Samarinda covered knife types and sharpening, flight-zone handling and the anatomical target of the cut (Wibowo and Suhardi 2022), and Indonesian rules require each ruminant abattoir to employ a halal slaughterer competent in Islamic law, veterinary public health and animal welfare (Kementan 2010). Community sacrifice lies largely outside abattoir supervision, and antemortem and postmortem inspection of sacrificial animals depends on volunteer programs (Handoko et al. 2025).

Similar gaps appear elsewhere. In south-eastern Nigeria, fatigued cattle were dragged to the killing floor and left restrained in lateral recumbency for about an hour before slaughter (Njoga et al. 2023). In Ecuador, antemortem indicators such as slipping, falling and vocalization were examined together with bleed interval and carcass microbial counts in 351 cattle (Cevallos-Almeida et al. 2021). Reviews of pre-slaughter management in beef cattle and goats reach the same practical conclusion: handling and restraint set the stress load that the slaughter method then adds to (Sullivan et al. 2022; Kumar et al. 2023b). For most animals in Indonesian community slaughter, the gap between best and actual practice in restraint and cutting is larger than the gap between well-performed stunned and non-stunned slaughter. A program that starts with knife checks, restraint boxes, cut position and training would reduce suffering without asking any religious authority to change its position on stunning. Figure 4 places these control points along the process.

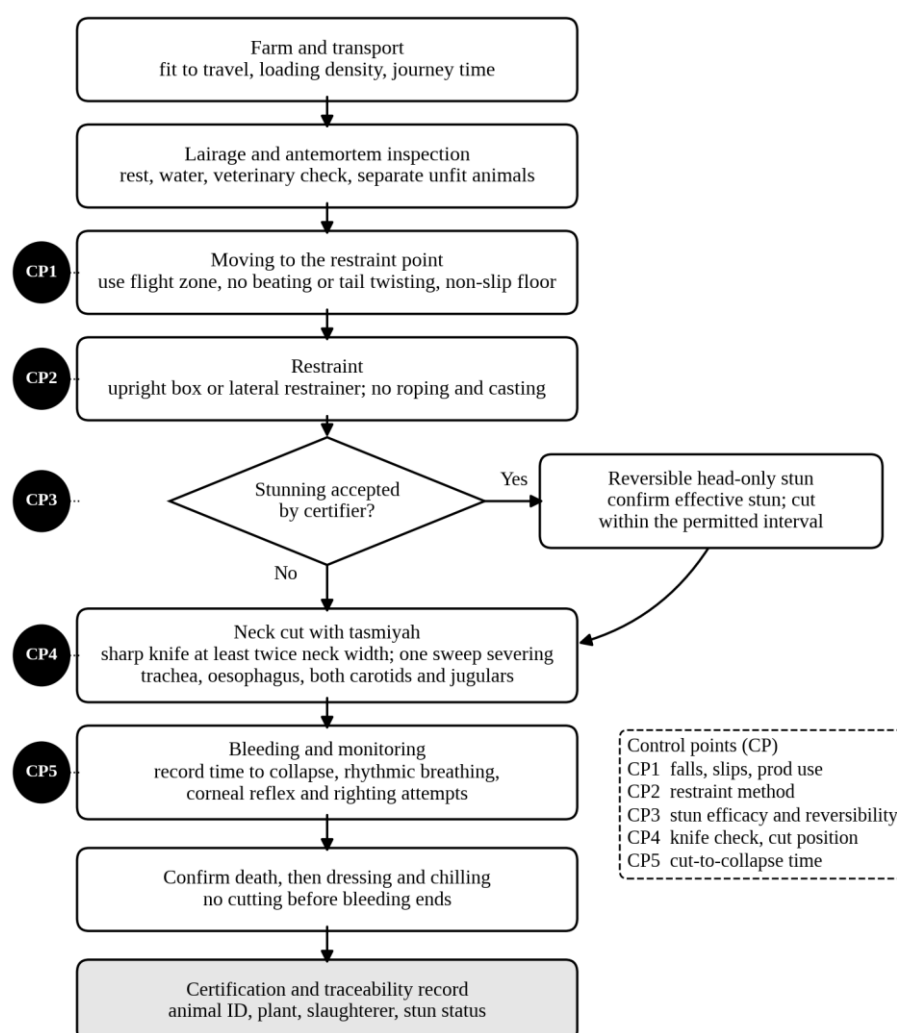


Figure 4. Flowchart of halal slaughter from farm to certification with five welfare control points (CP1–CP5). The stunning branch applies only where the certifier accepts reversible stunning.

Theme 3: Halalan tayyiban and animal welfare science

The Qur'anic pairing of *halal* and *tayyib* (al-Baqarah 2:168) places welfare inside religious compliance.

Halal marks what is lawful; *tayyib* marks what is good, wholesome and safe. Scholars read the second term as covering hygiene and freedom from chemical, microbial and physical hazards, and several extend it to the conditions under which the animal lived and was handled (Farouk et al. 2016; Rahman et al. 2024). Jurists derive from prophetic traditions rules against sharpening the knife in the animal's sight, against slaughtering one animal in view of another and against causing needless pain (Nakyinsige et al. 2013; Farouk et al. 2016). Rahman et al. (2024) describe Islamic ethics as having zero tolerance for animal abuse along the whole halal supply chain.

These rules map onto the Five Domains model, which assesses nutrition, environment, health, behavioral interactions and the resulting mental state of the animal (Mellor et al. 2020), and onto the view that animal welfare contributes to several Sustainable Development Goals (Keeling et al. 2019). Table 3 lists the correspondences and the indicators an auditor could measure. The overlap is real but incomplete. Islamic ethics judges the act and intention of the slaughterer, whereas welfare science judges the state of the animal. A slaughter can meet every legal condition and still leave a steer conscious for a prolonged period, and a stunned kill can satisfy a welfare auditor yet fail the jurist's test if the animal dies from the stun. Chao (2022) described how Malaysian veterinary scientists built common ground between secular and Islamic animal ethics, and outcome indicators of the kind shown in Table 3 offer a practical route for that work.

Table 3. Islamic ethical principles related to slaughter and their counterparts in animal welfare science

Islamic principle	Practice derived by jurists	Welfare science counterpart	Measurable indicator
<i>Ihsan</i> (doing well), hadith of Shaddad ibn Aws	Sharpen the knife; kill swiftly; relieve the animal	Minimize pain and duration of consciousness (mental state domain)	Knife sharpness check; cut-to-collapse time; rhythmic breathing after the cut
<i>Rahmah</i> (mercy) and prohibition of torment	No knife sharpening in the animal's sight; no slaughter in view of others; gentle handling	Avoid fear and distress during handling (behavioral interactions)	Falls, slips, vocalization, electric prod use (Grandin 2010)
<i>Tayyib</i> (wholesome, safe)	Healthy animal; clean slaughter; complete bleeding	Health domain; food safety	Antemortem findings, bruising, blood loss, carcass microbial counts
Duty to feed and water animals	Provide feed and water before slaughter	Nutrition domain	Water access in lairage, time off feed, body condition
<i>Amanah</i> and <i>khilafah</i> (trust and stewardship)	Responsibility from farm to fork	Life-cycle welfare; sustainability	Farm audits, transport records, traceability data
<i>Hayah mustaqirrah</i> (stable life at the cut)	Animal alive and uninjured at the cut	Verification of stun reversibility	Recovery checks on sample animals; stun-to-cut interval

Sources: Nakyinsige et al. (2013); Farouk et al. (2016); Mellor et al. (2020); Rahman et al. (2024); MUI (2009).

Theme 4: Consumer knowledge and trust

Consumer trust in halal meat rests partly on assumptions that certification does not verify. A survey of 788 Muslim adults in Türkiye tested knowledge of six farming practices permitted under halal guidelines: culling of male or unproductive chicks, beak trimming, early separation of cows and calves, absence of long-term care for injured or unproductive animals, slaughter of young animals and space restriction (Evirgen and Mirzaoglu 2025). Many respondents wrongly believed some of these practices were forbidden. After correction, close to 58% of those who had been wrong or unsure about beak trimming said they would be less likely to buy such products and about 42% said they would buy more plant-based alternatives; cow-calf separation drew the weakest response (44% and 32%). Older adults, women and people with more education or income expressed more willingness to change. The survey is a non-peer-reviewed report from one country, so its figures need confirmation, but its direction agrees with earlier work.

In the United Kingdom, acceptance of stunning among halal consumers depended on what they understood stunning to involve (Fuseini et al. 2017), and consumers in England mostly preferred meat from non-stunned animals (Fuseini and Knowles 2020). In Malaysia, the 2020 meat cartel scandal, in which imported meat of uncertain origin was sold as halal, shook consumer confidence and changed purchasing behavior (Maifiah et al. 2022). Two conclusions follow. When certification schemes cover only the moment of slaughter, the gap between what consumers assume and what is audited creates a reputational risk, and claims about humane treatment that no audit supports amount to welfare washing. Interest in halal cultivated meat also shows that some consumers and scholars are already looking beyond slaughter altogether (Attwood et al. 2023).

Theme 5: Regulatory frameworks and harmonization

Table 4 compares the main regulatory positions. In the European Union, Regulation (EC) No 1099/2009 requires stunning, allows a derogation for slaughter prescribed by religious rites under Article 4(4) and

permits stricter national rules under Article 26 (European Union 2009). When Flanders required reversible stunning for ritual slaughter, the CJEU held that member states may impose such a requirement to promote animal welfare without infringing the Charter of Fundamental Rights (CJEU 2020). In 2024 the European Court of Human Rights upheld the Flemish and Walloon bans and, for the first time, accepted that the protection of animal welfare can be linked to the protection of public morals under Article 9(2) of the Convention (ECtHR 2024; Ní Chinnéide and Van de Graaf 2024). In the United States the Humane Methods of Slaughter Act exempts ritual slaughter from its stunning requirement (HMSA 1978).

Table 4. Positions of selected jurisdictions on stunning in halal or religious slaughter

Jurisdiction	Main instruments	Position on stunning	Remarks
Indonesia	Law 33/2014; MUI Fatwa 12/2009; SNI 99002:2016; SNI 99003:2018; Permentan 13/2010	Permitted if temporary, non-lethal, without permanent injury and intended to ease slaughter	Mandatory halal certification; competent halal slaughterer required in ruminant abattoirs
Malaysia	MS 1500:2019; JAKIM certification	Permitted under conditions; animal must be alive at the cut	Oversight shared by several agencies
Gulf Cooperation Council	GSO 993:2015	Permitted if the stun does not kill the animal before the cut	Reference standard for imports into Gulf markets
Pakistan	National religious practice	Not permitted	Reported by Rahman et al. (2024)
European Union	Regulation (EC) 1099/2009	Required; derogation for religious rites (Art. 4(4)); stricter national rules allowed (Art. 26)	Derogation implemented differently by member states
Belgium (Flanders, Wallonia)	Regional decrees	Required; reversible stunning accepted for ritual slaughter	Upheld by CJEU (2020) and ECtHR (2024)
Denmark, Sweden, Slovenia, Norway, Iceland, Switzerland	National animal welfare laws	Pre-cut stunning required (Switzerland: except poultry)	Summarized by Rahman et al. (2024)
United States	Humane Methods of Slaughter Act	Ritual slaughter exempt from stunning	7 U.S.C. §1906

Muslim-majority states regulate the question through religious authority rather than rights balancing. Indonesia combines statute, fatwa and national standards: MUI Fatwa 12/2009 sets the conditions for stunning, SNI 99002:2016 and SNI 99003:2018 translate slaughter requirements for poultry and ruminants into auditable clauses, and Law 33/2014 makes certification compulsory (MUI 2009; Republic of Indonesia 2014; BSN 2016, 2018). Malaysia relies on MS 1500:2019 and JAKIM certification, the Gulf states on GSO 993:2015, and Pakistan does not accept stunning (GSO 2015; DSM 2019; Rahman et al. 2024). Implementation remains uneven. Risk assessments of abattoir-to-market chains in Bekasi treated welfare, halal status and food safety as linked supply-chain risks (Makarim et al. 2024), and oversight in Malaysia is divided among several agencies with overlapping roles (Rahman et al. 2024).

Traceability and authentication are the second half of harmonization. Fathima et al. (2024) grouped halal authentication methods by four kinds of non-compliance: improper slaughter, mislabeling, adulteration and contamination. Analytical methods can detect species substitution and some processing faults (Ng et al. 2022), but no laboratory test can tell whether an animal was conscious at the cut or whether a stun was reversible. Those facts must be recorded at the plant, which is why digital traceability that links animal identification, plant, slaughterer and stun status has attracted attention (Masudin et al. 2022). The main barriers to harmonization are different juristic positions on stunning, different legal cultures (rights balancing in Europe, religious authority in Muslim-majority states), many certification bodies with limited mutual recognition, and the absence of shared welfare outcome measures. The last barrier is the easiest to remove. Certifiers who disagree about stunning could still audit the same outcomes: falls, restraint method, knife checks, stun efficacy where stunning is used, and cut-to-collapse time.

Future research agenda

Table 5 sets out a research agenda derived from the gaps identified above. The most urgent scientific need is EEG and behavioral data from *Bos indicus* and crossbred cattle under commercial conditions, including trials of cut position. The most urgent institutional need is a set of outcome indicators that scientists and religious authorities develop together and that certifiers can audit whatever their position on stunning.

Table 5. Research agenda for halal slaughter science, ethics and policy

Direction	Gap	Suggested design	Expected output
Physiology of slaughter in tropical cattle	Few EEG and time-to-collapse data for <i>Bos indicus</i> under field conditions	Field EEG with behavioral indicators; randomized trials of high (C1) versus conventional cut	Benchmarks for cut-to-collapse time by breed and cut position
Bleeding and meat quality	Single breed and single post-mortem time	Factorial trials of bleeding time, chilling rate and aging; shear force, sensory and shelf-life tests	Evidence-based minimum bleeding time
Precision monitoring	Manual audits miss post-cut signs	Computer vision for movement and breathing after the cut; knife sharpness testing at the line	Automated, continuous welfare audit records
Ethics and jurisprudence	Fatwas seldom use outcome data	Joint panels of scholars and scientists; Delphi studies	Outcome indicators acceptable to certifiers
Regulation and traceability	Limited mutual recognition; paper records	Comparative legal analysis; pilots linking animal ID, slaughterer and stun status	Interoperable certification data
Consumers	Knowledge data from few countries	Randomized information experiments in Indonesia, Malaysia and the Gulf	Tested communication tools for certifiers

CONCLUSION

Halal slaughter joins meat science, veterinary physiology, Islamic law and trade regulation in one act, and the evidence reviewed here shows that the act is often judged by the wrong variable. Reversible head-only stunning performed within proper parameters changes blood loss and meat quality little, while head-to-back and high-current methods can impair both. Longer bleeding raises blood loss and firms the meat, but its benefit for shelf life and eating quality has not been tested under realistic chilling and aging. Field data from Indonesia show that roping, casting, blunt knives and poor cut technique leave many cattle moving and breathing after the cut, problems that no stunning policy addresses. The *halalan tayyiban* principle already treats these failures as religious as well as welfare failures. Regulatory divergence over stunning will persist, yet certifiers on both sides could adopt common, auditable welfare outcomes, and research on tropical cattle, precision monitoring and consumer communication should be organized around those outcomes.

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