

The stunning and slaughter of cattle within the EU: a review of the current situation with regard to the halal market

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Abstract

The slaughter of animals for the halal market is both ethically and economically significant. There are animal welfare and spiritual requirements that must be met for meat to be considered fit for Muslim consumption. These requirements are enshrined in Islamic law, known commonly as the Shariah law, derived from commandments in the Holy Quran and the Hadith (teachings or traditions of the Prophet of Islam, Mohammed, Peace Be Upon Him). Islamic jurists widely interpret the Shariah law differently, and this has led to debate as to whether pre-slaughter stunning is acceptable for halal slaughter. This paper reviews how these laws are interpreted and implemented and reviews the methods of stunning accepted by proponents of halal stunning. It also describes why some proponents of halal stunning do not accept irreversible stunning methods for producing halal beef within the EU, a situation which has meant that thousands of halal cattle are slaughtered without any form of stunning.

Keywords: animal welfare, cattle, halal, reversible stunning, slaughter, stunning

Introduction

European Union (EU) regulation, EC 1099/2009 requires all animals to be stunned before slaughter in order to minimise the pain and distress associated with the neck-cut. However, there is a derogation that allows member states to permit the slaughter of animals without stunning for religious consumption, however, some member states have chosen not to exercise this derogation. Halal and shechita slaughter are based on ancient rules laid down in the *Holy Quran* and *Torah*, respectively, which require animals to be slaughtered 'alive' and prohibits the consumption of flowing blood. Whilst some Muslim authorities allow the use of reversible (non-lethal) stunning, the Jewish community unanimously reject any form of stunning during shechita slaughter with the belief that the shechita method itself incorporates an irreversible stun. It must also be noted that some Muslim authorities within the EU accept irreversible stunning (eg use of captive-bolt guns) as long as the heart is still beating during the neck-cut. Proponents of animal welfare maintain that even if the ritual cut is able to sever both carotid arteries and jugular veins, oxygenated blood can still flow via the vertebral arteries from the heart to the brain which delays unconsciousness and death (Gregory *et al* 2008).

During conventional slaughter of cattle, a penetrative captive-bolt gun is usually used to deliver a percussive force to the head, this induces insensibility through the disruption of normal brain function (Gregory 2007). This method of

stunning causes gross physical damage (to the skull and brain) that can lead in the majority of cases to the death of cattle. Captive-bolt stunning is therefore considered by many to be inconsistent with Islamic dietary laws to be found in *Quran* 5:3 and quoted later in this paper, and most of the halal certification standards including Malaysian, MS1500 (2004, 2009); Halal Food Authority (UK), HFA Standard (2014); Indonesian Standard, MUI HAS 23103 (2012). A head-only electrical stunning system, the Jarvis Beef Stunner was therefore developed in New Zealand to meet the requirement of the halal market (Gilbert *et al* 1984; Wotton *et al* 2000; Weaver & Wotton 2009). However, this equipment also uses low-voltage electro-immobilisation to reduce post-stun convulsions which is contrary to EC 1099/2009 as it would mask any signs of recovery. It cannot therefore be used within the EU. Despite the approval of some stunning methods for other species by some of the Muslim authorities, there is currently no generally approved method of cattle stunning for the EU halal beef market. This has resulted in lost revenue for the EU beef industry due to their inability to tap into both the domestic and export halal markets. This has also led to the slaughter of thousands of cattle each year without stunning (in member states that permit slaughter without stunning). Experimental trials with microwave energy (Small *et al* 2013; Rault *et al* 2014) and Single Pulse Ultra-high Current (SPUC) (Robins *et al* 2014) have shown some promise that they could be developed as

commercial stunning systems that may meet the halal slaughter requirements. Due to the fact that stunning of any form is not currently accepted for shechita slaughter, this review will now focus on Islamic dietary laws and how these affect the stunning and slaughter of halal beef within the EU presently.

Islamic dietary laws

The rules governing what is permissible/lawful (halal) or prohibited (haram) for Muslims are enshrined in Islamic law, the Shariah. This encompasses guidelines on food, business transactions, marriage and all the expectations and general conduct of Muslims. The sets of moral codes are primarily derived from the sayings (*Hadith*), deeds (*Sunnah*) of the Holy prophet of Islam, and from the commandments in the Islamic Holy book, the *Quran*. Al-Qaradawi (1960) reported that one of the guiding principles regarding halal food is the belief that only God determines what is permissible or prohibited and these guidelines are detailed in the *Quran*, *Sunnah* and *Hadith* and that good intentions alone on the part of the halal consumer and food processor does not make food halal. Masri (2007) stated that Muslims are generally conversant with what is halal and what is haram. However, the sketchy and incomprehensible nature in which Islamic jurists present Islamic dietary laws to the Muslim community (Ummah) has resulted in confusion among Muslims. All Muslims must follow the dietary laws, except in a situation of genuine need and distress where, say, one's health or life is at risk. Various verses in the *Quran* lay down the dietary laws, however, *Quran* (5:3) gives a more comprehensive outline regarding halal meat, it also describes what was regarded as 'best practice' from food hygiene and animal welfare perspectives:

Forbidden to you is that which **dies of itself**, and blood, and flesh of swine, and that on which any other name than that of Allah (God) has been invoked, and killed by **strangling (animal)** or by a violent blow and that beaten to death, and that killed by a fall and that killed by being smitten with the horn, and that which wild beasts have eaten, except what you slaughter, and what is sacrificed on stones set up (for idols) and that you divide by the arrows; that is a transgression. This day have those who disbelieve despaired of your religion, so fear them not, and fear Me. This day have I perfected for you your religion and completed My favour on you and chosen for you Islam as a religion; **but whoever is compelled by hunger**, not inclining wilfully to sin, then surely Allah is Forgiving, Merciful.

Some aspects of Shariah law may sometimes require interpretation or clarification, and this is done by Islamic jurists or scholars (Fuqahā). Scholars are generally required to be of sound mind, apolitical, preferably an adult male or female and they must have a good understanding of the *Quran*, *Hadith* and able to speak Arabic. In terms of the dietary requirement of Muslims, the role of Islamic jurists is particularly important in issuing legal rulings (Fatwa) in situations where the *Quran* and the other Islamic scriptures do not specifically mention a technology, ingredient, species of animal or a method of slaughter. Advances in food and

slaughter technologies have resulted in modern systems of arable and livestock agriculture and slaughter techniques which are alien to the *Quran* and the *Hadith*, hence require interpretation by Islamic jurists. There are ongoing debates among these jurists regarding the acceptability of the following: pre- and post-slaughter stunning of animals, thoracic sticking (accepted for camels), restraining animals by inversion, mechanical slaughter of poultry, genetically modified organisms (GMOs), intensive livestock farming and the acceptability of Shechita-slaughtered meat for Muslim consumption. Many of these technologies were only developed recently, many centuries after the *Quran* was revealed through the Prophet Mohammed, so it was not possible for these techniques to have been covered in the scriptures. They are therefore open to the interpretation of various scholars, and there are differing views between them. Differences in the decisions made by Islamic jurists may be exacerbated by the fact that there are differences between the two main Islamic sects, Sunni and Shia Muslims, and then within the Sunni sect, there are four different schools of law or thought; the Maliki, Hanafi, Shafii and Hanbali law schools. Within the different Sunni schools of law, jurists do at times disagree on the halal suitability of certain agricultural practices, food ingredients, food processing technology etc. The halal market, in addition to religious factors, may also be influenced by non-religious factors, such as modern politics, power and positioning within the Muslim world and some economic forces. These non-religious factors are however not the focus of this paper.

Who interprets the Shariah Law

Islamic law is derived from the *Quran*, *Hadith* and *Sunnah*. Muslims who are well versed in the *Quran* and the other Islamic scriptures with sound mental capabilities usually interpret the law, these interpreters are called Islamic jurists. It must be noted that there is no central decision-making body for the whole Ummah regarding what is halal or haram. However, individuals who meet the requirements of Muslim jurists may interpret the *Quran* or *Hadith* in order to give a ruling on a subject matter. This is usually done where clarification is required on an issue or where a subject matter (eg stunning of animals) cannot be found in the *Quran* and *Hadith*. Many jurists are of the opinion that unless something is specifically mentioned as unlawful (haram), it must be deemed halal. Islamic jurists interpret Shariah law based on the following criteria:

- Ijtihad: Independent reasoning or a jurist's strive to understand an issue that is usually not covered in the *Quran* and *Hadith*, and subsequently makes a decision. This involves spending a great deal of time to research and understand the issue before arriving at a decision.
- Taqleed: Rulings made by jurists regarded as 'trustworthy' by the ummah which must be accepted without calling for a proof.
- Ijma: Rulings based on consensus by several scholars.

Sunni Muslims usually interpret Shariah law by using taqleed whilst the Shias follow rulings by ijtihad (Esposito

2015). The majority of Sunnis are of the view that their ancestors had ratified most of the major religious arguments thus the need to use taqleed instead of ijthihad, whilst the Shias believe in “human reasoning and intellect as a legal source that supplements God’s commandments in the *Quran* and the other Holy Scripture” (Esposito 2015). De Long-Bas (2004) reported that the decision by the Sunnis to reject the use of ijthihad in Islamic jurisprudence was made by the Maliki, Hanafi and a section of prominent jurist from the Shafii School of law. However, the Hanbali and some jurists of the Maliki School of law abstained from this decision. Esposito (2015) pointed out that Sunni proponents of ijthihad have always maintained that the advent of science and technology in food production requires the use of ijthihad to interpret the Shariah law especially if the technology cannot be found in the *Quran* or *Hadith*.

The differences that exist in the way Islamic scriptures are interpreted is one that is likely to continue for many years to come. This is because of the profound differences in opinion between Sunnis and Shias as well as within the Sunni schools of laws. The Shias are of the view that ijthihad, which gives jurists the power to research and understand a new phenomenon before making a decision, must be used to interpret the law whilst some Sunnis favour taqleed, where the decision by a trustworthy jurist on an issue is usually deemed the correct ruling without the need for the jurist to prove why he/she arrived at such a decision.

Why halal certification

The expansion in the Muslim population in the Western world has led to an unprecedented rise in the demand for halal food (Lever *et al* 2010). This has brought about the formation of several unregulated halal certification bodies in an attempt to assure Muslim consumers that halal-certified products meet the requirements of Islamic Shariah law. Generally, abattoirs and meat processors in Muslim-majority countries do not usually require halal certification because all foods in these countries are assumed to be halal, and halal consumers usually have little or no knowledge about slaughter methods. Furthermore, there are Muslim scientists and professionals, who will argue that very few, if any, slaughterhouses in predominantly Muslim countries produce proper halal meat. The animals may be non-stunned but this in itself does not make the meat halal, especially if animals are generally treated very badly (transported under horrendous conditions, dragged by their coats or horns, immobilised by the slashing of tendons, and so on). Masri (2007) reported that Muslims living in Muslim-majority countries do not appreciate the difficulties encountered by Muslims living in the West in trying to meet the strict Islamic dietary requirements, possibly due to stricter regulations surrounding the slaughter of animals and the risk of cross-contamination of halal food with non-halal food. Halal Certification Bodies (HCBs), although unregulated and often operating according to varying halal standards, are seen by many Muslims as the enforcers of halal dietary laws, particularly in Muslim-minority countries where there is the risk of cross-contamination with non-halal raw materials, such as pork. This is also

because most abattoirs in these countries are owned and operated by non-Muslims who may not have a good understanding of the Islamic dietary laws. As a general requirement, all HCBs must have an independent Board of Islamic Scholars/Jurists who must make decisions on what should and should not be certified as halal. The halal certifier must also have a team of well-trained auditors (preferably Muslims) who visit the food-processing plants and abattoirs to ensure that all processes are consistent with Shariah law. Unfortunately, this is not always the case, the authors are aware that some small-scale halal certifiers have been found to have neither Islamic Scholar Boards nor trained auditors, often operating from domestic premises. Even some of the well-established HCBs have been accused of issuing halal certificates to companies without visiting the slaughterhouse or processing site. Some food business operators, indeed, are thought to prefer the smaller halal certifiers because they are seen as less rigorous and consequently a person with little or no understanding of Islamic jurisprudence may on occasion make decisions about what is halal or haram.

Pre-slaughter restraint of cattle

Animals must be appropriately restrained prior to slaughter in order to restrict their movement, thus allowing for the accurate positioning of the stunning device, if used, and ensuring an accurate neck incision during slaughter. During halal slaughter without stunning, the accuracy of the cut may be affected if animals panic or are agitated by the restraint (Hollenben 2007). Lambooj *et al* (2012) reported that the use of less-stressful restraint techniques improve slaughter operative safety, animal welfare and product quality. To reduce the stress associated with restraint, the restraint must be well designed and excessive force should not be applied (Mitchell *et al* 1988). The design of a restrainer should exploit the animal’s natural behaviour. Grandin and Regenstein (1994) reported that the use of crush restraints could be injurious to both the animal and its handler. Struggling and vocalisation of cattle during restraint is a sign of excessive force being used by the handler (Grandin 1995). Mpamhanga and Wotton (2015) compared the post-stun/kill responses and carcass quality when a Jarvis Beef Stunner was used under commercial conditions, with and without the use of a prior crush restraint (for identification). They found a marked reduction in post-stun/kill limb movement, muscle tone and the prevalence of brainstem activities without the use of the prior restraint. Furthermore, the authors also found a significant reduction in blood splash. They therefore suggested the abolishment of the use of crush restraints pre-slaughter for the purpose of identification since cattle identity can be established post-slaughter without any traceability or food safety issues.

The impact of poor restraint on meat quality and profitability cannot be underestimated. Warriss (1990) reported that poor pre-slaughter handling and restraint significantly reduces the market value of beef due to injury, bruising and dark cutting beef whilst Boleman *et al* (1998) estimated the then current financial loss associated with bruising to be US\$4.03 per animal resulting in a total annual loss of over

US\$114m to the USA beef industry. It is against this backdrop that the proper design and sympathetic restraint of cattle during slaughter is important for both animal welfare and the quality of the meat produced, as well as the health and safety of slaughter operatives.

Restraint for halal slaughter without stunning

The Farm Animal Welfare Council (FAWC 2012), Eurogroup for Animals (2008) and the Federation of Veterinarians of Europe (FVE 2015) have expressed concern about the slaughter of any animal without stunning, particularly in cattle, where the duration of consciousness after the neck incision can be prolonged as a result of the formation of false aneurysms in the severed carotid arteries resulting in continuous supply of oxygenated blood via the vertebral arteries. Since the halal cut will not sever the vertebral arteries or the brachiocephalic trunk, this supply to the brain remains in place and intact. Other animal welfare proponents, such as the British Veterinary Association (BVA) and the Royal Society for the Prevention of Cruelty to Animals (RSPCA), have campaigned for the banning of slaughter without stunning on the grounds of animal welfare. However, the existence of derogation in the European regulation (EC 1099/2009) allowing for slaughter without stunning and the insistence of some halal stakeholders in member states to continue to slaughter all animals without stunning, means that a large number of animals are still being slaughtered without stunning. The regulation, however, requires animals to be properly restrained before, during and after slaughter until such time that the animal completely loses consciousness.

Many animal welfare scientists agree that apart from the pain associated with the cut during slaughter without stunning, other animal welfare aspects of concern include the stress associated with the restraint and the latency of the onset of unconsciousness (Grandin & Regenstein 1994; Gregory 2005; Gibson *et al* 2009). Several methods of restraint have been used over the years to restrain cattle during halal slaughter; hoisting of conscious cattle by the hind leg, lateral recumbency and restraining cattle by inverting them on their backs (Gregory 2005). The only method of restraining cattle acceptable for use in the UK is restraining in the upright or standing position (FAWC 2012). Worryingly, in some parts of the world, cattle are still being restrained by hoisting them by the hind leg whilst they are fully conscious, a practice found to cause animals significant pain and unnecessary suffering due both to the weight of cattle and to the anatomy of their digestive system (Grandin 2015). A European Commission-funded project, Dialrel (2010) found that hoisting conscious cattle by the hind leg during halal slaughter is still a common practice in Turkey. Despite persistent calls by FAWC (1985, 2003, 2012) for the abolishment of the inversion of cattle on their backs, article 15 of EU regulation, EC 1099/2009, still permits the practice for slaughter without stunning. However, some member states, including Sweden, the UK, Denmark and others (eg Norway, Iceland and Switzerland) have banned this method of restraint. Islamic dietary laws

emphasise the need for animals to be alive at the point of slaughter and prohibits the consumption of flowing blood, however, little mention is made about the type and method of restraint acceptable during halal slaughter, although many Muslims appear to favour the restraining of animals on their left side (lateral recumbency).

Upright restraint of cattle

Restraining animals in an upright position allows for them to be slaughtered in their natural standing position. Upright restraint can be accomplished in a box or pen and most restraints are fitted with a chin lift that stretches the neck to ensure easy access during the halal cut. A chin lift also prevents movement of the head and ensures that the wound edges are kept apart during bleed-out. A belly lift may also be fitted to an upright restraint. Grandin (1995), and Grandin and Regenstein (1994) suggested that belly lifts must not be used to lift cattle off their feet as this puts considerable pressure on the thoracic cavity. The Welfare of Animals (Slaughter or Killing) (England) Regulation (WASK) (1995) requires halal cattle killed without stunning to be restrained in an upright position, this is echoed by FAWC (2012). However, poorly designed upright restraints can cause stress and avoidable pain to animals (FAWC 1985, 2012; Grandin & Regenstein 1994; Berg 2007). Gregory *et al* (2009) reported that an important animal welfare concern during the upright restraint and slaughter of cattle without stunning (for halal and kosher) is the aspiration of blood into the lungs. In addition, the upright restraint of animals during the neck-cut will result, even with a belly lift, in the loss of posture of the animal within the restrainer. This loss of posture is not as prominent as a collapse and animals remain conscious at this point. The slight lowering of the fore breast in relation to the upper part of the neck or head will have an effect on bleed-out efficiency, there are occasions in practice where the loss of posture shortly after the neck-cut result in poor blood loss due to clamping of the blood vessels in the neck against the head restrainer, hence delaying the loss of consciousness. Although the restraint and slaughter of cattle in an upright position is not the preferred method by many Muslim groups, the practice is now widely accepted during halal slaughter across Europe by halal authorities. Many Muslims are of the view that only camels have historically been slaughtered in their natural standing position but Islamic Shariah law does not give comprehensive guidelines on the pre-slaughter restraint of animals.

Rotating pens to invert cattle on their backs (dorsal recumbency)

The use of rotary pens to invert cattle on their backs is still used in some parts of Europe during halal slaughter. In the UK, this is illegal under the current regulation, WASK (1995) and the impending regulation, the Welfare of Animals at the Time of Killing (WATOK) Regulation (2015). Koorts (1991) compared the restraint of cattle by inversion with the upright restraint and concluded that restraining cattle on their backs is time-consuming, increases vocalisation as well as the level of blood cortisol (an indicator of stress). Gregory (2005) found that cattle struggled more vigorously when they were inverted on their backs before the use of head

restraints in comparison with the application of head restraints before inversion on their backs. Dialrel (2010) also concluded that the restraint of cattle on their backs does not provide good animal welfare. Blood and gut content were found in the trachea and larynx post mortem depending on the extent and position of the ritual cut. Due to the animal welfare implications of restraining animals in the dorsal recumbency position, FAWC (1985, 2012) recommended the abolition of this method of restraint. Many halal authorities perceive this method of restraint to be better than restraining cattle in the upright position because it facilitates the neck cut (Dialrel 2010).

Restraining cattle in lateral recumbency

Cattle may be restrained in a lateral recumbency position during halal slaughter without stunning, ie restraining animals at a 90° angle such that they lie on their sides. This is the preferred method of restraint by most halal authorities because halal cattle have historically been slaughtered lying on their left sides. It is, however, not a strict requirement because it is not specifically mentioned in the *Quran* and *Hadith*, the sources of Islamic dietary laws. Scientific investigations comparing this method with the rotating pen in which cattle are inverted on their backs found that the lateral recumbency method of restraint was less stressful (Petty *et al* 1994; Pesenhofer *et al* 2006). The authors explained that in lateral recumbency, there are no breathing difficulties because there is no rumen pressure on the diaphragm and the thoracic cavity. During lateral recumbency, cattle lie on their sides so there is no difficulty with supporting their bodyweight during and after the cut. Pesenhofer *et al* (2006) concluded that cattle restrained in lateral recumbency during foot-trimming were significantly less stressed compared with those restrained in an upright position. However, as with any system of restraint, the use of lateral recumbency is not without some problem. Putting animals in a lateral recumbency position can exert some pressure on the internal organs of cattle (Tagawa *et al* 1994). The authors restrained healthy cattle of the Holstein breed in dorsal and lateral recumbency positions but did not slaughter them. They observed that lateral recumbency and restraining animals on their back affected the normal functioning of the respiratory systems due to stresses exerted by the method of restraint. Researchers in the Dialrel project (2010) reported that restraining cattle on their sides is prevalent in some member states. They found that cattle restrained on their sides did not have problems with pressure on the diaphragm, aorta or major veins.

Restraint for post neck-cut stunning

Post neck-cut stunning, in comparison with the slaughter of animals without any form of stunning, provides an improvement in animal welfare (Gregory *et al* 2012). The aim of post neck-cut stunning is to abolish consciousness at the time of bleed-out and so reduce the time taken by animals to lose sensibility until death supervenes. More importantly, it satisfies an integral aspect of halal slaughter, the requirement for animals to be alive at the time of slaughter. Despite providing assurance of a fully conscious animal at the point

of slaughter, post neck-cut stunning still divides opinion amongst religious authorities. The UK Halal Food Authority (HFA) in oral evidence to a recently commissioned All Party Parliamentary Group (APPG) inquiry into religious slaughter of lamb and beef (2014) indicated that the organisation would accept post-cut stunning for halal slaughter in order to reduce the duration of pain after the halal cut. Conversely, in their written evidence to the APPG, Shechita UK dismissed the idea with an explanation that they believe animals are already rendered irreversibly unconscious immediately when slaughtered (cut) in accordance with Shechita guidelines. Most halal authorities within the EU recognise this practice as halal. However, Dialrel (2010) recommended further research and dialogue to assure the Muslim community that the practice does not contravene the halal slaughter guidelines.

Restraining of cattle for post neck-cut stunning present similar problems as that for un-stunned slaughter in a sense that there is often vigorous struggling after the cut so the stun must be applied immediately to induce immediate loss of consciousness and insensibility. Thus, one of the other challenges of post neck-cut stunning is to maintain the animal in place for the correct positioning of the stunning equipment. Different slaughter techniques have been developed for cattle and veal which facilitate rapid (within seconds after the completion of the cut) post-cut stunning. The time between neck cutting and the application of the stun may be influenced by factors, such as: the requirement of the religious authorities (Berg 2007); the level of experience and expertise of the slaughter operatives; the temperament of the animal; and the method and type of the restraining device used. Binder (2010) reported that the type of restraining device employed dictates the time interval between neck cutting and stunning. Berg (2007) measured the time interval to be 40 s or longer when an upright restraint was used. Other researchers have recommended that the time interval should be no more than 5 s (Velarde *et al* 2010). During post neck-cut stunning, there is also a requirement for a neck stretch to ensure unimpeded sticking or neck cutting and the stretched neck must be maintained to facilitate bleed-out, therefore a full head restraint and chin lift is maintained which will facilitate shooting.

Restraint for electrical stunning

There is no difference between the way cattle are restrained during halal and conventional electrical stunning. The main difference in electrical stunning during halal and conventional slaughter is the way the system is applied; whilst ventricular fibrillation is acceptable in conventional slaughter, this is proscribed under Islamic Shariah law, according to Islamic jurists, this is because it will not support recovery. Head-only electrical stunning is therefore the only acceptable method of stunning because it provides some level of assurance that animals are alive (with a patent heart beat) at the point of slaughter.

Cattle to be electrically stunned must be individually restrained to reduce movement and ensure the accurate positioning of electrodes. Hollenben and others (2002)

reported that bruising and blood splash, which reduces the marketability of meat, can be minimised by ensuring that animals are well restrained and less agitated during electrical stunning and slaughter. It is also important to ensure that the vision of cattle at the entrance to the restraint box is screened of people and objects in close proximity and the animal must not be restrained too tightly (Ewbank 1992).

Stunning of cattle

As early as the 15th century, mechanical stunning by percussive blow was practiced in China (Mellor & Littin 2004). The authors explained that the aim of stunning at the time was to improve operator safety and facilitate post neck-cut operations, not for the protection of animal welfare. MacLachlan (2006) reported that up until the beginning of the eighteenth century, the English were described as being uniquely callous in their handling and treatment of animals. However, by the start of the twentieth century, concern for animal welfare made England one of the leading countries supporting the humane treatment of animals (Otter 2004). Zivotofsky and Strous (2012) asserted that Western societies found it necessary to use stunning in order to minimise pain and suffering of animals during slaughter only in the last 150 years or so. Today, stunning is used to make animals insensible to pain prior to slaughter (Gregory 2007). Electrical stunning remains the commonest method of stunning employed during the slaughter of sheep, rabbits and pigs (Zivotofsky & Strous 2012) whilst cattle are generally stunned by the use of a penetrating captive bolt (Gregory & Shaw 2000). Electrically stunned animals are insensible to pain because stunning results in brain dysfunction brought about by the disruption of neurons and the release of neurotransmitters in the brain that results in a tonic/clonic state similar to epilepsy (Hollenben *et al* 2010). The loss of consciousness must be immediate in order to minimise pain, distress and suffering during the humane killing of food animals. If, for any reason, the stunning method cannot induce immediate loss of consciousness, then the induction of unconsciousness must be non-aversive (Hollenben *et al* 2010). Due to the differences that exist among Islamic jurists in the interpretation of the Shariah law, some Muslim groups accept pre-slaughter stunning on condition that it does not kill animals prior to the neck-cut whilst others reject it with the belief that the Prophet of Islam did not practice it. Opponents of stunning during halal slaughter also believe that even reversible stunning does not guarantee a live animal at slaughter.

Electrical stunning of cattle

Electrical stunning is the passage of electric current through the brain in order to induce unconsciousness and insensibility through the depolarisation of brain cells (neurons) (Blackmore & Delaney 1988) which results in tonic/clonic epileptic seizures (Gregory 1987). In addition to electrophysiological evidence, human beings have reported no pain or other sensations during tonic/clonic epileptic fits (Bager *et al* 1992). The behavioural reaction of humans during epilepsy is similar to that induced during electrical stunning as is the EEG trace produced, it is therefore

assumed that if human beings do not feel pain during epilepsy, animals will experience the same. Rosen (2004) suggested that the passage of electricity through the brain is painful. However, in an experiment using human subjects, Levinger (1976) demonstrated that even if the passage of electric current through the brain is painful, by the time the person perceives the pain, he/she would have been in a state of unconsciousness. The time to perceive pain from the initiation of a noxious stimulus has been estimated to be between 100 and 150 ms (Liu *et al* 2011) which is more than the time needed for the current to disrupt normal membrane potential and result in brain dysfunction and unconsciousness. Therefore, electrical stunning of cattle, when carried out successfully, appears a humane pre-slaughter procedure (Bager *et al* 1992). Gregory (2007) suggested that electrical stunning equipment must be regularly maintained and inspected to ensure that it is able to discharge the recommended stunning parameters at the right position and, further, that the reaction of the animal must be continually, carefully observed. One of the drawbacks of electrical stunning is that it is short-acting, that is, the duration of unconsciousness induced by the current can be very short. Researchers have estimated this duration to be between 40 and 60 s (Daly & Warriss 1986; Wotton *et al* 2000). This presents a welfare concern in that cattle may recover before they are bled-out if ventricular fibrillation is not induced. In addition to ventricular fibrillation, cattle may also be thoracically stuck to ensure rapid blood loss, which quickens death and may prevent recovery. There is also a health and safety concern regarding electrical stunning from the slaughter operatives' point of view. The clonic phase of epilepsy is characterised by violent convulsions that may be injurious to the slaughter operatives. EFSA (2004) reported that there are two forms of electrical stunning; head-only and head to body electrical stunning. In head-only stunning, the heart tends not to be affected, however, in head to body stunning the heart may be affected and the stun may not be reversible. Muslims generally regard only reversible stunning as halal (Anil *et al* 2006) so any stunning used during halal slaughter must not also be able to result in the death of animals were they not to be bled out. As stated above, there is currently no suitable head-only electrical stunning system for halal beef within the EU, although a significant proportion of halal lamb is slaughtered using head-only electrical stunning. There is, therefore, an urgent need for research to be carried out in this area to design and implement an electrical stunning system for the EU halal beef market.

Head-only electrical stunning

This type of electrical stunning involves the transcranial application of electric current to produce tonic/clonic seizures (epilepsy). Most Muslims favour this form of electrical stunning during halal slaughter because death does not occur as a consequence of the stun and the animal is able to make a full recovery if bleed-out does not occur. It is, therefore, important that the animal is bled-out immediately to ensure that it does not recover during bleed-out. This is, however, constrained by the fact that the clonic phase of epilepsy,

which is characterised by violent kicking, makes sticking difficult and can cause significant delays. Although the use of thoracic sticking is prohibited during halal cattle slaughter (probably because the prophet never practiced it), it has been shown by Anil and others (1995) to reduce blood pressure to nearly zero within 8 s. This method of exsanguination could be used to curtail the problem of animals recovering during bleed-out after head-only electrical stunning. Robins *et al* (2014) reported that some halal authorities permit the use of thoracic sticking during halal slaughter. These authorities, however, require a delay of up to 2 min after the halal cut. The problem with this criterion is that unconsciousness cannot be maintained for 2 min thus the animal may recover during bleed-out and before it is chest stuck. As emphasised earlier, there is currently no suitable head-only electrical stunning system for the halal market in the EU although most halal authorities have ruled that such a system will be accepted for use during halal slaughter.

Head to body electrical stunning

This method of electrical stunning induces epilepsy in the brain followed by ventricular fibrillation (cardiac arrest) to ensure that the animal does not regain consciousness. The method has significant animal welfare and health and safety advantages over head-only electrical stunning. Gregory and Wotton (1984) suggested that where there is delayed bleed-out, this method ensures prompt and terminal fall in blood pressure and thus prevents the resumption of consciousness. The irreversible nature of head to body electrical stunning together with spinal discharge also ensures that post-stun convulsions, synonymous with head-only stunning, are prevented and a less mobile animal results, which is safer and easier to work with. The induction of ventricular fibrillation also ensures that the possible bruising of carcasses following stunning and during slaughter, eg during impact whilst rolling out from the stun pen, is reduced (Gregory *et al* 1988) and research has shown that overall bleed-out is not affected as result of ventricular fibrillation (Raj & Johnson 1997).

Wotton and others (2000) explained that fibrillation of the heart was achieved by the Jarvis Beef Stunner when a 550-volt sinusoidal alternating current (AC) at 50 Hz, using a choke limited current of approximately 3.5 A, was applied between nose and brisket electrodes. In an attempt to explain cardiac dysfunction, Hollenben *et al* (2010) reported that the probability of fibrillating the heart is determined by electrical frequency, current flow, current pathway and animal species.

Despite the advantages of head to body electrical stunning, it is not consistent with halal slaughter according to the major halal standards (MS1500 [2009]; HFA [2014]; MUI HAS 23103 [2012]). This is because of the fibrillation of the heart that will eventually lead to the death of the animal if not slaughtered.

Mechanical stunning of cattle

Mechanical stunning and killing is achieved by the use of penetrative and non-penetrative captive-bolt stunning (Blackmore & Delaney 1988; Anil 2012) that induces immediate loss of consciousness through concussion, which

causes neural dysfunction (Gregory 2005). The aim of both penetrative and non-penetrative captive-bolt stunning is to induce unconsciousness through the transfer of kinetic energy to the brain through the differential acceleration of the head/skull and the brain to cause concussion. EFSA (2004) recommended the disuse of non-penetrative captive-bolt stunning in cattle because of concerns over its effectiveness. Council regulation EC 1099/2009 prohibits the use of non-penetrative captive-bolt stunning in cattle over 10 kg. Concerns have also been raised about the risk to public health when animals are stunned or killed with penetrative captive-bolt guns because they have been shown to transfer brain tissues to edible parts of carcasses (Anil *et al* 2002). This method of stunning is generally not accepted for the pre-slaughter stunning of cattle during halal slaughter. Most halal certifiers reject mechanical stunning of animals during halal slaughter for the following reasons:

- Mechanical stunning does not guarantee the recovery of all animals, which makes it inconsistent with Islamic dietary laws;
- Mechanical stunning involves the induction of unconsciousness through a mechanical blow to the head. This is contrary to the teachings of the *Holy Quran* (*Quran* 5:3). This verse prohibits Muslims from consuming meat from animals killed by a blow to the head;
- There is damage to the skull in both penetrative and non-penetrative captive-bolt stunning. Islamic Shariah law requires the animal to remain 'intact' after slaughter, with the exception of the slaughter wound.

Compatibility of stunning for halal slaughter

Cattle slaughtered for Muslim consumption are exempt from pre-slaughter stunning in some EU member states, including England (WASK 1995; WATOK 2015). Gregory (2005) reported that from an animal welfare viewpoint, the slaughter of animals without stunning remains a contentious issue for three reasons; the distress caused by the restraint, the pain associated with the cut and the latency of the onset of unconsciousness. These animal welfare implications are scientifically well-described and generally accepted in the scientific community (Ferguson & Warner 2008; Gibson *et al* 2009; Gregory *et al* 2009; Mellor *et al* 2009; Gregory *et al* 2010). Despite the welfare implications of slaughter without stunning, some Muslim authorities insist on slaughtering animals whilst they are fully conscious.

Within the Muslim community, the debate surrounding the acceptability of stunning is one that is likely to linger on. The fact remains that stunning is not mentioned anywhere in the *Quran* or *Hadith* so its acceptance or rejection is open to the interpretation of Islamic scholars. It is important to note, however, that stunning is a relatively new technique that came into practice some centuries after the various Holy books (the *Torah*, the *Bible* and the *Quran*) were revealed. Some Muslim authorities reject stunning because it was not practised by the prophet of Islam, however, they do accept other practices that were not observed by the prophet, such as intensive livestock agriculture, inversion of live animals at slaughter, the use of growth hormones and

antibiotics, castration of animals, artificial insemination etc. Others are of the view that the stunning of animals does not guarantee a live animal at slaughter and that meat quality and the efficiency of bleed-out are adversely affected when animals are pre-stunned. Published work has, however, shown these specific claims to be invalid (Anil *et al* 2004, 2006; Khalid *et al* 2015).

Despite the refusal of some Muslim groups to accept stunning as part of halal slaughter, the practice is becoming popular among the Muslim community in general, and more recently in Muslim-populated countries, such as Malaysia, Indonesia, Egypt, Saudi Arabia, the United Arab Emirates, Yemen, Tanzania etc. This is partly due to the fact that Islamic scholars in these countries are now well-informed about stunning and there is a realisation through recovery trials that some methods of stunning do not result in death before bleed-out, which make them compliant with Islamic slaughter requirements. Stunning is accepted as halal on condition that it does not kill the animal before the ritual cut is made. Prominent Islamic scholars around the world are now issuing declarations or rulings (Fatwas) in support of stunning. Notable among the Fatwas issued in support of stunning include the following:

- Fatwa issued in 1978 by the Egyptian Fatwa Council at Al Azhar University. The Fatwa was made specifically to confirm the suitability of electronarcosis for halal slaughter.
- Fatwa issued in 1987 by the Fiqh Council in Makkah, Saudi Arabia. This Fatwa was issued regarding reversible electrical stunning during the 10th session of the Islamic Fiqh Council at the Muslim World League held from 24th to 28th of October 1987.
- Fatwa issued in 2006 by the Council for Legal Verdicts in Yemen. This Fatwa was made in reference to reversible electrical stunning.

It is clear from all the Fatwas issued in support of pre-slaughter stunning of animals during halal slaughter that there is emphasis on the reversibility of the stunning method. Despite the clear guidelines issued by Islamic scholars on the need for the stunning method to be reversible, it has been reported by Berg and Jakobsson (2007) that some Muslim authorities in Sweden, in addition to using reversible electrical stunning, also do employ irreversible stunning methods, such as captive-bolt stunning which does not result in immediate induction of cardiac fibrillation. This practice is also prevalent in the UK (FSA 2012, 2015).

The way forward

Some Muslim authorities generally accept reversible stunning during halal slaughter. However, an increasing number of cattle are still being slaughtered without stunning for Muslim consumption within the EU because there is no approved reversible stunning system for the halal market. Further research is therefore needed to identify suitable reversible stunning technologies that will meet both humane slaughter requirements and halal slaughter guidelines. Below are two important head-only stunning systems that are being investigated, that may meet these requirements.

Single Pulse Ultra-high Current (SPUC)

Robins and others (2014) reported a novel system of head-only stunning of cattle using an SPUC generated by a capacitance current spike of a minimum of 5,000 V and a current of 70 A. They suggested that a process known as electroporation probably induced unconsciousness; this involves the creation of pores in neural membranes due to the high voltage gradients. It is a technique that is currently used in human biology to introduce foreign matter, such as drugs and DNA, into tissues. They also observed that tonic/clonic seizures associated with epilepsy were absent, a feature that could improve meat quality and operator safety. Although further work is needed to properly investigate and commercialise this system, the authors suggested that the system could be used for halal slaughter since it is reversible. The Humane Slaughter Association (HSA) is currently funding research in the UK that is investigating implementation of an SPUC system.

Use of microwave energy

The use of microwave energy has been used to successfully stun animals by increasing the temperature of their brains (Small *et al* 2013; Rault *et al* 2014). This system has the potential for use during halal slaughter because reversibility can be achieved if the increase in temperature does not result in protein denaturation and tissue death. Further research is however needed to ensure that the system meets humane slaughter guidelines and to ensure its commercial application. One of the drawbacks of this system of stunning is the fact that its application results in excessive surface heating (Small *et al* 2013) which has been shown to be painful to animals (Rice & Kenshalo 1962).

Halal-compliant slaughter of cattle; overview

The conventional slaughter of cattle in most developed countries involves stunning before the neck incision in order to disrupt normal brain function and induce unconsciousness, so that the pain associated with the neck-cut is eliminated. The rate of bleed-out may be expedited by thoracic sticking; this involves the severance of the brachiocephalic trunk located near the heart to ensure rapid loss of blood. Conversely, during halal slaughter, some authorities are against the use of stunning and thoracic sticking leading to the slaughter of conscious animals that subsequently endure pain and suffering from the point of slaughter until consciousness is eventually lost. Robins *et al* (2014) reported that cattle for the halal market are usually slaughtered by drawing a sharp knife across the neck to sever the oesophagus, trachea and both the carotid arteries and jugular veins. Historically, halal slaughter has been done by ventral incision although it is permissible to slaughter camels by chest stick whilst they are standing. Due to the differences that exist among Islamic scholars in the interpretation of the Shariah law, there are disagreements pertaining to some aspects of halal slaughter. This has led to differences in the halal standards used by the major HCBs and the major importing countries. The inability of Islamic scholars to collectively approve (or otherwise) some important practices, such as stunning, mechanical slaughtering (in the case of poultry)

Table 1 The acceptability of stunning among UK halal certifiers and the recognition of certificates issued by these certifiers in the major halal-importing countries.

Halal Certification Bodies (see text)	Acceptance of stunning	Certificate recognition in major halal-importing countries			
		UAE	Indonesia	Malaysia	Singapore
HMC	No	Yes	No	No	No
HFA	Yes	Yes	Yes	Yes	Yes
HAB	Yes	No	No	No	No
HCL	Yes	No	No	No	No
Assure-IP	No	No	No	No	No
EHDA	No	No	No	No	No
IJJ	Yes	No	No	No	No

Data correct as at 19/10/2015.

and thoracic sticking has left halal consumers, food business operators and animal welfare scientists unclear as to the true requirements of Islamic Shariah law.

One aspect of halal slaughter that has attracted a lot of attention is whether stunning is halal or not. This is because of the significant role that pre-slaughter stunning plays in the protection of animal welfare during slaughter. In the UK, the HFA is the largest certifier of stunned halal meat and certificates issued by this organisation are widely recognised across the globe. The HFA accepts specific forms of pre-slaughter stunning. Other UK HCBs that accept pre-slaughter stunning include: Halal Consultations Ltd (HCL), the Halal Authority Board (HAB), Universal Halal Agency (UHA) and the Institute of Islamic Jurisprudence (IIJ). On the other side of the argument are the Halal Monitoring Committee (HMC), European Halal Development Agency (EHDA) and the Assure-IP. The HMC, the UK's largest certifier of un-stunned halal meat does not accept any form of pre- or post-slaughter stunning as part of their halal certification procedures. Table 1 shows the position of some UK halal certifiers on the acceptability of stunning for halal slaughter and the recognition of the various certification schemes in the major halal-importing countries.

Animal welfare aspects of halal slaughter without stunning

The slaughter of animals without stunning remains a contentious issue (Grandin 2010). It has been demonstrated that the process is likely to cause pain to animals (Ferguson & Warner 2008; Gibson *et al* 2009; Mellor *et al* 2009; Gregory *et al* 2010). It is against this backdrop that EC 1099/2009 requires the stunning of all animals before slaughter with the exception of animals slaughtered for religious reasons. Halal slaughter requires all animals to be alive and healthy at the time of slaughter and according to the teachings of Islam, a sharp knife must be used to sever the carotid arteries, jugular veins, trachea and oesophagus to ensure rapid blood loss and death. Although the *Quran* stip-

ulates that the animal must be alive at the time of slaughter, some Islamic jurists have interpreted this to mean the animal must be conscious, whilst others are of the opinion that a pumping heart will suffice. Some concerns regarding the welfare of animals slaughtered by the methods described above, particularly when carried out without stunning have been raised. The stress of the restraining method, the pain associated with the ritual cut itself, the likelihood that animals may experience undue distress during bleed-out and the long duration of time cattle may take to lose consciousness are some of the concerns from an animal welfare perspective (Grandin & Regenstein 1994; Gregory 2005; Gibson *et al* 2009).

The ventral cut made on the neck of animals during ritual slaughter, particularly when carried out without stunning, may be painful and may prolong the time for animals to lose brain function (Ferguson & Warner 2008; Gregory *et al* 2010; Nakyinsige *et al* 2013). The time taken for animals to lose consciousness has been measured using electroencephalogram (EEG) and Somatosensory Evoked Potentials and appears to vary (Gregory & Wotton 1984; Daly *et al* 1986; Gibson *et al* 2009; Gregory *et al* 2010). Gregory and Wotton (1984) suggested that calves lose brain function promptly whilst Bager *et al* (1992) suggested that loss of brain function in some calves can take longer.

Animal welfare implications and conclusion

The slaughter of animals without stunning remains a contentious issue from an animal welfare perspective. This is particularly important during the halal slaughter of cattle by ventral neck-cut (and with shechita). In cattle, even when both carotid arteries and jugular veins are severed, oxygenated blood can still be supplied to the brain through the vertebral arteries, which means that cattle can remain conscious for a significant amount of time during bleed-out. Of concern, thousands of cattle are still being slaughtered this way for Muslim consumption because there is no approved stunning method for the EU halal market. According to many

proponents of halal stunning, for a stunning method to be acceptable as halal, it must be reversible, that is, it must not cause the death of the animal prior to the neck-cut and the animal must be able to make a full recovery if not slaughtered. Head-only electrical stunning appears to be the most suitable system that could meet the halal slaughter requirements described above. A new system of stunning, Single Pulse Ultra-high Current (SPUC), which was initially tested in Australia, is being further investigated in the UK with the aim of producing a commercial unit that could meet the requirements of halal slaughter. Other researchers are currently looking at the use of microwave energy to stun cattle, which again, may be accepted by the Muslim community for use during halal slaughter.

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