

Effects of slaughter method on carcass and meat characteristics in the meat of cattle and sheep

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Background

It has become apparent that the market for meat from animals slaughtered by religious methods is a significant proportion of the UK production and supply.

Although there has been research in this area, most information originates from work in conventional slaughter methods with limited comparison to religious slaughter. However, a few specific projects, for example Humane Slaughter Association funded work, have addressed aspects of animal welfare as well as quality issues of religious slaughter (see list under relevant publications).

The most recent project that has attempted to gather information on religious slaughter methods, practices, markets and consumers is the DIALREL project funded by the European Commission. Its findings in relation to current situations in member countries, rules, markets, consumer concerns and demands as well as a set of recommendations for best practices has been collected (see www.dialrel.eu). In addition, gaps in information and areas that need addressing have been identified.

In the UK, much discussion about religious slaughter is in progress. The following project has been carried out in order to inform and facilitate discussions on the merits of different slaughter practises and with particular reference to carcass and meat quality characteristics of cattle and sheep slaughtered by religious methods as required by EBLEX.

Objectives of the work

1. Research and collate information relating to conventional and religious slaughter methods and write an overview of Halal slaughter with and without stunning, Shechita and conventional/non-religious slaughter methods.
2. Prepare and submit a literature search and review document to include the effect of slaughter method on slaughter parameters (e.g. times to loss of consciousness, bleed out rates and duration, amount of blood retained, methods to determine effective slaughtering including indicators of unconsciousness, signs of recovery, sets of recommendations and guidelines)

3. Review research on the effect of slaughter methods on carcass and meat quality, including objective assessment criteria (e.g. pH, colour), eating quality and effective microbiology, food hygiene implications.
4. Prepare a report on current national practices, religious slaughter rules, identify gaps in knowledge and suggest areas that need addressing.

Deliverables

A written interim report within 2 months of starting date, followed by a final report to be submitted by 30 October 2011 provided the project starts on 1 July 2011.

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Stunning and slaughter methods

1 Overview of current slaughter practices

Animal production and stunning and slaughter procedures that produce meat for the consumer need to maintain product quality as well as protecting animal welfare. Slaughter methods, if not optimally employed, can adversely affect quality, operator and food safety and as a result cause downgrading of carcass and meat. Undesirable defects include haemorrhages, bruising, broken bones, pale soft exudative (PSE) and dark firm dry (DFD) meat, short shelf life and even condemnation of meat. Inefficient or incorrect stunning and slaughter could not only compromise animal welfare but endanger operators and public health.

Slaughter procedures are usually regulated by legislation, codes of practice and recommendations for different species also exist. The suitability of commonly used methods depends on species, availability of facilities, consumer demands and economic considerations. This review deals with aspects of conventional methods as well as religious slaughter methods and their acceptability in terms of legislation, effects on welfare and quality.

Following sources were extensively used and have more in depth information:

- DIALREL. Reports and factsheet. <http://www.dialrel.eu/dialrel-results>
- Anil, Haluk and Lambooj, Bert 2009. Stunning and slaughter methods. In: Welfare of production animals: Assessment and management of risks, Volume 5, Food safety Assurance and veterinary Public Health, Eds: Smulders, FJM and Algers, Bo. Wageningen Publs.
- Levinger, I.M., 1995. Shechita in the Light of the Year 2000. Maskil, L. David (Publ).
- Al-Hafiz, B.A. Masri. 1989. Animals in Islam. The Athene Trust. ISBN 1-870603-01-X
- Rosen, S.D., 2004. Physiological insights into Shechita. The Veterinary Record 154, 759-765.

Slaughter methods can be classified as conventional and religious applications.

1.1 Conventional methods

Effective stunning is aimed at ensuring that animals do not feel pain and distress as well as facilitating carcass control and effective bleed out either in unconscious animal or killing by cardiac arrest.

According to the EU Council Directive (European Community, 1993) and the impending European **COUNCIL REGULATION ((EC) No 1099/2009)** (European Community,2009) on the protection of animals at the time of slaughter it is stated that animals brought into abattoirs for slaughter shall be either moved or lairaged, restrained and stunned to make them

unconscious before slaughter. Permitted methods for stunning are 1) captive bolt pistol: mechanical methods, 2) electrical stunning and 3) gas stunning.

1.1.1 Electrical stunning

This is the most common stunning and slaughter application (Gregory and Wotton, 1985; Anil *et al*, 1997) It works by producing brain dysfunction and unconsciousness with or without subsequent killing by cardiac arrest so that bleed out (exsanguination) is carried out (Cook *et al*, 1996; Anil, 1991; Anil and McKinstry, 1991; Anil and McKinstry, 1992; Cook *et al*, 1999).

Head-only electrical stunning

Electrical currents, in sufficient quantities, applied on the head produce epilepsy (“grand mal” or seizure-like state), spreading across parts of the brain stimulating other cells. This effect, characterised by rapid and extreme depolarisation of the membrane potential and development of a synchronised electrical response, can be measured and observed on the recorded electroencephalogram (EEG) as small waves with high amplitude in the tonic phase (rigid), and low frequency in the clonic phase (high motor activity in muscles) resulting in depression of electrical activity in pigs, sheep and cattle (Lambooij, 1982a,b; Anil, 1991; Anil and McKinstry, 1992; Anil and McKinstry, 1998). Human subjects are known to become unconscious during epilepsy, by analogy, the effect is also assumed to be similar in other mammals. It has been demonstrated that several neurotransmitters are released in the brain during such an insult. Several studies have suggested that the general epileptiform insult induced by electrical stunning is dependent on the release of vasopressin, oxytocin, glutamate, aspartate and GABA (gamma amino-4-butyric acid). The first effect, tonic phase, occurs through the release of glutamate, followed by the release of GABA that helps with recovery if the animal is not killed. A minimum current threshold level that is a function of electrical impedance in the head is required for producing such an effect.

The most common electrical stunning method for animals uses a frequency of 50 Hz alternating current (AC.), similar to mains electricity, with sinusoidal waveform. The frequency can be high e.g. 1800 Hz (Anil and McKinstry, 1992; Lambooij *et al*, 1997) and the waveform can be square or rectangular. High frequency electrical stunning can induce epilepsy in the brain. However, the durations are shorter than those with 50 Hz and high frequencies do not fibrillate the heart.

Head-to-back (cardiac arrest) electrical stunning

This method involves induction of an epileptic state in the brain with concomitant cardiac arrest by electrical currents applied in the chest. The idea behind this method is that animal welfare is maintained because any possible recovery is prevented as stopping the heart kills the animal (Anil and McKinstry, 1991; Wotton *et al*, 1992; Gregory, 1994). Additionally, convulsions caused by epilepsy are greatly reduced making carcasses more manageable hence improving operator safety. Neuro-physiological studies and assessment of other parameters than general epileptiform insult and analgesia have indicated stunning and killing system may be humane. EEG and neurotransmitter release measurements have been used to assess the effects of electrical head only stun duration on welfare (Cook *et al*, 1992, 1995, 1996, 1999; Lambooij, 2004). Stress before killing increases some neurotransmitters that in turn may affect post stun reflexes and unconsciousness (Bodnar, 1984; Tume and Shaw, 1992; Cook, 1999). Combining head-only stunning with exsanguination could have a synergistic effect on

the release of glutamate and aspartate thereby increasing the duration of unconsciousness (Cook, 1996). Exsanguination/sticking after a stun needs to be carried out as soon as possible when using head-only stunning as it takes time depending on the species before brain responsiveness is lost following sticking (Hoenderken, 1978; Anil *et al*, 1995a,b). Cardiac arrest at stunning has distinct advantages in that a rapid loss of brain function occurs as well as ensuring animal does not regain consciousness because killing is not dependent on accurate sticking.

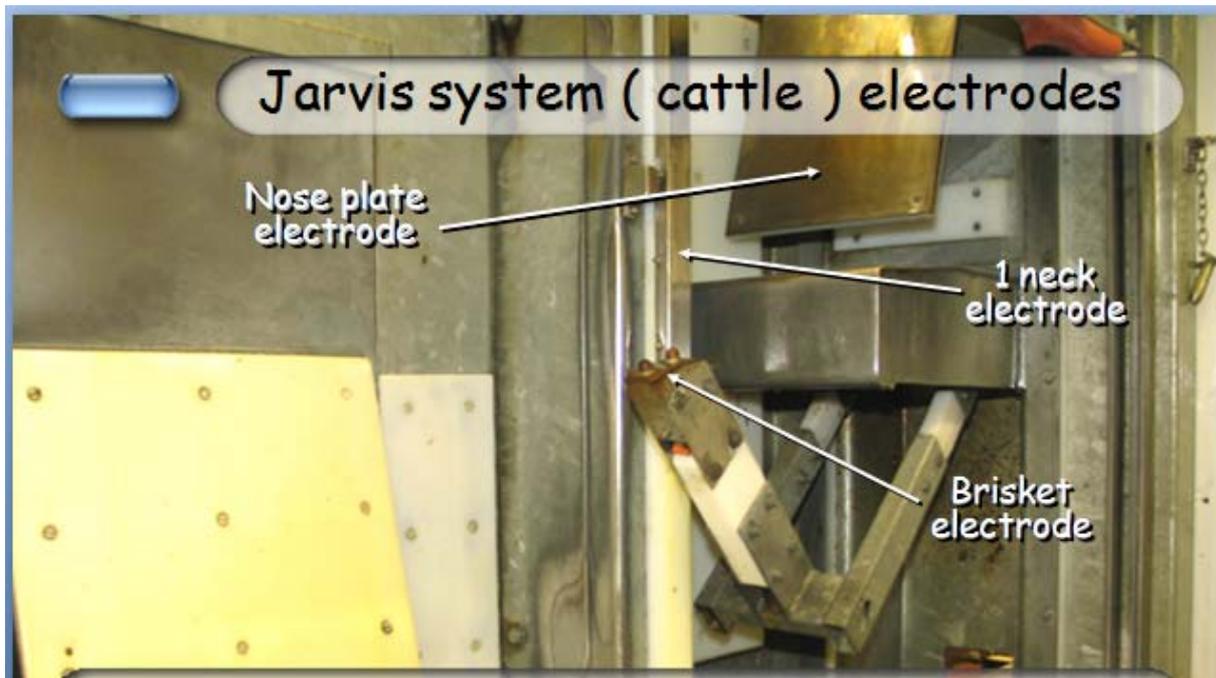


Figure 1. Jarvis Electrical stunning (www.awtraining.com)-cradle and electrode positions

Electrical stunning of cattle has become popular in recent years and is the chosen method in New Zealand where Jarvis stunning system that is incorporated in a restraining box is used. In the UK a few meat plants in England, Scotland and Northern Ireland also installed this system. Two main applications are possible: head-only stunning, mainly used for Halal slaughter, and head-to-body stunning (stun/kill method). However, disadvantages of the head-only technique in cattle/calves include relatively short duration of the epilepsy and excessive convulsions. Inclusion of cardiac ventricular fibrillation or rapid sticking (chest sticking) can prevent the former and electro-immobilisation using a low voltage applied on spinal cord before sticking can resolve the latter problem. However, electro-immobilisation may potentially mask signs of recovery or consciousness. The following applications can be used:

Jarvis cycle

- First, a 3 sec head-only cycle (nose electrodes to neck yoke) to induce unconsciousness
- Second, a 15 sec cardiac cycle (brisket/nose electrodes) to induce cardiac Fibrillation (This would be excluded for Halal).
- Third, a 4 sec spinal cycle (rear end/nose electrodes) can be applied to prevent kicking. The stunner delivers current at 550 V, 50 Hz sinusoidal AC about 3.5 A

If the above application is usually part of an integrated Jarvis system that includes a restraining pen with in-built electrodes. Once stunning is carried out, the animal is ejected out of the pen onto a cradle for exsanguination. If cardiac arrest was applied, then a chest stick is carried out on the cradle in horizontal position before hoisting. In cases of Halal slaughter, electro immobilisation on the spinal cord is applied before the neck cut.

In trials carried out by Wotton et al (2000) it has been shown that currents in excess of 1.15 amperes using 50Hz AC would be required for successful stunning of cattle. The same study showed that unconsciousness lasted for 50 seconds before return of rhythmic breathing, palpebral reflexes. In order to achieve cardiac arrest a 5 seconds application of 1.15 amperes was sufficient.

In other studies with adult cattle, different types of electrodes have been tested for head-only electrical stunning (Cook *et al*, 2002). Devine *et al* (2002) stunned cattle with 2.5 A (400 V, 50 Hz) passed through neck yoke electrodes behind the ears in a stunning pen.

With respect to stunning calves,) 1.25 A (50Hz, 150 V) is needed when the current is applied (Lambooij *et al*, 1983. Gregory *et al* (1996) recommended using at least 150 V.

After head only stunning of cattle and calves prompt sticking is essential to ensure no recovery occurs before death.

If neck cutting is carried out studies have shown that an isoelectric, flat EEG is observed within 30 to 127 sec after stunning (Bager *et al*, 1992; Devine *et al*, 1986; 1987). However, chest sticking, severance of the major blood vessels arising from the heart, has been shown to reduce this interval (Anil *et al*, 1995a,b).

In practice, 60 sec could be said to be the time interval between stunning and sticking for cattle. If head-only stunning is followed by the induction of cardiac fibrillation recovery is prevented. Because cardiac output and blood circulation is impaired, reducing oxygen supply to the brain and unconsciousness will be permanent.

Commercially available equipment that is used in New Zealand is effective but expensive for use in many other countries. Some handheld electric stunning systems have also been used for stunning adult cattle. However, this type of manual application is not as effective. Disadvantages and potential problems with electrical stunning cattle manually are:

- Cattle are big size animals and during passage of current from the head to the feet the animal may feel pain if current bypasses the brain or if the animal is not immediately made unconscious.
- Hand held tongs are difficult to apply and maintain contact during fall of the animal.
- Convulsions are too severe for carcass control and shackling and pose a threat to operator safety
- Exsanguination needs to be carried out quickly if cardiac arrest is not used

Excessive convulsions after electrical stunning in cattle need to be managed both to protect operators and facilitate high throughputs. Electrical immobilisation (90 V and 10 ms pulses delivered at 15 Hz during the bleeding procedure) to suppress convulsive activity used in New Zealand is not acceptable in most European countries. In addition, this technique can have adverse effects on pH and meat quality. Simmons et al (2006) have considered ways of solving this problem by suggesting combinations of waveforms and frequencies developed by Daly (2005).

For sheep the head-only technique is commonly employed using hand held electrodes placed between the eyes and the base of the ears on both sides. This method can be carried out either individually in standing animals in a pen or in a restraining conveyor, usually V-type. Stunning is usually applied on exit and exsanguination is performed on recumbent animal before shackling. Head-to-back (stun/kill) technique is also popular especially for conventional slaughter that involves passing a current simultaneously through the brain and through the heart .

In cattle and calves major challenges with head-only electrical stunning are short duration of the epileptiform activity and the occurrence of strong clonic convulsions. Various studies have shown that the duration of unconsciousness – measured from the resumption of normal breathing – was between 20 and 90 seconds. Effective bleeding must be achieved within this period to avoid resumption of consciousness. As thoracic (chest sticking) sticking induces a dramatic blood pressure loss within eight seconds and evoked responses were not present after five seconds in calves (Anil et al, 1995b), simple calculation of 20 minus eight seconds suggests that thoracic sticking should be carried out within 12 second after the stun. Thus rapid thoracic sticking resolves the problem of short duration of unconsciousness after electrical head only stunning. In Australia and New Zealand thoracic sticking immediately after the Halal neck cut is routinely practised to avoid problems of prolonged consciousness but also carcass quality problems, which could arise if bleeding is impaired (Pleiter, 2005).

The recommended minimum amperage is 1.5 ampere for adult cattle and 1.3 ampere for calves up to six month of age. In practice depending on the construction and placement of electrodes often two to three ampere are applied in cattle. Voltages used are 350 to 400 Volts. Electrode position for handheld tongs is preferably temporal between the eye and the ear. With automatic current application the current flows through the brain between neck electrodes and a nose plate. Current can be applied for at least four seconds to the head (EFSA, 2004). If ventricular fibrillation is to be induced at least 1.5 ampere are recommended for cattle and about 1.0 ampere for calves, applied for minimum five seconds, but in practice again often higher currents and longer application times are used (EFSA, 2004).

For sheep and goats the same principles apply as for cattle (EFSA 2004; Blackmore and Delany, 1988). The tongs should be positioned between the eyes and the base of the ears on both sides of the head preferably on wet skin. Lower effectiveness of stunning is achieved through presence of wool and a dry skin surface or when tongs are in caudal position behind the ears (Velarde *et al*, 2000). Pointed electrodes (electrodes with pins) give good grip and electrical contact, because they penetrate the wool. Electrodes with serrated edges may work in shorn sheep and if the area of application is wetted. With small areas of contact between the sheep's head and the electrodes, wool-burning and marked carbonising of the electrodes can occur. This, in turn, leads to a poor electrical contact due to an increased electrical resistance in the pathway and special care is necessary to keep the electrodes clean.

It is claimed that although lower currents in excess of 0.5 A may be sufficient effective head-only stunning in sheep should be induced using minimum currents of 1.0 Ampere. A minimum of 250 Volt should be used to deliver the current. Duration of current flow should be a minimum of two seconds and maximum stun-to-stick interval is suggested to be between eight seconds (EFSA, 2004) and 15 seconds (Anil and McKinstry, 1991).

Signs of efficient stunning in sheep include tonic and clonic activity and absence of normal rhythmic breathing. Resumption of rhythmic breathing can occur during the second clonic phase, as in lambs the seizure activity after high voltage head-only stunning includes a tonic and two clonic phases (Velarde *et al*, 2002).

1.1.2 Captive bolt (Mechanical) stunning

This method, used correctly, can provide a satisfactory stun instantly meeting the main objective of stunning:

“to render the animal immediately unconscious”. To maintain welfare the “unconsciousness” must be maintained until death without any recovery. Therefore, captive bolt stunning must either be irreversible or possible recovery must be prevented. It is mainly used in cattle, less frequently in sheep.

Mechanical equipment used for stunning and killing, can be classified as penetrating and non-penetrating guns and work by inducing concussion. These devices referred to as captive bolt guns used for this purpose also include use of free bullet and rifles. Captive bolt guns are different from the latter two in that they fire blank cartridges and expel housed bolts at high speed that retract back inside the barrel. In addition to conventional stunning cattle and to a lesser extent sheep guns are routinely used for emergency killing casualties, on-farm culling and for disease control. Captive bolt guns are required by legislation to be present as backup devices in case of failure of the main stunning equipment at abattoirs.

Other missiles used for stunning and killing of animals include free bullet, water jet and air pressure. After successful stunning animals collapse immediately and have a short tonic spasm for approximately 10 s prior to relaxation and immediately followed by excessive convulsions (Lambooij and Spanjaard, 1981). EEG (electroencephalogram) reveals major changes (delta and theta waves, slow waves and isoelectric lines) and the animal is regarded to be unconscious due to similar EEG changes described in man (Lambooij, 1982b; Lopez da Silva, 1983; Daly and Whittington, 1986; Daly *et al*, 1986; Daly *et al*, 1987; Daly and Whittington, 1989; Daly, 2003). For a captive bolt to be effective certain criteria need to be met. Firstly an appropriate gun with high enough cartridge strength needs to be employed so that the bolt is fired at high speed. Provided the correct target is hit then the impact on the skull should cause concussion by accelerating the head and the brain (Lambooij, 1981; Lambooij and Spanjaard, 1981). This is possible if the bolt at high speed imparts sufficient kinetic energy.

In general, firing of a missile onto the head and brain can cause injury by laceration and crushing (<100 m/s), by shock waves [about 100 to 300 m/s] (Hopkinson and Marshal, 1967) and by temporary cavitation effect (>300 m/s). Using the following formula:

$$e = \frac{1}{2} mv^2, \text{ where } e = \text{energy, } m = \text{mass, and } v = \text{velocity}$$

We can show that the delivered energy required for effective stunning is determined by the velocity that determines the energy (Daly *et al*, 1987; Anil and Lambooij, 2009). However, secondary tissue damage by penetration also prevents possible recovery.

The following factors determine success of captive bolt stunning:

- Provision of a suitable gun with the correct strength in optimum working order
- Hitting the right target area (variations between species)
- Bolt velocity (at least 50 m/second) and impact on head
- Tissue damage
- Penetration

- Amount of energy (most important determinant)
- Gun type and condition, choice of cartridge/air pressure Carbon deposits built up inside the barrel must be brushed out.

CB guns, depending on type, are activated by either trigger or on contact. The choice is usually based on availability, personal preference and experience.

Cartridge strength is expressed in terms of grain size, 21 grain equals 0.0648 gram. It is essential that correct cartridges are used for each type of gun. The colour for cartridge strength, gun power (0.22 or 0.25 calibre) and head stamp on cartridge (manufacturer) are used as identifiers.

Table 1. Typical cartridges

Animals	Gun calibre	Cartridge
Very large (e.g. heavy bull)	.22	4-4.5
	.25	4-6
Other large (e.g. cattle, horse)	.22	3-4
	.25	5
Small (sheep, calves)	.22	1.25

Pneumatically operated captive bolt guns are not recommended for sheep and cattle because of increased risk of contamination of carcasses with brain material.

- Shooting positions – see diagrams for species. More critical for correct stunning cattle than for sheep. Repeat shooting must be avoided as second and subsequent shots would not be as effective.
- Bolt velocity must be at least 50 m/seconds for effective stunning on impact
- Tissue damage ensures non-recovery, but would not improve stunning effectiveness. Non-penetrating CB stunning can also induce a stun.
- Penetrating CB stunning results in the bolt entering the cranial cavity (7.5-8 cm) and causing tissue damage. However, the main determinant of the stun is the impact. Although non-penetrating CB stunning can induce a stun, some recovery is possible if bleed out is delayed.
- Effectiveness of captive bolt stunning is determined by the amount of energy imparted by the bolt during the impact on head:

Energy - Kinetic energy

Energy = $\frac{1}{2}mv^2$, where; m = mass, size of bolt & v = bolt velocity

Therefore, the amount of energy imparted by the bolt is more important than penetration. Hence, non-penetrative stunning guns can be as effective.

Types of guns

- Penetrating : - blank cartridge, air injected bolt, air activated/injected bolt
- Non-penetrating Mushroom head bolt delivering a blow without penetration

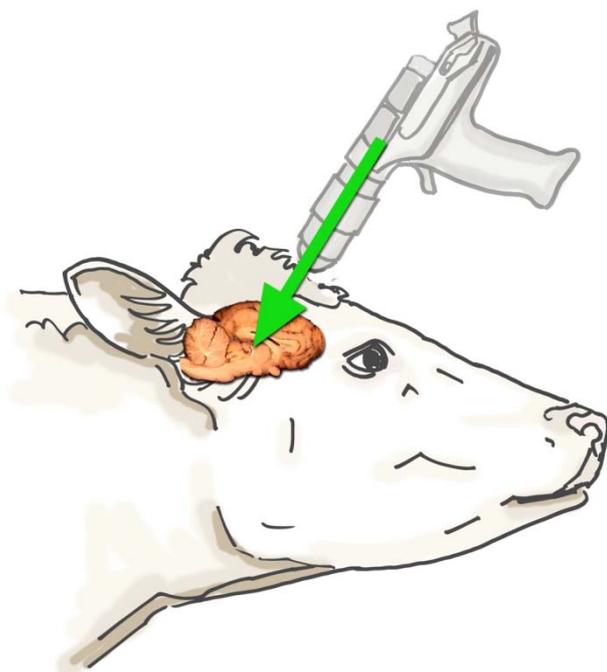


Figure 2. Penetrating guns fire the bolt into the brain through the cortex, midbrain and brain stem

This type of captive bolt stunning is designed to cause concussion by transmitting the energy from the missile (bolt) into the cranium and brain. Kinetic energy is transferred by the impact of a cylindrical steel bolt (mass) at speeds of 100 m/s in the air. As a result fractures occur and shearing forces also cause haemorrhages and lacerations. Captive bolt stunning is widely used for red meat farm animals. To fire the bolts cartridges filled with gunpowder, compressed air or springs under tension can be used against and through the skull of farm animals. After penetration about 7.5 cm the bolt returns back into the barrel by the action of the buffers. The ideal shooting position in cattle is the intersection of two lines between eyes and horns on the frontal bone (Figure 2).

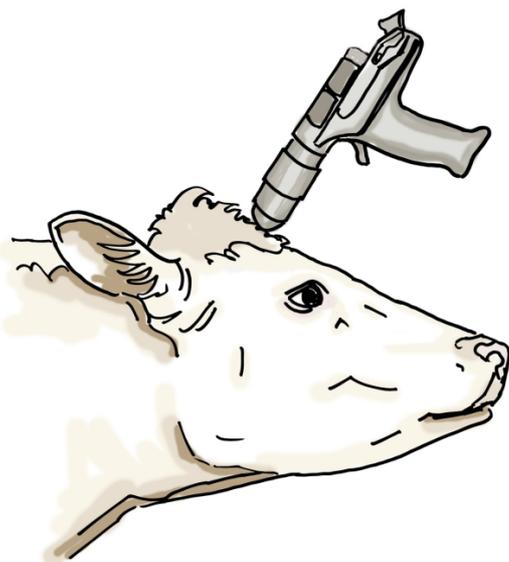


Figure 3. Non-penetrating guns deliver a blow on the skull damaging the cortex, midbrain and brain stem

Cerebral concussion is generally agreed to be a traumatically induced derangement of the nervous system, resulting in an instantaneous diminution or loss of consciousness without gross anatomical changes in the brain (Ommaya *et al*, 1964; Ommaya and Gennarelli, 1974). Irrespective of the type of force which produces the traumatic depolarisation of the cell membrane there is now evidence that powerful pressure waves are provoked within the cranial cavity by a blow on the head and that the frequency and force of the waves vary in different parts of the brain (Ommaya *et al*, 1971). It has been suggested that it is not the pressure as such developed by these waves that is the important factor but the rapid oscillations in this pressure (Lambooij *et al*, 1981). It should be noted that many investigators (EFSA) consider blood flow impairment as being primarily responsible for the electrical changes in the brain, although the immediate changes in the brain cannot be explained by this theory.

With the impending introduction of the new directive (EC) No 1099/2009 (European Community, 2009) non-penetrating captive bolt guns will no longer be permitted to be used in adult from January 2013 only to be permissible in animals below 10 kg. This is the result of scientific considerations concluding that current design of non-penetrating guns are not effective enough.

Checks for effective captive bolt stunning should be made regularly to ensure good welfare and diagnose potential and existing problem:

Signs of an effective captive bolt stun:

- Animal should collapse immediately
- Eyes fixed
- No corneal reflex (no blinking when eye ball is touched)
- No rhythmic breathing, but heart does not stop for sometime

Signs of an ineffective captive bolt stun:

- Attempts to raise head and stand up requiring repeat stuns
- Eyes rolled down
- Positive corneal reflex
- Rhythmic breathing

The intersection point of the imaginary lines from the top ridge of the eyes to the top of the horn buds.

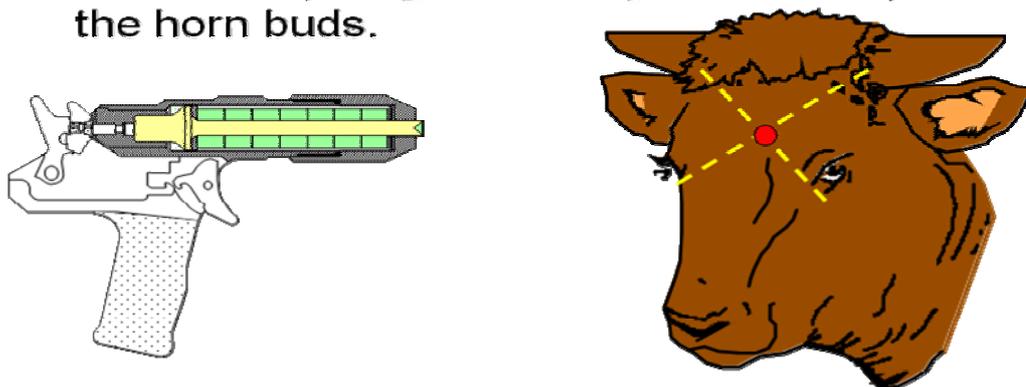


Figure 4. Shooting position in cattle

- **Cattle:** Intersection point of the lines drawn between the back of eyes and horn buds (Figure 4)
- **Sheep with no horns:** Highest point on head gun aimed vertically (Figure 5) (Same for all goats).
- **Sheep with horns:** Midline behind the ridge between horns aimed at base of the tongue.

Ideal shooting position in sheep

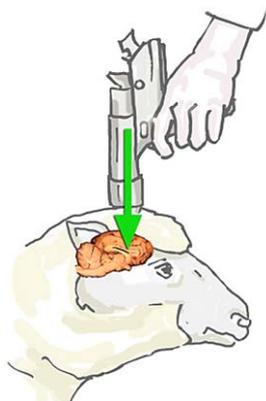


Figure 5. Captive bolt shooting in sheep

Sticking after CB stunning

Bleed out either by neck cutting or by chest sticking should be carried out as soon as possible. After the use of penetrating CB stunning, provided that there are no signs of recovery sticking can be delayed for over a minute for operational reasons. However, if non-penetrating CB gun is used, sticking must be performed immediately. For a good bleed out the current widely popular method is chest sticking which involves cutting the skin longitudinally from the neck down to the chest following the midline and then cutting into the chest near the heart (see sticking). However, transverse neck sticking could also be used which must include severance of both carotid arteries and jugular veins.

General recommendations on captive bolt stunning:

- Follow manufacturer's recommendations/instructions.
- Keep guns in good working order, use devices suitable for species, correct cartridge size
- Clean out guns regularly every day -bolt , barrel and buffers.
- Send guns for servicing every two years. Elongated bolts often need replacing .
- Keep a back-up gun for failure/emergency slaughter.
- If an animal fails to collapse immediately, check guns, shooting position and cartridge.
- The small area to be targeted on the head for effective stunning in cattle needs to be presented in such a way to facilitate correct shooting.
- Check for signs of effective stun must be before shackling.
- Avoid injury from kicking to operatives during shackling. e.g. provide sufficient space.

- Exsanguination (sticking) should be carried out as soon as possible.

Free bullet and rifle

Killing by free bullets is not used regularly for cattle except, for emergencies e.g. by a marksman and not used for sheep in the UK. In some other countries for example Canada rifles have to be used for logistical reasons if animals are in wild areas. Bisons are also shot with special free bullets that remain inside the cranium.

Free bullets have a lower mass than bolts of captive bolt stunners, and travel with higher velocity (typically >300 m/s for rifles).

1.1.3 Other stunning and slaughter methods

Carbon dioxide

Because conventional electrical stunning methods can have adverse effects on carcass and meat quality gas stunning methods have been introduced and used in the last 3 decades. Carbon dioxide, the principle agent, and inert gases such as argon and nitrogen can be used and pigs and poultry are the chosen species. Although cattle and sheep are not suitable for gas stunning due to size and presence of wool some recent trials in sheep have been carried out at IRTA, Spain successfully (Dalmau et al, IRTA, Spain, personal communication).

Water jet and air pressure

High water jets developed for cutting and drilling in solid materials are available for use as stunners. Experiments to explore the suitability of water jets for stunning and killing purposes were conducted under laboratory conditions using post mortem materials (e.g. pig heads) and also on live slaughter pigs (Schatzmann *et al*, 1990). Immediate unconsciousness as determined by EEG, was initiated by a rapid penetration of the skin and skull. In these studies destruction of the brain occurred within 0.2 to 0.4 s. The water jet, if employed, should be aimed frontally on the head and injected into the cranial cavity at the intersection of the imaginary lines from the ear to the opposite eye. A potential problem with water jets could be the excessive convulsions, that can appear after the use of this stunning method (Lambooij and Schatzmann, 1994). This is because – whenever an animal is decerebrated - convulsions (i.e. muscle contractions) of the carcass, caused by stimuli evoked in the medulla oblongata, mainly occur in the hind limbs.

Neck dislocation and neck cutting

Some predators use the method of cervical dislocation to immobilise and kill their victims. This is achieved by turning the head in opposite direction to the body while stretching the neck and concomitantly crushing and bleeding vessels. This method is not used in cattle and sheep. However, punctilla employed in South America operates by thrusting a knife into the intervertebral space between the head and the 1st or 2nd vertebra of cattle. After dislocation or

thrusting a knife a tonic cramp occurs resulting in paralysis after 5 to 10 s (Gregory and Wotton, 1990). Removal or inhibition of the contact between brain and spinal cord causes apnoea and loss of (pain) sensory perception from the body and spinal shock, with the exception of the face innervated by the 5th cranial nerve (Eichbaum, 1975).

Heating

Since the end of the 19th century high frequency electric currents have been used to heat tissues. Long wave diathermy, using frequencies in the order 1 MHz required the use of electrodes which were in direct contact with the skin and consequently the risk of burning was high. Later frequencies known as short wave diathermy were introduced with the advantage that it was not necessary for the electrodes and the skin to be in contact being air between it (Lambooij *et al*, 1990). In a reported procedure (Guy and Chou, 1982) heads of rats were irradiated with micro waves of 2450 MHz for 1 s the temperature in the brain increased up to 75-90 °C within the next 1 s. Consequently it was shown the brain enzymes are inactivated very rapidly, that they can be used in neuro-chemical investigations. It was observed that an increase of about 10 °C in the brain resulted in a clinical state of unconsciousness using 2450 MHz (6kW) for 1,5 to 2 sec. A change of 6.4 °C at a depth of 3 mm could cause a stunning effect using 915 MHz after seizure the rats lay in an unconscious state for a period of 4 to 5 min.

Cooling down

The current pre-slaughter process used for fish consists of live chilling to immobilize them prior to evisceration. Assessment of live chilling revealed that this method is stressful as vigorous activity of the animals and irregular heart rates were observed (Lambooij *et al*, 2002). Responses to pain stimuli disappeared at a body temperature of approximately 8 to 10 °C, that occurred after 10 to 15 min, suggesting that consciousness is lost by this time. A patented alternative method of stunning and killing eels (Lambooij *et al*, 2002) involves cooling them down gradually until death. According to the patent description the eels should ideally remain at least for 10 min in a medium with a temperature below -20 °C. A saturated brine solution at -15 °C may also be used. In addition, the eels should be stunned prior to killing by cooling down the body temperature to between 0 and 5 °C. Placing eels in brine at -18 °C is an effective method to kill the eels. However, it cannot be recommended to place conscious eels in cold brine water, because it takes more than 27 s before unconsciousness may be induced.

Fragmentation

Instantaneous fragmentation in a high-speed grinder could kill a small animal within a short time. Grinders with rotating blades are employed for small birds (see Anil and Lambooij, 2009). However, there are objections on welfare grounds that it is argued that animals should be made unconscious first (e.g. placement in CO₂ atmosphere first).

Magnetic stimulation

All stunning methods have disadvantages relating to quality, public health as well as possible misstuns. There is a need for research to develop alternative, ideally non invasive, stunning methods (Knight and Anil, 2003). A non-invasive method that does not result in tissue damage before death could also be acceptable by Jewish and Muslim communities. Magnetic stunning is based on passing a large current through a copper coil by which an intense magnetic field is generated. The coil is positioned close to the head so that the brain lies within this magnetic field. Transcranial magnetic stimulation (TMS) has been used in humans for years. The technique also reliably initiates seizures in humans as an alternative to ECT for the treatment of depression (Lisanby, 2002). Bristol research has provided evidence for insensibility during the TMS application (Anil *et al*, 2000). Using similar technology, studies aimed at producing seizure activity and prolonged insensibility without a painful induction have been conducted using new equipment and special coils in sheep, pigs (Anil *et al*, unpublished) and broilers (Lambooi, Anil *et al*, 2011). If fully developed, magnetic stimulation, a potential technique for stunning animals, could be used in future.

1.2 Effects of stunning and slaughter on carcass and meat quality

Stunning methods can have adverse effects on carcass and meat quality and cause downgrading. These could be visual effects such as bruising and haemorrhages, pelt burn in sheep, bone fractures, colour changes caused by DFD as well as those manifested in eating quality such as toughness.

In regard to specific effects in cattle and sheep the following can be listed as:

- Petechial haemorrhages (blood splash) and bruising in both species caused by:
Electrical stunning, traumas during transport and preslaughter handling
Bruising in cattle:
 - during heavy falls after stunning
 - impact from shutting gates on the back in race and stunning pen
- Animals developing bruising after hitting gateways and race fittings during passage to pens and restrainers
- Pelt-burn in sheep during head-to-back stunning where the rear electrode makes contact on back of neck
- Petechial haemorrhages in sheep can be seasonal and related to nutritional factors
- DFD in cattle due to tiredness and long term stress, (Gregory, 1998)

During electrical stunning blood pressure changes, muscle spasms and convulsions can cause ruptures and haemorrhages in vessels and muscle as well as fractures (Gregory 1998). Various stunning methods and electrical parameters have been reported to have a different effect on pH and *Post mortem* rigor development in various studies (Devine *et al*, 1984; Gregory, 1994; Bilgili, 1992; Hillebrand *et al*, 1996; Bilgili, 1999; Roth *et al*, 2002; Roth *et al*, 2003). *Post-mortem* metabolism can be influenced by indirect stimulation by nerves. Broken vertebrae can occur when stunned with head-to-back electrode positioning if the voltage and the current is too high (Troeger and Woltersdorf, 1991; Wotton *et al*, 1992). Sinusoidal alternating currents with 50 Hz frequency have strong stimulation on muscles. This can however be reduced by higher frequencies to prevent occurrence of broken backs (Gregory *et al*, 1991), almost to the point of zero with 1500 Hz. The disadvantage of high frequency is that possibility of stopping the heart, if required, is also reduced (Anil and McKinstry, 1992; Wotton *et al*, 1992) Although haemorrhages can be induced by stunning and killing, the underlying mechanism is thought to be multi-factorial (Troeger and Woltersdorf, 1991; Gregory *et al*, 2011; Kranen *et al*, 2000). Morphology of haemorrhages was shown to be dependent on the

affected tissue, for example in the pectoral muscles extravasating blood followed direction of the muscle fibre;. In fat tissue haemorrhages were petechial and diffuse haemorrhages in loose connective tissue (Hillebrand *et al*, 1996; Kranen *et al*, 2000). Histological studies on structures where haemorrhages occurred showed that blood leaking out of vessels is determined by the type of surrounding tissue and also the amount of blood leaving the circulation. Some haemorrhages were associated with hyper contracted and disrupted muscle fibres, indicating that they were caused by severe muscular strain. Many haemorrhages were found near venules or veins where rupture was observed, not in arterial vessels. This indicates that venous blood pressure increase can cause rupture of venules and small veins (Kranen *et al*, 2000).

In order to reduce petechial haemorrhages and bruising following can be considered:

- Shorten stunning to sticking interval so that blood leakage through ruptured vessels is reduced
- Captive bolt stunning may be preferable to electrical stunning if blood splash is a problem as muscle spasms are less pronounced after captive bolt
- Electrical stunning currents are applied in a continuous and uninterrupted manner
- In lambs electrical stunning with cardiac arrest may reduce blood pressure and blood splash.

Stunning methods and public health implications

Although, stunning methods have effects on animal welfare, in some instances, public health measures taken and concerns, especially as a result of the BSE threat, have inevitable welfare consequences too. To this end, a detailed EFSA opinion on stunning methods and public health implications has been prepared (EFSA, 2004). Potential public health concerns from TSE infected animals have been considered and reviewed (Anil *et al*, 1999; Anil and Austin, 2001). CNS embolism of 4 and 2 *per cent* in jugular blood of cattle stunned with penetrating and non-penetrating captive bolts, respectively, has been reported (Coore *et al*, 2004; 2005). In sheep, higher frequencies (23 and 14 *per cent*, respectively for cartridge activated and pneumatically activated guns) of CNS embolism in jugular blood have been reported (Anil and Harbour 2001; Coore *et al*, 2004). As the heart continues pumping for several minutes between the stunning and the end of exsanguinations, some of the embolic CNS material dislodged by the penetrating captive bolt gun might enter venous blood vessels draining the head and consequently be disseminated to other organs/tissues. This can happen not only with use of a penetrating gun that injects air into the brain (Schmidt *et al*, 1999) but also when stunning is performed without air injection (Anil *et al*, 2002; Coore *et al*, 2004; Coore *et al*, 2005) In NPCB stunned cattle, CNS material was detected in jugular blood of 2% animals (Coore *et al*, 2004; Coore *et al*, 2005). In addition to haematogenous contamination of edible tissues with CNS material, other public health concerns may also be associated with PCB methods. For example, cross- or airborne contamination of the stunning gun operator, the environment such as the stun-box and / or the animals consecutively stunned with the same gun could occur, based on studies using experimental contamination with marker bacteria (Prendergast *et al*, 2004; Daly *et al*, 2001).

2. Religious slaughter methods

Religious slaughter of meat animals has been subjected to much controversy and received attention in recent decades. This debate has intensified especially with the concomitant increase in Muslim populations in European countries, meat exports into the Middle and Far East and also consumer concerns and demands in both secular and Muslim groups. Questions and calls

for changes about and for current practices and legislation have also become more frequent. Most religious slaughter in Europe and the Western countries, where allowed by law, is carried out either by mostly the Muslim/Halal and to a lesser extent by the Jewish (Shechita) methods. As a result of the above, an EC funded project, DIALREL, has attempted to consult interested parties, collect information stimulated a debate about religious slaughter (<http://www.dialrel.eu>)

Although legislation in most European countries requires preslaughter stunning, there can be exemptions for animals slaughtered by religious methods if individual countries so decide. Several countries in Europe (EU and others) do not allow slaughter without stunning (e.g. Sweden, Denmark, Norway and Switzerland). As far as UK is concerned, where this exemption exists, the Farm Animal Welfare Council published a report on religious slaughter methods in 2003 (FAWC, 2003) on the welfare of livestock when slaughtered by religious methods. This report recommended that UK government should repeal the exemption, however this was rejected. Therefore current legislation (WASK 1995) allows these practices with or without preslaughter stunning.

Debate and concerns about religious slaughter focus on three questions:

- i) Is there undue stress during handling prior to religious slaughter (Dunn 1990; Grandin, 1994; Grandin and Regenstein, 1994);
- ii) Is the neck incision painful during the cut and/or immediately afterwards (Gibson *et al*, 2009a,b,c,d);
- iii) Is sensibility and consciousness lost quickly enough following exsanguination ["sticking"] (Daly *et al*, 1988; Kalweit *et al*, 1989; Grandin and Regenstein, 1994; Anil *et al*, 1995a,b; Rosen, 2004)

In regard to stress of handling, as no specific religious requirements exist, the first question also applies to all other methods of slaughter. Some traditional practices however are still reported such as tying legs of sheep probably before religious slaughter that would be of concern. Others in cattle include the use of a casting pen (no longer permitted in the UK) and hoisting cattle by one of the hind legs prior to slaughter. It is argued that above practices are unduly stressful if practised.

The second and third questions are related. Scientific methods to trying to measure 'pain' had limitations and did not provide 'proof' to answer the second question conclusively for many years. However, irrefutable loss of sensibility has been possible to assess by measuring evoked responses and brain activity. Studies on this have reported early loss of sensibility (10-20 seconds) following incision although others have shown delays lasting up to 2 minutes. Objections to these findings have been made on grounds that possible sensations did not necessarily mean pain. C. Johnson and his team in Zealand have recently developed a new technique to study pain in slaughter animals. Their series of publications report examination of EEG patterns in calves following neck cutting (Gibson *et al*, 2009a,b,c,d). Their reported comparative analysis concludes that ventral neck cutting results in responses to noxious

stimuli, in particular when blood vessels are severed. These reports now provide scientific evidence to suggest pain after slaughter without stunning and the debate continues. In contrast Rosen (2004) claimed that Shechita cut is painless because the cut is made with a very sharp knife and no pain can be possible because brain function is lost immediately. There is some evidence to suggest specific problems may occur in calves and adult cattle if the cut carotid ends develop clots restricting blood flow following slaughter (Anil *et al.*, 1995a,b). The development of these occlusions has been attributed to inadequate sharpness of the knife by some claims. However, this problem has also been reported following Shechita slaughter employing a razor-sharp knife (Anil, personal observations; Levinger, (1976). It is now believed other factors are involved. Gregory *et al.* (2011) observed an incidence of 10% carotid occlusions (aneurysm) in cattle slaughtered by Halal and Shechita and suggested an alternative neck cutting position higher up in the neck.

The potential problem of sensibility during and after neck cutting could be minimised by the use of preslaughter electrical stunning provided that this is correctly applied and is acceptable. In regard to Shechita preslaughter stunning is precluded. Some Shechita in the UK used to be practiced with post cut captive bolt stunning. However, UK and European Shechita organisations do not accept that any more. In contrast, stunning provided it does not stop the heart before exsanguination, for is used Halal slaughter in some countries in Europe, Far East and invariably employed in New Zealand and Australia for export to countries in the Middle and Far East with the approval of the appropriate religious authorities. However, objections to stunning during Halal slaughter have been increasing in recent years in Europe. Reasons for this trend include potential welfare problems during stunning, perceived uncertainty regarding the effects of stunning on heart function and other myths about stunning and reluctance to move away from tradition (see Halal rules 2.1.1).

2.1 Halal slaughter

In practice Muslim method of slaughter, now commonly referred to as Halal method, is shown to vary in the way it is applied. The variations are possibly due to differences in the interpretation of the Koran and the Hadith (the sayings of the prophet Mohammed), different traditions as well as lack of sufficiently trained slaughtermen, interested individuals and certifiers. This situation is in contrast with the approach of Shechita organisations that have strict and more consistent rules and applications.

The act of slaughter (Al-Dhabh) is allowed in the name of God; therefore pronouncing the name of Allah is the usual practice. This is to remind the slaughterer that he is taking the life of a living creature. Animals are restrained but there are no specific religious regulations as to how this should be done other than traditional methods employed. Following restraint, slaughter is carried out by severing the neck to achieve instant and copious exsanguination using a sharp knife. The usual type of incision is transverse severance of the vessels in the retrograde fashion following an initial stab incision in the neck.

Muslims believe that they are required to ensure rapid and maximum blood loss and that this is crucially important during and after Halal slaughter, because consumption of blood is forbidden. Effective exsanguination however, has been a source of concern in that in some cases occlusions can impede bleed out rate and delay loss of consciousness (Anil *et al*, 1995a,b). Another claim was that stunning methods could impede blood loss during Halal slaughter. Comparative studies in sheep and cattle have shown, however, that there is no significant difference between stunned and non-stunned sheep (Anil *et al*, 2004) and cattle (Anil *et al*, 2006). This issue will be discussed later in this review.

2.1.1 Rules of Halal slaughter

Slaughtering practices before acceptable meat products are obtained for Muslim consumers are of utmost importance (Halal slaughter and meat), especially for those who want to ensure they comply with requirements (Anil and Sheard, 1994). There are references in the Koran and the Hadith (the sayings of the prophet) to permissible and forbidden foods as well as practices and rules of slaughter. However interpretations and perceptions of the effects of procedures may differ. Since pig meat is forbidden, other red meat and poultry species is the subject of interest.

The above mentioned differences in interpretations of rules have led to some confusion and controversy regarding Halal slaughter. One of the major aims of Dialrel project was, to consult scholars to explore of determining and verifying Halal slaughter rules. This was achieved by holding consultations and workshops in cooperation with a partner in Egypt (Mansoura University) including scholars from Al-Azhar University, known as the centre of excellence in Islamic studies. The following is a summary of the work in Egypt as well as other relevant information and religious decrees (fatwas) on rules in literature, misunderstandings of slaughter practices, international efforts in finding a globally agreed set of standards and certification issues.

Provision and consumption of meat for Muslim communities is an essential part of the religious life and certain conditions must be met so that the meat is lawful, Halal. If the treatment and slaughter of meat animals do not meet the criteria then the meat may be regarded as unlawful, Haram.

Some species such as pigs, carnivorous animals and carrions are forbidden. Rules relating to Halal slaughter are based on i) The Holy Quran; ii) Sunnah and Hadith and iii) Views of religious scholars.

There are direct and indirect references in the Quran (Quran translation) relating to food in general and slaughter (1).

The following verses are some examples Sura: Verses 2: 168,172,173; 5: 1,3,5,87,88;6: 118,119,121,145,146; 16: 114-118 (Provided by Prof. Dr. Mohammed Fouda, Dean of Veterinary Faculty, Mansoura University)

2:168. *O ye people! Eat of what is on earth, Lawful and good; and do not follow the footsteps of the evil one, for he is to you an avowed enemy.*

2:169. *For he commands you what is evil and shameful, and that ye should say of Allah that of which ye have no knowledge.*

2:170. *When it is said to them: "Follow what Allah hath revealed:" They say: "Nay! we shall follow the ways of our fathers." What! even though their fathers Were void of wisdom and guidance?*

2:171. *The parable of those who reject Faith is as if one were to shout Like a goat-herd, to things that listen to nothing but calls and cries: Deaf, dumb, and blind, they are void of wisdom.*

2:172. *O ye who believe! Eat of the good things that We have provided for you, and be grateful to Allah, if it is Him ye worship.*

2:173. *He hath only forbidden you dead meat, and blood, and the flesh of swine, and that on which any other name hath been invoked besides that of Allah. But if one is forced by necessity, without wilful disobedience, nor transgressing due limits, - then is he guiltless. For Allah is Oft-forgiving Most Merciful.*

5:1. *O ye who believe! fulfil (all) obligations. Lawful unto you (for food) are all four-footed animals, with the exceptions named: But animals of the chase are forbidden while ye are in the sacred precincts or in pilgrim garb: for Allah doth command according to His will and plan.*

5:3. *Forbidden to you (for food) are: dead meat, blood, the flesh of swine, and that on which hath been invoked the name of other than Allah. that which hath been killed by strangling, or by a violent blow, or by a headlong fall, or by being gored to death; that which hath been (partly) eaten by a wild animal; unless ye are able to slaughter it (in due form); that which is sacrificed on stone (altars); (forbidden) also is the division (of meat) by raffling with arrows: that is impiety. This day have those who reject faith given up all hope of your religion: yet fear them not but fear Me. This day have I perfected your religion for you, completed My*

favour upon you, and have chosen for you Islam as your religion. But if any is forced by hunger, with no inclination to transgression, Allah is indeed Oft-forgiving, Most Merciful.

5:5. *This day are (all) things good and pure made lawful unto you. The food of the People of the Book is lawful unto you and yours is lawful unto them. (Lawful unto you in marriage) are (not only) chaste women who are believers, but chaste women among the People of the Book, revealed before your time,- when ye give them their due dowers, and desire chastity, not lewdness, nor secret intrigues if any one rejects faith, fruitless is his work, and in the Hereafter he will be in the ranks of those who have lost (all spiritual good).*

5:87. *O ye who believe! make not unlawful the good things which Allah hath made lawful for you, but commit no excess: for Allah loveth not those given to excess.*

5: 88. *Eat of the things which Allah hath provided for you, lawful and good; but fear Allah, in Whom ye believe.*

6:118. *so eat of (meats) on which Allah's name hath been pronounced, if ye have faith in His signs.*

6:119. *Why should ye not eat of (meats) on which Allah's name hath been pronounced, when He hath explained to you in detail what is forbidden to you - except under compulsion of necessity? But many do mislead (men) by their appetites unchecked by knowledge. Thy Lord knoweth best those who transgress.*

6:121. *Eat not of (meats) on which Allah's name hath not been pronounced: That would be impiety. But the evil ones ever inspire their friends to contend with you if ye were to obey them, ye would indeed be Pagans.*

6:145. *Say: "I find not in the message received by me by inspiration any (meat) forbidden to be eaten by one who wishes to eat it, unless it be dead meat, or blood poured forth, or the flesh of swine,- for it is an abomination - or, what is impious, (meat) on which a name has been invoked, other than Allah's". But (even so), if a person is forced by necessity, without wilful disobedience, nor transgressing due limits,- thy Lord is Oft-forgiving, Most Merciful.*

6:146. *For those who followed the Jewish Law, We forbade every (animal) with undivided hoof, and We forbade them that fat of the ox and the sheep, except what adheres to their backs or their entrails, or is mixed up with a bone: this in recompense for their wilful disobedience: for We are true (in Our ordinances).*

16:114. *So eat of the sustenance which Allah has provided for you, lawful and good; and be grateful for the favours of Allah, if it is He Whom ye serve.*

16:118. *To the Jews We prohibited such things as We have mentioned to thee before: We did them no wrong, but they were used to doing wrong to themselves.*

In addition to the Quran, Sunnah and Hadith are used for guidance. Sunnah is the tradition and the examples set by the Prophet, model for Islamic life and practice, whereas Hadith is stories and the sayings of the Prophet. Crucially the importance and requirement of animal welfare in Islam have often been emphasized. The following Hadith of the prophet is a good example:

“Allah Who is Blessed and Exalted, has prescribed benevolence towards everything; so when you must kill a living being, do it in the best manner and, when you slaughter an animal, you should sharpen your knife so as to cause the animal as little pain as possible”.

There are numerous other Hadith that can be cited (Masri 1989). These include accounts that place more emphasis on animal welfare such as preclusion of sharpening a knife before an animal, preventing animals witnessing slaughter.

Discussions at Mansoura Workshop

Details of this workshop are included in the report on the Dialrel website. The following is a summary.

According to Prof. Dr. Samir El-Sheikh Professor of Islamic Law, Al-Azhar University, Cairo, and agreed by other scholars, the following are based on Islamic Sharia (Law):

- *Islam is comprehensive; Sharia looks after everything for good. Allah u Teala provided rules*
- *All food, fish, nuts, grains, vegetables, fruits are good for us. Haram things are unlawful. Also animals are lawful and must be killed according to Islamic rules*
- *Haram (unlawful) foods include pigs, dogs, donkeys, carnivores, reptiles, insects, animals killed by strangulation, blow/clubbing; natural death/causes, beasts with fangs, birds of prey are carrion,. Fish are exempt prophet pbu allowed things that come from sea as lawful, they are not no carrions. Animals if not sacrificed according to Islamic rules and those killed for gods other than Allah are Haram.*
- *Tasmiyyah is essential*
- *To avoid certain diseases blood must be cleared out of animal’s body. Blood should not be retained in the veins and congeal, for hygiene reasons. Good flow of blood is required*
- *Animal must only die from slaughter, no dressing while alive*
- *However, anything can be eaten during necessity*
- *Muslims or People of the books (Christian and Jews), male or female can slaughter animals*
- *Besmele/ Tasmiyyah, citing of god’s name, is a must.*
- *Facing Kible (Mecca) is recommended, but not required. Majority of scholars agree*
- *Animal’s head must not be removed during slaughter*
- *Run away animals that are out of control can be shot*
- *In regard to stunning if suffering occurs, or if animal dies before slaughter and if blood is congealed and retained, then that would be haram. Otherwise stunning is acceptable if the following are observed: 1) Tasmiyyah 2) No suffering 3) Flow of blood*

It is understood that there are 2 main requirements 1) Mercifulness to animal 2) Slaughtered animal must be healthy.

New technological methods would be fine as long as suffering is minimised and sufficient blood flows out to protect consumers. Islam does not say it has to be done by hand. Automatic cut is fine. Electric current killing is haram, but electric blades are fine.

The meeting continued with discussions on importance of blood loss, perception of pain and its duration during Halal slaughter with or without stunning and effects of various stunning methods. Although there was agreement on importance of exsanguinated blood being Haram (forbidden), and mercifulness to animals, it became clear there were some misunderstandings of scientific findings (listed under myths). These included lack of difference between stunning and slaughter methods and blood loss, immediacy of stunning methods and when death occurs after stunning and slaughter. The above were explained by examples of literature and video recordings and discussed.

The following conclusions were arrived at the Workshop held in Mansoura:

- *Alive animal is required before death by exsanguination*
- *Flow of blood before death is essential*
- *Tasmiyyah is required during slaughter, not required for each bird if automatic neck cutting is used*
- *Eating of any meat in necessity and from people of the books is acceptable*
- *More flexibility in rules than thought*
- *Kible(facing Mecca) is not necessary, but optional*
- *Recommendation for latest techniques confirmed*
- *Stunning acceptable if above conditions are met*
- *Misunderstandings of techniques and effects still exist that require addressing globally*

Decisions (Fatwas) on Halal Rules in regard to slaughter

Although there is no universally accepted hierarchical system there have been attempts over the years to issue rulings on Halal slaughter. For example in 1978 Al Azhar University issued a fatwa allowing stunning of animals before slaughter (in those countries where stunning is performed); previously in 1977 a fatwa had been issued in Saudi Arabia that allowed captive bolt stunning. However, in 1995 Al Azhar issued another fatwa stipulating that stunning by captive bolt should not be allowed because it was similar to delivering a manual blow on the head of animals.

The debate on deciding the correct rules is still continuing that include a number of organisations and working groups in the world. The prominent ones are the Organisation of Islamic Countries (OIC) working group and Malaysian standards. OIC Standards are now used by individual countries as guidelines -the following excerpts from the OIC draft (courtesy of Dr Hamid Ahmad) is presented as an example:

This Standard was developed by the Standardization Expert Group of the Organisation of the Islamic Conference (OIC).

GENERAL GUIDELINES ON HALAL FOOD

3.1 Islamic Rules

It means what ALLAH Legislate for Muslims which gain its rules from the wholly Qur'an, and the honourable prophet method (Sunnah).

3.2 Halal Food

Halal food is the food which is allowed to be consumed according to Islamic rules and that comply with the requirements mentioned in this standard.

3.3 Prerequisite Programmes (¹PRPs)

Basic conditions and activities necessary to maintain a hygienic environment throughout the food chain suitable for production, handling and provision of safe final products and safe food for human consumption.

3.3.1 Good Manufacturing Practice (GMP)

Actions regarding personnel and building hygiene in order to ensure safe and healthy production, storage and distribution of food.

3.3.2 Good Hygiene Practice (GHP)

Measures taken in stages of food chain to ensure the provision of safe food for consumption.

3.4 Food safety

Concept that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use.

3.5 Food Chain

All stages involved in the production of food including processing, production, packaging, storage, transportation, distribution and supply to the market, from raw material and its origin to consumption.

5.1.1.1 Halal animals

The following examples are considered as Halal:

Domesticated animals such as cows, buffalos, sheep, goats, camels, chickens, geese, ducks, and turkeys.

Non-predatory wild animals such as deer, antelope, chamois, wild cows, zebras.

Non-predatory birds such as pigeons, sparrows, quails, starlings, and ostriches.

Grasshoppers

5.1.1.2 Non – Halal animals

The following examples are considered as non Halal:

Pigs, dogs and their descendants

Animals not slaughtered in the name of Allah

Animals not slaughtered according to Islamic rules

Animals that died by themselves.

Animals with long pointed teeth or tusks which are used to kill prey or defend themselves such as tigers, bears, elephants, cats, monkeys, wolves, lions, tigers, panthers, jackals, bears, foxes, squirrels, martens, weasels, and moles, etc.

Predatory birds with sharp claws such as hawks, falcons, eagles, vultures, ravens, crows, kites, owls

And also lizards, snails, insects, mouse, crocodiles and alligators.

Pests and venomous animals such as rats, centipedes, scorpions, snake, wasps and other similar animals.

Animals which are considered repulsive like flies, maggots, ticks, spiders and other similar animals.

Animals that are forbidden to be killed in Islam such as honeybees and hoopoe.

Donkeys and mules.

Any ingredient derived from the non-Halal animals is not Halal.

5.1.2 Aquatic animals

Poisonous aquatic animals that are harmful to human health are non Halal, unless the harmful or poisonous material is removed. Also all fish with scales including their eggs as well as shrimps are considered as Halal.

5.1.3 Amphibious animals

All amphibious animals are non Halal.

5.1.5 Blood and other materials of human or animal origin

All types of blood and products made from blood are non Halal.

5.2 Rules of Slaughtering

5.2.1 Requirements of the Animals to be slaughtered:

- a) The animal to be slaughtered has to be an animal that is Halal.*
- b) A certificate must be issued by a Veterinary Authority which attests that animals to be slaughtered are healthy.*
- c) The animal to be slaughtered shall be alive or deemed to be an alive at the time of slaughter. The slaughtering procedure should not cause torture to animals and should be done with animal welfare/rights consideration.*
- d) For a certain period before slaughtering, animals should be fed with Halal food. This period is minimum 3 days for Halal animals. Feeding of animals should be cut down for a period of 6 hours before slaughtering.*
- e) If animals have arrived from long distance, they should first be allowed to rest before slaughtering.*

5.2.2 Slaughterer

- a) The slaughterer shall be a Muslim who is mentally sound and fully understands the fundamental rules and conditions related to the slaughter of animals.*
- b) The slaughterer shall have a certificate of Halal slaughtering issued by a competent authority supervising matters relating to health, hygiene, sanitation and rules of Halal slaughtering.*
- c) A slaughterer performed by religiously observant Jews or Christians who properly meets all Halal requirements described herein may be used when a Muslim slaughterer is not available and not with persons from other religion.*

5.2.5 Stunning

- a) *Stunning is not recommended. One of the Halal slaughter methods recognized at national/international level shall be preferred. Exemplary durations and electrical current values with regard to stunning are given in Annex A for information. Animals must be alive during using the electrical shock and must be low voltage on the head only.*
- b) *Electrical current and duration shall be validated and determined by the organization, taking into account the type and weight of the animal and other varying factors.*

5.2.6.1 Slaughtering procedure of animals

In addition to Clause 5.2.1, the following requirements are applied.

5.2.6.1.1 Health checks of animals before slaughtering

In addition to ante mortem control, the following requirements are also applied.

Animals to be slaughtered shall undergo health checks. These checks include assessment of veterinary medicine residues, age, and pregnancy, diagnosis of diseases which hinder slaughtering (such as anthrax and rabies and etc.), communicable diseases or any febrile diseases. Those animals which are found sick or suspected to be sick shall immediately be segregated in an isolation area and legal formalities should be fulfilled.

Animals which have completed 1/3 of their pregnancy shall not be slaughtered.

5.2.6.1.4 Leading animals to slaughtering area

Animals to be slaughtered shall be led into the slaughter area by qualified personnel through a corridor. Giving a light slap to legs with a stick or slight twisting of tail in the case of cows and use of low voltage electrical operated device are considered as normal practices.

At the end of the corridor that animals are led through for slaughtering, it should be ensured that animals waiting in the line are prevented from seeing those being slaughtered, with the help of a movable curtain or a partition system.

5.2.6.1.5 Procedure

- a) *The animal may be slaughtered, after having been hung or laid preferably on its left side facing Kiblah (the direction of Mecca). Care shall be given to reduce suffering of the animal while it is being hung or laid and not to be kept waiting much in that position.*
- b) *At the time of slaughtering the animals, the slaughterer shall utter "BISMILLAH WALLAHUAKBAR" which means "In the Name of Allah Almighty Great" and he should not mention any name other than Allah otherwise this make it non-Halal. Mentioning the name of Allah should be on each carcass "Zabaha" (killed by slaughter) or on each group being slaughtered continuously and if the continuous process is stopped for any reasons he should mention the name of Allah again.*
- c) *Slaughtering shall be done only once to each animal. The "sawing action" of the slaughtering is permitted as long as the slaughtering knife shall not be lifted off the animal during the slaughter.*
- d) *The act of Halal slaughter shall begin with an incision on the neck at some point just below the glottis (Adam's apple) and after the glottis for long necked animals.*
- e) *The slaughter act shall sever the trachea (halqum), oesophagus (mari) and both the carotid arteries and jugular veins (wadajain) to hasten the bleeding and death of the animals.*

The bleeding shall be spontaneous and complete. The bleeding time must be not less than 2.5 minute to insure fully bleeding.

5.2.6.2.3 Procedure

a) Slaughterer should grab the head by left hand, stretching it down tightly and shall cut the throat by a sharp slaughtering knife held in the right hand. The sharp edge of knife which used for slaughter should be not less than 12 cm.

5.2.6.2.3.1 Mechanical slaughter

a) The operator of the mechanical knife shall be a Muslim.

b) The slaughterer shall recite "BISMILLAH WALLAHUAKBAR" prior to switching on the mechanical knife and shall not leave the slaughter area.

c) Should the slaughterer leave the slaughter area, he shall stop the machine line and switch off the mechanical knife. To restart the operation he or another Muslim slaughterer shall recite "BISMILLAH WALLAHUAKBAR" before switching on the line and mechanical knife.

d) The knife used shall be of single blade type and shall be sharp. e) The slaughter act shall sever the trachea (halqum), oesophagus (mari) and both the carotid arteries and jugular veins (wadajain) to hasten the bleeding and death of the animals

f) The slaughterer is required to check that each poultry is properly slaughtered and any birds that missed the mechanical knife shall be slaughtered manually.

g) A backup slaughterer with knife shall be ready to check any neck not cut well during mechanical slaughtering and rapidly cut it manually.

h) Bleeding period shall be minimum 60 seconds but during winter this period shall be increased by 5-10 seconds.

5.2.6.3.1 *Fish and grasshoppers do not need to be slaughtered. In case of fish they should be taken from water while still are alive and death should happen outside the water.*

5.2.6.3.2 *Animals that are hunted and killed properly are regarded as being slaughtered. However, those animals captured alive should be slaughtered according to the Islamic rules.*

b) The honeybees falling parts in the honey and the non avoidable parts are excluded from the non-Halal animals.

c) the product or its ingredients shall be safe and not harmful.

d) the product is prepared, processed or manufactured using equipment and facilities that are free from contamination with non-Halal materials.

e) during its preparation, processing, packaging, storage or transportation it shall be physically separated from any other food that does not meet the requirements specified in items a),b),c) and d) or any other things that are described as non Halal by Islamic rules.²³

⁴

Guideline parameters for electrical stunning

Type of animal	Current (Ampere)	Duration (Second)
<i>*Chicken</i>	<i>0,25-0,50</i>	<i>3,00-5,00</i>
<i>Lamb</i>	<i>0,50-0,90</i>	<i>2,00-3,00</i>
<i>Goat</i>	<i>0,70-1,00</i>	<i>2,00-3,00</i>
<i>Sheep</i>	<i>0,70-1,20</i>	<i>2,00-3,00</i>
<i>Calf</i>	<i>0,50-1,50</i>	<i>3,00</i>
<i>Steer</i>	<i>1,50-2,50</i>	<i>2,00-3,00</i>
<i>Cow</i>	<i>2,00-3,00</i>	<i>2,50-3,50</i>
<i>Bull</i>	<i>2,50-3,50</i>	<i>3,00-4,00</i>
<i>Buffalo</i>	<i>2,50-3,50</i>	<i>3,00-4,00</i>
<i>Ostrich</i>	<i>0,75</i>	<i>10,00</i>
<i>Note: Electrical current and duration shall be validated and determined by the organization, taking into account the type and weight of the animal and other varying factors.</i>		

***DIALREL NOTE:** *The above table will need to be amended. For example the high currents given for poultry, if used with 50Hz, would kill the birds before slaughter.*

References used:

1. *General Guidelines for use of the term Halal CAC/GL 24-1997, The Codex*
2. *ISO 22005:2007 Traceability in the feed and food chain - General principles and basic requirements for system design and implementation*
3. *ISO 9001:2005, Quality management systems – Requirements*
4. *MS 1500:2004 Halal Food-Production, Preparation, Handling, And Storage-General Guidelines, Malaysia*

Halal Standards and Certification:

Efforts are being made to produce agreed Halal standards. Organisation of Islamic Countries (OIC) and Malaysian Standards are examples. However, issues listed below need to be resolved before Universal standards are agreed. Similarly, the issue of fragmented certification system is also a problem. Existing self-appointed certification bodies in different countries compete with each other by claiming their products to be more Halal than others at present.

Problem/contentious areas:

The following is a list of current outstanding issues that have emerged:

- Halal Certifiers- Authenticity, lack of standards, insufficient checks/documentation
- Illegal slaughter and unfit meat sale
- Lack of auditing standards (from stable to the table)
- Mechanical killing of animals
- Recorded Tasmiya (Islamic prayer) during poultry slaughter
- Animal welfare compromises not being recorded
- Labelling– stun/non-stun (New European law may require labelling of non-stunned animals in future)
- Islamic rules-interpretation unclear
- Lack of training for Muslim slaughtermen and certifiers
- Almost all attention of Halal on fresh meat
- Hygiene standards questionable

Stunning and Halal slaughter:

Preslaughter stunning is carried out for conventional killing of meat animals with the aim of managing the carcass and preventing potential pain and distress during the neck cut. Stunning is required to induce immediate unconsciousness that should last until death usually by exsanguinations. There are various stunning techniques that include electrical, mechanical and gas stunning with different applications and effects on both welfare and product quality. Whether stunning should be acceptable before Halal slaughter has been subject to controversy for decades. Certain types of stunning methods have been regularly used for decades in some countries. For example New Zealand, where stunning is compulsory, has been exporting Halal red meat since the 80s and in UK, Germany, Holland, France and Spain Halal meat is produced from both stunned and non-stunned animals (where legislation provides exemption) for the Muslim market. Poultry slaughter in large numbers also often employs preslaughter stunning in these countries and in Turkey. Some European countries, however, such as Sweden, Norway and Switzerland have imposed bans on slaughter without stunning. A New European Union regulation that will come into force in 2013 will maintain the exemption. However, each member country will have the option to implement it or have derogation. The most popular stunning method is the use of electrical currents. Specific electrical currents and frequencies need to be used for Halal slaughter, mainly so that death is prevented but only a stun is achieved. Either non-lethal voltages and currents or high frequencies (>100 Hz) are used only to stun animals for Halal slaughter.

There are 3 views in regard to stunning: i) Those who accept it if conditions are met because welfare of animals is protected and rules are maintained (Al-Hafez Masri 1989); ii) Some reject the idea of stunning completely as they think stunning is not necessary, against religious rules or creates problems for animals (Katme 1986); iii) Others either not sure or want assurances in both cases. Dialrel project has found that consumer trust in Halal products is low in Europe. In addition to legislative changes, post-cut stunning is also being considered as a compromise for the objectors in Europe.

Myths about stunning and slaughter methods and their effects

When considering different techniques and their effects on physiological parameters, animal welfare and carcass quality it soon becomes clear that there are a number of misunderstandings in the meat industry as well as among interested parties. These so called myths often cause confusion. Some examples are presented below:

Myth/claim: Bleed out is better if no stunning method is employed

Answer: Research carried out comparing neck cutting with or without stunning has found no difference in bleed out rate and total blood loss in sheep (Anil et al 2004) and in cattle (Anil et al 2006).

Myth/claim: Electrical stunning methods kill animals before neck cut and exsanguination slaughtered

Answer: Only 50Hz frequency sinusoidal waveform if applied in the chest can kill by stopping the heart. High frequencies over 100 Hz should not stop the heart (e.g. poultry stunners used for Halal slaughter).

Myth/claim: Animals do not recover from a stun if not slaughtered

Answer: Recovery of animals has been shown in sheep in the UK Eblex DVD which is available to interested parties. This has also been demonstrated in poultry (Dialrel Final Workshop, Istanbul).

Myth/claim: Stunning methods are cruel; neck cutting without stunning is more humane.

Answer: If a stunning method is used correctly with appropriate parameters unconsciousness is produced immediately and the animal will not feel any sensation. Welfare problems, illegal by law, only occur with misapplication of stunning methods.

Neck cutting without stunning needs to be carried out rapidly and effectively. In practice, welfare problems caused by bad cuts and delayed loss of consciousness are well documented and need addressing (Holleben et al , Dialrel deliverable).

2.1.2 Current Halal slaughter practices

There are 2 surveys available on the current situation in Europe.

Country	Percent of calves with post-cut stun	Percent of cattle with post-cut stun	Percent of calves without stun at all	Percent of cattle without stun at all
France*	0%	0%	20%	20%
Belgium**	0%	0%	21%	10%
Spain	0%	0%	5%	10%
Netherlands	0%	0%	+/- 5%	+/- 5%
Hungary	0%	0%	0%	5%
UK***	0.4%	0.8%	0.4%	0.8%
Austria	0%	0%	0%	< 1%
Germany ²⁴	--	--	marginal	marginal
Cyprus, Czech Republic, Denmark ²⁵ , Estonia, Finland, Luxembourg, Slovenia, Sweden	0%	0%	0%	0%

* This data provided from OABA in response to survey of animal welfare organisations.

** This data for Belgium is only an estimation of the percentage of animals slaughtered ritually as opposed to conventionally; it is not sure whether the animals are stunned beforehand.

*** The UK competent authority has expressed that this data is from 2003 and the numbers may have increased significantly since then for calves.

Source: Survey of competent authorities (France: OABA).

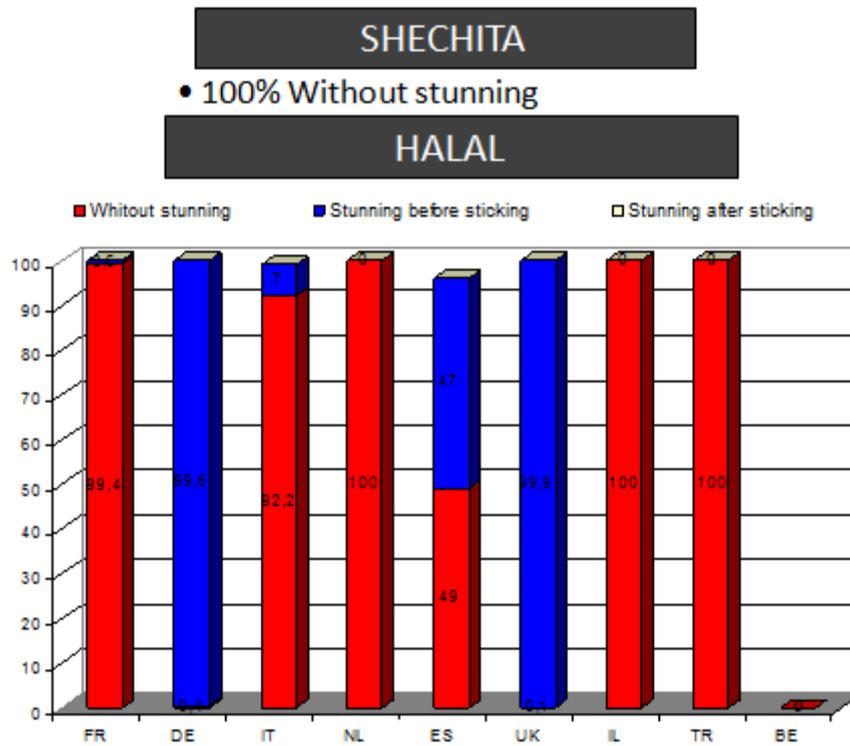
UK- Current estimated figures: Less than 0.4% calves and 0.8% cattle

Table 2. Percentage of cattle slaughter by different methods

Country	Percent of lamb without stun at all	Percent of sheep without stun at all
Belgium*	40%	92%
France**	80%	80%
Netherlands	?	+/- 80%
Spain	15%	20%
Austria	?	< 5%
UK***	5.2%	2%
Czech Republic	0.97%	0%
Cyprus	0.08%	0%
Germany ²⁴	marginal	marginal
Denmark ²⁵ , Estonia, Finland, Germany, Luxembourg, Slovenia, Sweden	0%	0%

2003 data-UK 5.2% Halal lambs not stunned

Table 3. Percentage of sheep slaughter by different methods



UK- 99.9% Halal stunned

Figure 6. Sheep- DIALREL Survey

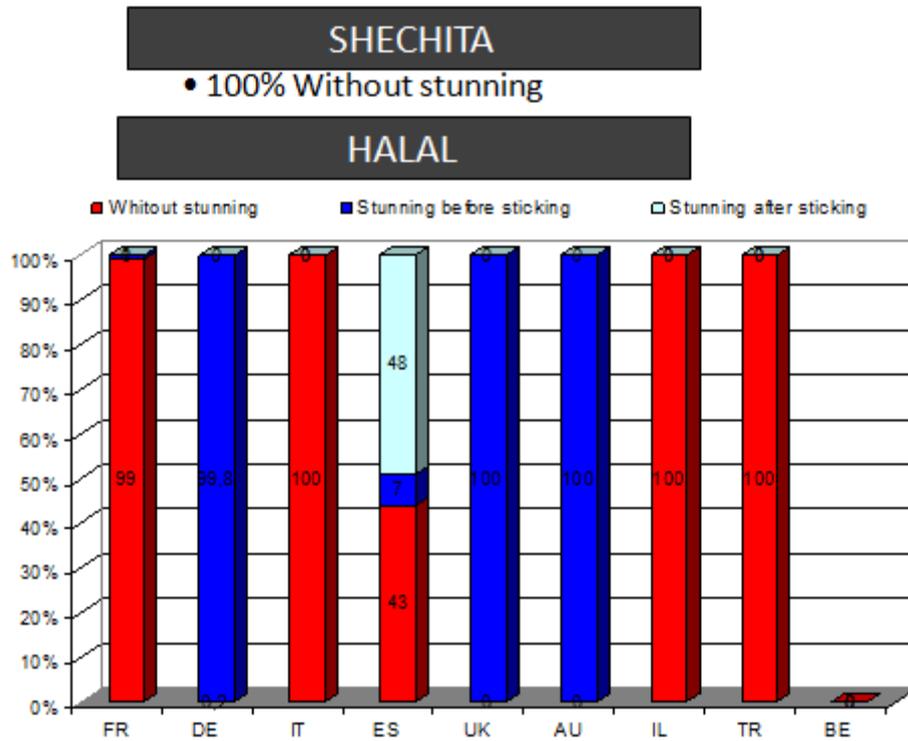


Figure7. Cattle-DIALREL Survey

Another survey was carried out by Dialrel that involved written questionnaires and spot visits in UK and other European countries (see Dialrel reports, current practices). Figures 6 and 7, although insufficiently representative due to limited access, are examples of the DIALREL Survey. Available survey results clearly show discrepancies, however, as far as UK is concerned, there has been a recent increase in numbers of un-stunned animal slaughter. Anecdotal information and figures from EBLEX indicate that about 30 *per cent* of UK slaughter may be for the religious slaughter sheep market, 20 and 10 per cent being killed with and without stunning, respectively.

General conclusions and summary:

Dialrel report aimed to summarise rules relating to Halal slaughter based on religious written sources and recommendations as well as consultations with a variety of interested parties and scholars from different countries and background. Although religious rules regarding Halal slaughter are still controversial, consultations carried out by Dialrel project have tried to shed some light on this important issue. The main findings of the consultations in Egypt as well as contrasting views are listed above.

The main difference between the conventional and Halal slaughter is the bleed out. In order to obtain Halal meat animal's death must be the result of exsanguination after a neck cut. Earlier stopping of the heart would render the carcass unacceptable.

The main controversy, undoubtedly, is still whether or not preslaughter stunning is acceptable. Although, the consultations and research in Egypt and Europe have revealed that reversible stunning would be permissible, subject to conditions, there are and will be objections. Some of those are based on legitimate concerns about stunning effects, however, the others stem from misunderstanding or lack of knowledge about stunning techniques. Unless these challenges are addressed satisfactorily, a two-tier application involving both stunning and slaughter and neck cutting without stunning, where allowed nationally, will be used in practice. To this end, Dialrel, following research and consultations have produced a set of recommendations for good practices under different scenarios.

2.2 Shechita-Jewish methods

Jews consume beef, veal, mutton, lamb and poultry, but not pork. These meats must be slaughtered and prepared in accordance with the rabbinical laws (Levinger, 1976).

Slaughter may only be carried out by an approved and trained slaughterman of the Jewish faith, called a Shocet. He must be a person of recognised high moral character and consistent religious practice, often a Rabbi. He must obtain a licence from the Rabbinical Commission in addition to the usual local authority licence.

The slaughter is carried out by a Shocet. A single, transverse cut is made across the neck using a very sharp, special knife (chalaf). The knife has to be examined for its sharpness between each cut. It is usually 16 inches long for cattle. In the UK, after the neck cut, captive bolt stunning is used at some abattoirs.

Once an animal is dead, an incision is made through the abdominal wall and a Jewish Inspector feels at arm's length into the thorax to check for pleural adhesions or any other signs of abnormality. If any abnormality is found, the entire carcass is rejected for Jewish consumption on the ground that the animal was not healthy at the time of slaughter.

Current day practice

Slaughter may only be carried out by an approved slaughterman of the Jewish faith, called a Shocet. He must be a person of recognised high moral character and consistent religious practice, usually a Rabbi. He must obtain a licence from the Rabbinical Commission in England and Wales (or from the Chief Rabbi in Scotland), in addition to the usual local authority licence. The Shocet is not employed by the abattoir in which he serves but is appointed by the local Shechita Board.

The Jewish method of slaughter, Shechita, is preceded by positioning the animal, though this is not subject to regulation by the religious authorities. Sheep are placed on their backs in a cradle; cattle are placed in a restraint apparatus in an upright position and their neck is extended by a mechanically operated 'chin lift'. Most animals are restrained using the so-called Cincinnati pen. This is used in preference to the Weinberg type of pen, whose use was banned on 5th July 1992, following the recommendation of the Farm Animal Welfare Council (FAWC, 1983), on the grounds that it was unnecessary and inhumane to invert an animal 180° before cutting its throat.

The slaughter is carried out by a Shocet. A single, transverse cut is made across the neck using a very sharp, special knife (chalaf). The knife has to be examined for its sharpness between each cut. It is usually 16 inches long for cattle.

2.2.1. Rules of Shechita

Shechita, the essential slaughtering step in the production of kosher meat is based on Halacha that constitutes the Jewish religious law. This law since its arrival continued to develop over the course of millennia across much of the globe. Zivotofsky (Dialrel project) described in his report the background and development of Shechita in detail.

Over the last 1500 years books have been written on the subject (A recent historical survey in English can be found in Jeremiah J. Berman, *Shechita: A Study in the cultural and social life of the Jewish People*, Bloch Publishing Company, NY 1941).

Of the Jewish Bible, the Tanach consisting of 24 Books, the first five are the most important known as Torah or the “Five Books of Moses. In addition to the verbatim instructions in these books, Moses was also given an oral Law. Rabbis later on wrote some of this information in Mishna. Because the Mishna is difficult to understand, rabbis produced versions of the Talmud that contains the Jewish Law.

The prohibition of “tza’ar ba’alei chayim” – causing anguish to living beings, is a general principle that is discussed in several contexts in the Talmud.

There is no question that in Judaism the consumption of meat is permissible and that man may make use of animals. In the opening chapter of Genesis (1:26) God states His intention to create man and declares that man would “have dominion over the fish of the sea, and over the birds of the air, and over the cattle, and over all the earth, and over every creeping thing that creeps upon the earth,” and He so instructed them after their creation (Genesis 1:28). After the second “creation” when Noah and his sons leave the ark, God again blesses them that “the fear of you and the dread of you shall be upon every beast of the earth... into your hand are they delivered” (Genesis 9:2).² But this authority over lower life forms in no way was viewed as a *carte blanche* permission to abuse them. Quite the contrary, with power comes responsibility, and in Judaism man is viewed as responsible for the well-being of those animals under his control. Dails of Jewish rules regarding animals and food can be found in Zivotofsky’s review who explains that. It is against this background of a tradition of general and specific rules designed to safeguard an animal’s physical and psychological welfare that the laws of shechita are laid down in the Talmud and codified in the codes.

Kosher meat: There is a great deal more to kosher meat than the method of slaughter. It is emphasized that kosher meat is not meat “blessed” by a rabbi who only supervises the process. .

Kosher species: The first requisite in the production of kosher meat is that the animal source be of a kosher type of the animal kingdom of five categories. These are: (1) terrestrial mammalian quadrupeds, (2) birds, (3) fish, (4) invertebrates, and (5) “bugs”. Each of the first four categories includes kosher species. All members of the fifth category and any creature that does not readily fit into one of the other categories are not kosher.

Among terrestrial mammalian quadrupeds, the Torah specifies physical characteristics of the kosher species. An animal is kosher if it both chews its cud and has fully split hooves. The kosher species include cows, sheep, goat, deer, antelope, and giraffe. Non-kosher species include camel, pig, rabbit, and dog.

According to the Torah, fish are kosher if they possess two physical signs: fins and scales. The Mishna (Niddah 6:9) observes that all fish with scales also have fins, although

not all fish that have fins necessarily have scales. Thus, a fish that has scales may be categorized as kosher, and in practice there is really only one sign required in order to declare a fish as kosher. Kosher fish include tuna, salmon, carp, bluefish, flounder, herring, whitefish, and bass. Non-kosher fish include catfish, eel, and shark. In addition non-fish seafood such as lobster and crab are non-kosher.

In order to be kosher invertebrates must have four physical signs: four walking legs, four wings, the wings cover the majority of the body, and two jumping legs.

The most widely accepted kosher species is *Schistocerca gregaria*, the desert locust.

Accepted kosher birds include chicken, turkey, duck, goose, pigeon, pheasant, and quail. Non-kosher birds include eagle, owl, and vulture.

Grasshoppers and fish do not require shechita and may be killed in any manner.

Shechita is the killing of the animal by exsanguination in as painless a means as possible. This is accomplished by cutting the throat with a sharp, smooth knife resulting in the severing of the trachea, oesophagus, jugular veins, and carotid arteries, but without decapitation, leading to almost immediate loss of consciousness and subsequent death.

The method of killing was commanded to Moses on Sinai.”

Shechita is an incision performed on the neck, preferable from the front, although if done from the side it is also valid. However, if the cut is made from the back of the neck it is invalid. The neck is defined by upper and lower landmarks on the trachea and oesophagus as detailed in the Shulchan Aruch (Yoreh De'ah 20) that essentially includes the entire neck.



Figure 8. Shechita knife (Chalaf)

Implement: It is universally done with a special knife known as a chalaf (Figure 8). The chalaf is a sharp, smooth knife whose length is at least twice the diameter of the animal's neck. The essential point is to guarantee that the knife has absolutely no nicks, and in order to guarantee this, the chalaf must be examined for nicks along its cutting edge and on both sides. There is a requirement to inspect the chalaf both before and after the shechita. If it is found defective before it may not be used, and if upon inspection after the cut the chalaf is found to be defective it is presumed to have been nicked on the skin or some other object before the actual shechita and the Shechita is thus invalid. Shechita is performed only by a highly trained professional known as a shochet (ritual slaughterer). In order to train to be a shochet one must first study several years in a yeshiva (advanced religious seminary). If the student shows promise in mastering the requisite religious texts he may then be accepted as an apprentice to a shochet who will guide his studies, train him in the practical aspects, and eventually certify him. The training also includes the practical aspects of slaughtering and of inspecting each and every organ for treifa (rejected parts). Finally, and perhaps the most rigorous aspect, is learning to examine the knife for even the smallest nick and if found wanting, repairing the knife on whetting stones. Even after the entire training process and years of experience a shochet is never without supervision. The halacha requires that he regularly submit his knife to the local rabbi for inspection (Shulchan Aruch, Yoreh De'ah 18:17). In addition, a shochet operating in a commercial operation is under the supervision of the plant mashgiach (kosher supervisor by a certified, professionally trained shochet.), who is ultimately responsible for overseeing all aspects of the production. Thus, this is a major difference between kosher slaughter and other slaughter:

2.2.2 Current Shechita practices

Act of shechita - The act of shechita involves the shochet using a sharp, smooth chalaf to cut the animal's neck. There are five principal rules governing this act, if violated, render the shechita invalid (Shulchan Aruch, Yoreh De'ah 23:1). They are: 1) The cut must be made without interruption. 2) No pressing down, just the sharpness of the blade must cut; 3) The knife must not be burrowed but rather must be exposed and visible from the beginning to the end of the cutting. Because there can be no undo pressure applied, animals used to be put in dorsal recumbency and slaughtered. In earlier times animals were thrown to the ground by tying two or three of their feet. More modern methods have been introduced such as the rotating or upright pens since then. Shochet involvement does not end with the death of the animal. An incision is made through the abdominal wall and a Jewish Inspector feels at arm's length into the thorax to check for pleural adhesions or any other signs of abnormality. If any abnormality is found, the entire carcass is rejected for Jewish consumption on the ground that the animal was not healthy at the time of slaughter.

Following this inspection, the meat is 'porged' to remove veins and other forbidden tissues. There are portions of the animal that are not kosher and must be removed. The three items are: blood, certain fats known as chailev, and the sciatic nerve known as the gid hanasheh. The consumption of blood is an abhorrence, the admonition of which is repeated several times in the Bible. The process of removing the large blood vessels, the forbidden fat, and the sciatic nerve is known as nikkur (in Hebrew), porging (in English), or treiberer (in Yiddish) and is done by a trained menaker, porger, or treiberer. Because the vast majority of the

chailev and the gid hanasheh are in the hind quarter of the animal (approximately defined as posterior to the 12th rib), the task of porging the hind quarters is significantly more tedious and time-consuming than the task in the forequarters and is generally not done except occasionally in Israel.

In the UK and possibly Europe, the hindquarter part of the carcass, because it is not easy to porge, is usually sold to domestic markets.

There are potential treifa in essentially every organ of the body. The shochet u'bodek must be intimately familiar with animal anatomy and what is and is not normal. Because there is a long list of potential treifa and most animals are healthy and do not have these defects there is in general no obligation to perform a comprehensive post-mortem to look for them. That is, the Shu"b does not have to open the skull and check the meninges, and then take out the spleen and examine it, and then kidneys and check them, etc. But as the animal is being dismembered attention must be paid to the possibility of such Treifa and anything that appears out of the ordinary must be examined in greater detail. This also requires that every piece be clearly labelled such that it can be traced back to a particular animal. In case a triefa is found in an organ, all of the pieces of that animal need to be removed from the kosher production.

Shechita rules have been discussed in detail and effects on physiology, meat quality and animal welfare values explained by the following: Zivotofsky, Dialrel report; (Rosen, 2004; Levinger, 1995; Levinger, 1976; Levinger, 1961): It is claimed that Shechita is a humane method and death occurs immediately with no adverse quality effects. However, available scientific findings do not agree with some of these and will be discussed later in this review. Nevertheless, it is clear that shechita, is a skilled procedure carried out in selected kosher species by a highly trained professionals, a shochet (Shochetim, plural). A special knife (chalaf) is used, to ensure that the animal did not die on its own or not slaughtered properly (neveila) and the meat is not unfit (treifa), the post-mortem inspection carried out and non-kosher parts are removed before Kosher meat is ready.

2.3 Other religious slaughter methods

The only known religious slaughter method other than Halal and Shechita is Jakhta used by Sikhs (Anil and Sheard 1984). It is believed not to be commonly applied these days.

3 Preslaughter handling

3.1 Restraint during conventional slaughter

Animals have to be transferred from the lairage pens either directly or through a race into an area where stunning and slaughter is carried out.

In order to facilitate stunning and also to protect the operatives some kind of restraint is necessary. Restraint should allow correct application of stunning equipment and protect animal welfare as well as providing protection from potential injury for the operatives especially from large animals. This could be achieved in a number of ways:

- Manual restraint in an open pen

This is usually done by manually handling the free standing animal in an open area or a pen. Animal can enter the pen either directly from holding areas or through raceways. Electrical or captive bolt stunning in sheep and religious slaughter (6.6) can be carried out this way. However, safety and welfare problems can be common features especially when handling cattle.

- Restraint in a squeeze / crush pen.

This principle involves holding the animal by pressure from the sides. Usually one side moves, not commonly used.

- Cattle stunning pens

Different designs of cattle restraint pens can be used (Figures 9-11). The objective is to confine the animal in a pen so that stunning and slaughter can be carried out effectively and safely. Animals usually enter the pen after going through a race. Pens must have gates to close after entry. Race should have smooth curved sides if long, have sufficient light. Use of prods should be minimum.

For captive bolt stunning, facilities to present the head for correct stunning at the front would be useful. Some cattle pens are specially constructed for captive bolt, electrical stunning and/or religious slaughter. Upright and Facomia pen designs have additional features for extra restraint such as belly lift, back push and chin-lift. Facomia pen tilts the animal around 45 degrees. Rotary pens that turn the animal 180 degrees are more stressful and banned in the UK.

The new impending European **COUNCIL REGULATION ((EC) No 1099/2009)** requires a study of cattle restraint systems and a report to be submitted by the end of 2012. Its aim is to establish whether certain optimum types of restraint apparatus employed for cattle as some existing ones may have inherent undue stress factors. Although this development has implications for both conventional as well as religious slaughter, the latter could be more affected. In particular restraint periods before and after a neck can be long in some systems. For example, some rotary pens take unduly long to rotate and present cattle for slaughter.

- V – type restrainers

These use the principle of suspending the animals in a funnel shape apparatus often having a conveyor system commonly used for pigs and sheep. It seems to work better for sheep than pigs. Sheep can be electrically stunned, either head-only or head-to-back at the end of the conveyor either manually or automatically.

- Monorail restrainers

This system holds the animal in a straddle position over a rail. Combined with a conveyor system, animals re moved to the point of stunning with possibly less stress than with V- restraint. This system is successfully used in pigs.

3.1.1 Restraint of cattle for slaughter without stunning

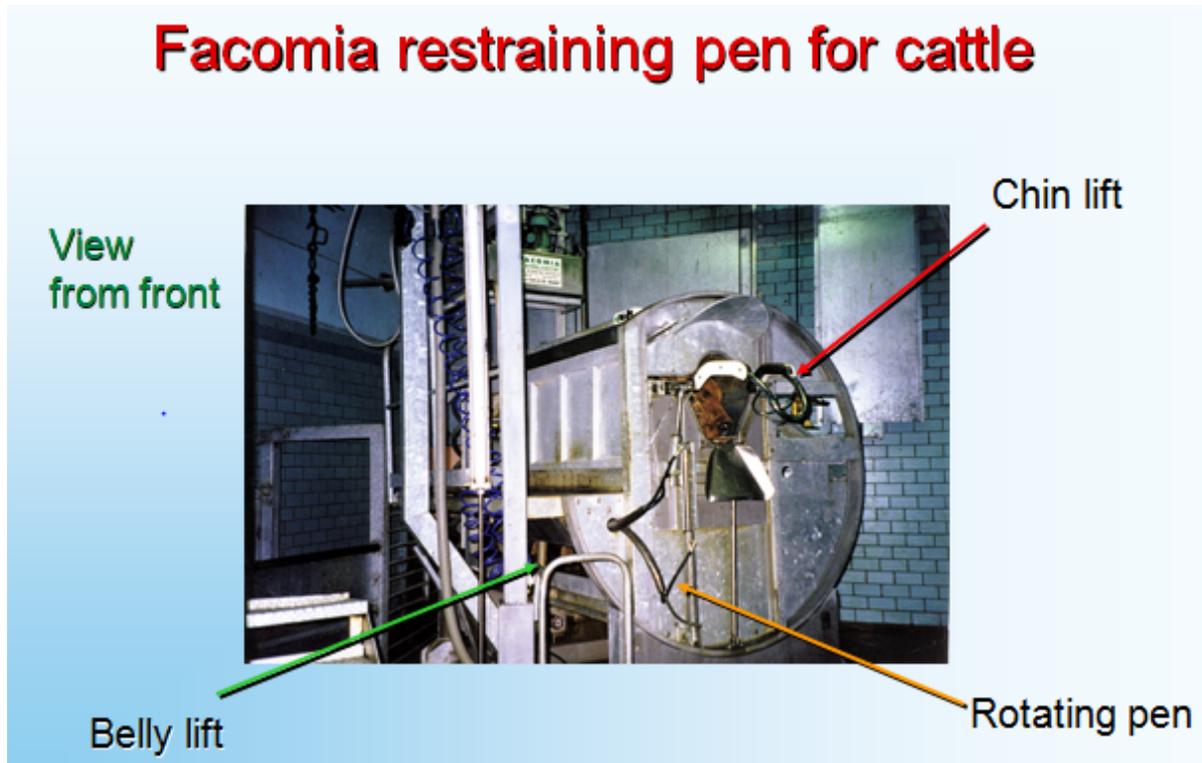


Figure 9. Facomia rotating pen (45 degrees)



Figure 10. Upright pen with chin lift

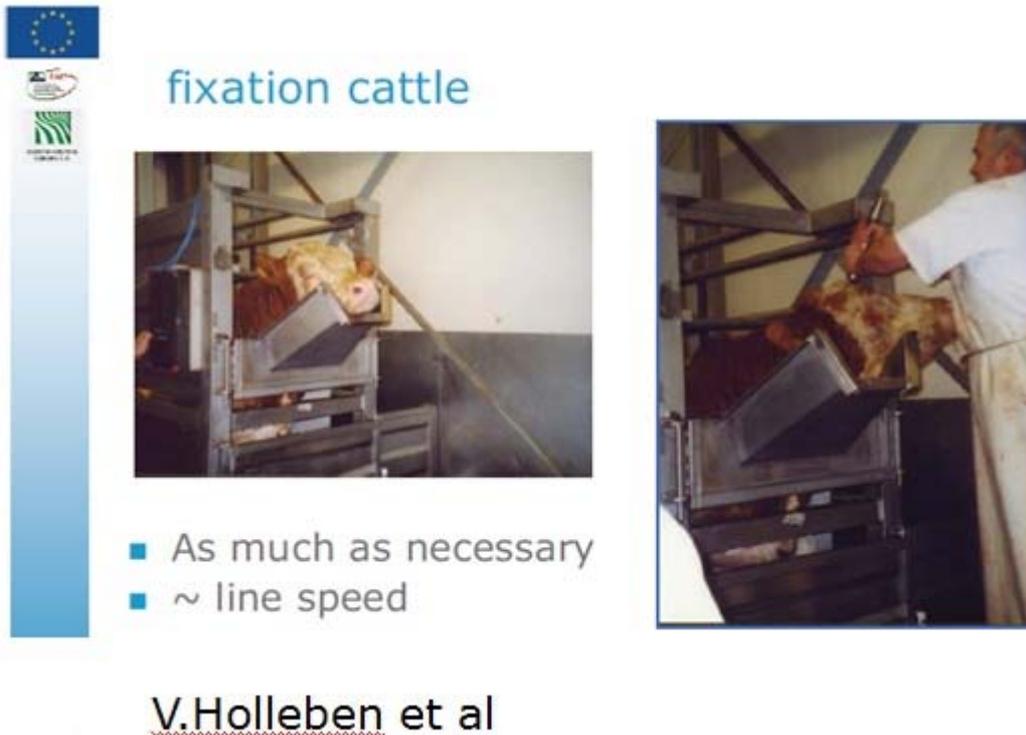


Figure 11. Head restraint prior to stunning cattle

3.1.2 Restraint of small ruminants for slaughter without stunning

Religious slaughter of sheep can be carried out either on a cradle or a V-type restraining device. In the former case a specially constructed cradle is used, each individual animal is lifted up, carried and placed in a horizontal position before neck cutting. After the neck cut is performed the animal has to be held until the prescribed period (20 seconds for sheep in UK) has elapsed before release. This is a permissible method in the UK. However, disadvantages include stress of preslaughter handling and potential carcass damage as well as slow operation.

Alternatively, neck cutting can be done inside a V restraining conveyor or at the exit point. If stunning was employed that is usually applied at exit then followed by sticking in the horizontally positioned animal on a moving conveyor before shackling. In regard to neck cutting without stunning both EU and UK regulations require a time period during which no manipulation is applied to the animals. In the former regulation, UK WASK, this interval is 20 seconds for sheep in order to allow sufficient time for signs of recovery to disappear permanently, whereas the 1099/2009 EC regulation does not specify a figure, instead regular check need to be made to ascertain that the animal does not recover. In cases where a moving V- restraining conveyor, instead of a fixed cradle, is employed, there seems to be concerns in the UK. Defra's interpretation of the EU legislation is that neck cutting without stunning should be carried out on individually placed animal in isolation and the restraining conveyor is not moved for for the prescribed period. This has the potential of slowing down the operation and throughput. In addition the other concern is whether the individual animal is unduly stressed. Al-Gahtani and Rodway (1991) demonstrated that isolated sheep are most stressed compared to other restraint methods based on increased beta-endorphin levels.

However, use of V-restraining conveyors loaded with sheep in a line is known to be effective and does not appear to be stressful. This concern needs to be addressed in the UK.

3.3 Restraining for post neck cut stunning

Post-cut stunning has become a potential welfare intervention method when religious requirements preclude the use of preslaughter stunning. It is aimed at minimising the time to loss of consciousness after the neck cut and preventing possible recovery. It is used with some Halal slaughter applications in Europe. A similar approach used to be applied in the UK after the Shechita cut with a captive bolt in 80s and early 90s. However, this was later abandoned by the Shechita Board and is not acceptable to them anymore.

Restraint of animals for post cut stunning requires that the neck can be adequately stretched to perform the cut. In addition, the severed neck needs to remain open for effective bleeding. Measures also need to be taken so that stunning equipment is applied correctly. The interval between the cut and stunning equipment depends on the restraining method and available facilities (Binder, 2010).

In cattle it is possible to stun with a captive bolt within 5 seconds after the cut if the head is held by the neck lift. However Berg (2007) measured the intervals in an upright pen as between 30 and 40 seconds and sometimes even longer. If a rotary pen was used it took 12 and 15 seconds to rotate the animal. In a Facomia pen 45 degree rotation has been shown to facilitate captive bolt stunning promptly.

Dialrel recommendations include some suggestions regarding handling for post cut stunning (see 8. Codes of practices and recommendations).

4 Effects and consequences of slaughter methods

4.1 Physiological effects

Neck cutting

Neck cutting is one of 2 slaughter methods to achieve exsanguinations in both cattle and sheep. Following conventional stunning and slaughter chest sticking is also commonly used. This, also known as thoracic stick, is carried out on the recumbent or hoisted stunned animal and involves severing large vessels inside the thoracic cavity for rapid blood loss. Chest sticking has been shown to be very effective in that brain function is lost immediately (Anil et al 1995b). However, during religious slaughter chest sticking is not applied as it is not practical and probably against rules and tradition. Instead, invariably a transverse neck cut is used to sever tissues and blood vessels in the neck, except the spinal cord. If effective stunning is used then as long as exsanguinations is carried out soon enough there should be no recovery unless delays occur after reversible stunning. In regard to religious slaughter without stunning questions arise as to whether pain is felt and how long it takes before loss of consciousness and/or brain function. In the following section the question of whether pain can be felt during the cut and times to loss of brain function after the cut is discussed.

The issue of whether the neck cut is painful has received much controversy and discussion. Then pain that may be perceived by the animal during its application and afterwards depend on a number of factors. Under the most optimistic successful slaughter conditions, it could be argued that if the incision is performed by a highly skilled slaughterman using a sharp knife

the least amount of pain will be inflicted though not totally eliminated (Brooks and Tracey, 2005; Woolf, 2004). Deviation from this scenario will probably worsen the severity of pain in an exponential manner. The greater the damage to tissues in the neck more nociceptors will be activated than after good cuts, thereby firing fibres and relaying signals to the brain (EFSA, 2004).

There are two camps about the pain issue. Those who think the cut is quick and painless and therefore slaughter without stunning can be effective and acceptable and other who argue that varying degrees of severe pain is inevitable. Levinger (1976) claims works as a stunning method and death occurs immediately due to rapid loss of blood. Grandin and Regenstein (1994) reported that they noticed no visible reaction from the body and legs of cattle to the neck cut in, provided that animals were restrained without -stress in upright pens, but only a slight flinch where the blade made contact. Bager *et al* (1992) also previously reported no recognisable reaction from calves.. Most reports regarding reactions of animals during slaughter without stunning are anecdotal with no detail of specific conditions (e.g. cut, sharpness of the knife, skills of the operator), whether reactions occurred after the first cut. Another problem is it is possible that reactions may be masked due to the following: position of animal, restraint by a shackle or head restraint, fainting caused by haemorrhagic shock, defensive immobility (playing dead) or severance of tissues (e.g. no vocalisation because of cut trachea. Therefore little or no reaction does not necessarily indicate absence of pain (EFSA, 2004).

Rosen (2004) in his comprehensive review also argues that Shechita maintains animal welfare and creates a situation where no pain is felt by the animal due to rapid physiological changes. Extreme sharpness of the Shechita knife (Chalaf), together with the smooth incision performed, implies minimal stimulation of the incised edges, below the threshold level required for activation of pain pathways. This is compared to the experience of surgeons, who cut themselves during an operation only to noticed it later (Rosen, 2004). However, it must be borne in mind that a neck cut would involve a large area and also pain is not merely related to the quality of the cut. In human subjects if injuries are deep and extensive (e. g. fractures, crushed tissues, amputations and lacerating stab wounds), many of experience immediate pain (72%). Whereas in cases of injuries limited to the skin (e.g. lacerations, cuts, abrasions, burns), 53% have a pain free period immediately afterwards, and following fractures, numbness is felt first and persistent pain develops later when the pressures associated with haemorrhage, oedema and inflammation develop (Gregory, 2004; Melzack et al, 1982).

Other scientists argue that there will be substantial pain involved. For an effective bleed out the cut is required to cause deep and extensive tissue damage where many pain receptors (nociceptors) are located to be activated (Kavaliers 1989). Tissues to be severed include skin, long hyoid bone muscle, trachea, oesophagus, both jugular veins and carotid arteries, nerves, and muscle. This high level of activation would lead to perception of pain (EFSA, 2004).

Nevertheless behavioural observations provide a useful tool when assessing pain and suffering, especially in field conditions. Obtaining values of physiological measurements, such as heart rate, respiration rate and body temperature can be useful if combined with behavioural findings where possible (Barnett, 1997). However, some of the physiological changes do not occur immediately, for example the lack of an increase in blood cortisol reported in some studies (Tume and Shaw, 1992) is not surprising.

Recording and analysis of brain electrical activity to assess noxious stimuli and perception has been used for years. The signals recorded represent relayed information about not only pain but also other types of sensation. After recent methodological developments related to quantitative analysis of the electroencephalogram (EEG), the experience of pain can now be assessed more precisely. This methodology has been applied to the question of pain during slaughter of calves by ventral-neck incision. The results show clear evidence for the first time that the act of slaughter by ventral-neck incision is associated with noxious stimulation that would be expected to be perceived as painful in the period between the incision and loss of consciousness (Mellor et al, 2009). Initially an EEG spectral analysis and a minimal anaesthesia model were validated for assessment of noxious sensory input such as acute known painful procedures in calves such as dehorning (Gibson et al, 2009a,c). Then this model was used as a reference to test the effect of ventral-neck incision (Gibson et al, 2009b) that revealed a ventral neck incision has the potential to be a noxious stimulus and therefore painful in conscious animals. Subsequently, a second study showed the EEG responses after ventral neck incision were caused by severance of neck tissues but not interruption of blood flow to and from the brain (Gibson et al, 2009a). Although not tested in sheep it could be anticipated that the effect could be similar.

Gregory (2004) describes that the cut nerve after neck cutting would be able to relay signals for up to four seconds and directly activate neurones with the overall effect to be comparable to an electric shock. Subsequently, undamaged nerve endings and also nociceptors in the neck wound could be stimulated by other mechanical effects before consciousness is lost. Another concern, if consciousness is not lost, is aspiration of blood into the trachea during exsanguination after a neck cut in cattle during religious slaughter without stunning (Gregory et al, 2009).

Anecdotal reports from Dialrel spot visits indicate reactions to the cut as vocalisation, retracting movements, struggling or shivering in cattle during Halal slaughter without stunning and Shechita carried out in turning pens.

It can be concluded that whilst the potential for pain perception exists, other risk factors such as changes in direction of the cut, multiple cuts or performance of back up cuts, in adequately sharpened blades, thick necks, skin folds and insufficient tension of the neck could increase chances of more pain perception.

4.2 Stress, fear and distress

Stress is physiological disturbance imposed by a stressor, e.g. threatening or harmful situation. At the brain level stress trauma and pain activate hypothalamo-pituitary-adrenal (HPA)-axis and sympathetic nervous system (SNS) leading to increased heart rate, blood pressure, stress hormones and enhanced fight or flight behaviour. The HPA-axis is also activated by trauma (Gregory, 2004). Measurable stress indicators can be used as tools as well as changes in behaviour for assessment.

Fear and anxiety are emotional states leading to physiological and behavioural changes induced by perceived danger (Boissy, 1995). These conditions have important implications for animal housing and management and handling prior to slaughter (Grandin, 2000).

There are four types of fear commonly recognised in animals:

- Innate fears – e.g. isolation, fear of the dark, snakes, spiders;
- Novelty – e.g. strange objects, sudden movements;
- Fears learned by experience – anticipated pain;
- Fear provoked by signs of fear in others;

4.3 Consciousness and unconsciousness

4.3.1 Assessment of consciousness / unconsciousness

When assessing consciousness, physical collapse and uncontrolled movements are usually regarded as significant signs, albeit no definite signs of unconsciousness (Muir, 2007). This state indicates that cortex and cerebellum profoundly lost control of posture and function. It is also possible to regain and lose consciousness again.

Basic movement control and maintenance of posture is controlled by different parts of the brain as well as the autonomic nervous system and the spinal cord. Two types of movements can be observed: 1) Voluntary; 2) involuntary movements.

Some movements observed after slaughter such as attempts to stand up and head righting could be obvious indicators of consciousness. However, others are more difficult to interpret, e.g. convulsive physical activity due to earlier stunning (clonic phase) or loss of cortical function. Nevertheless collapse of a standing animal is the earliest indicator of loss of consciousness after a neck cut.

Different cognitive responses can be used when assessing presence or loss of consciousness. These could be listed as blinking and head withdrawal responses to threatening movements, positive responses to painful stimuli or wilful responses of different body parts. These responses are said not to occur without a functioning nervous system and could be used as useful tools (Limon et al, 2010).

Clinical indicators of general anaesthesia (Muir, 2007) can be used to assess insensibility and unconsciousness as long as the slaughter method itself does not change or mask the clinical signs. However, under certain circumstances such as after electrical stunning checking reflexes could be fruitless due to excessive convulsions caused by stunning. Nevertheless reflexes especially those including the cranial nerves are helpful to assess brain function. If all negative, it could be assumed that brain function is profoundly impaired (Gregory, 1998).

The following reflexes can be used as tools to confirm loss of consciousness:

- No eye reflex or blinking (palpebral or corneal)
- Widened pupils
- Fixed eye
- No response to threatening movements
- Absence of breathing activity
- Floppy head and relaxed tongue

The following reflexes may indicate residual consciousness:

- Rhythmic breathing
- Vocalisation
- Kicking/struggling movements (except typical convulsions during epileptiform activity)
- Righting
- Attempts to stand up and escape behaviour

4.3.2 Measurement and interpretation of brain electrical activity

In addition to the above mentioned indicators, if available, recorded electrical activity of the brain, electroencephalogram (EEG with surface electrodes) or electrocorticogram (ECoG with implanted electrodes) can be used to assess brain function. Suppression or lack of electrical activity, changes in amplitude and frequency of waves are useful tools. Absence or significant reduction in size of somatosensory, auditory or visually evoked responses can be used to determine whether an animal is unconscious or dead.

It is generally agreed that grand mal epilepsy, quiescent period, amplitude less than 10 per cent of the pre-stun recording in the EEG and absence of evoked responses are indicative of unconsciousness. However, presence of evoked potentials does not necessarily imply consciousness, because visual evoked potentials can be recorded in animals under anaesthesia (EFSA, 2004; Zeman, 2001; Gregory, 1998). Kalweit et al (1989) recorded visual (VERs) and somatosensory (SERs) evoked responses after Shechita neck cutting without stunning in cattle and compared responses after captive bolt stunning. In the latter cases, both recorded responses were lost immediately, whereas after neck cutting without stunning in the former, responses, although gradually being reduced, lasted sometime (Figures 12 and 13). Therefore, the fact that brain function is not completely lost gives an element of doubt about presence of sensibility if no stunning is used.

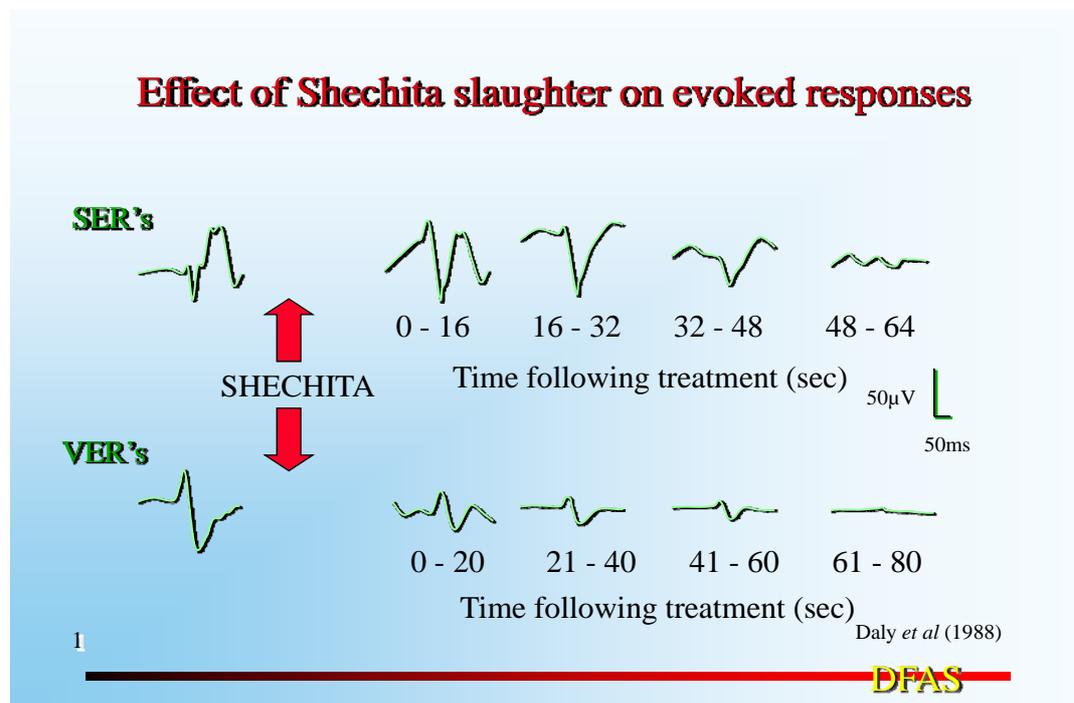


Figure12. Effect of Shechita on evoked responses (SER: Somatosensory evoked potentials; VER: Visually evoked potentials)

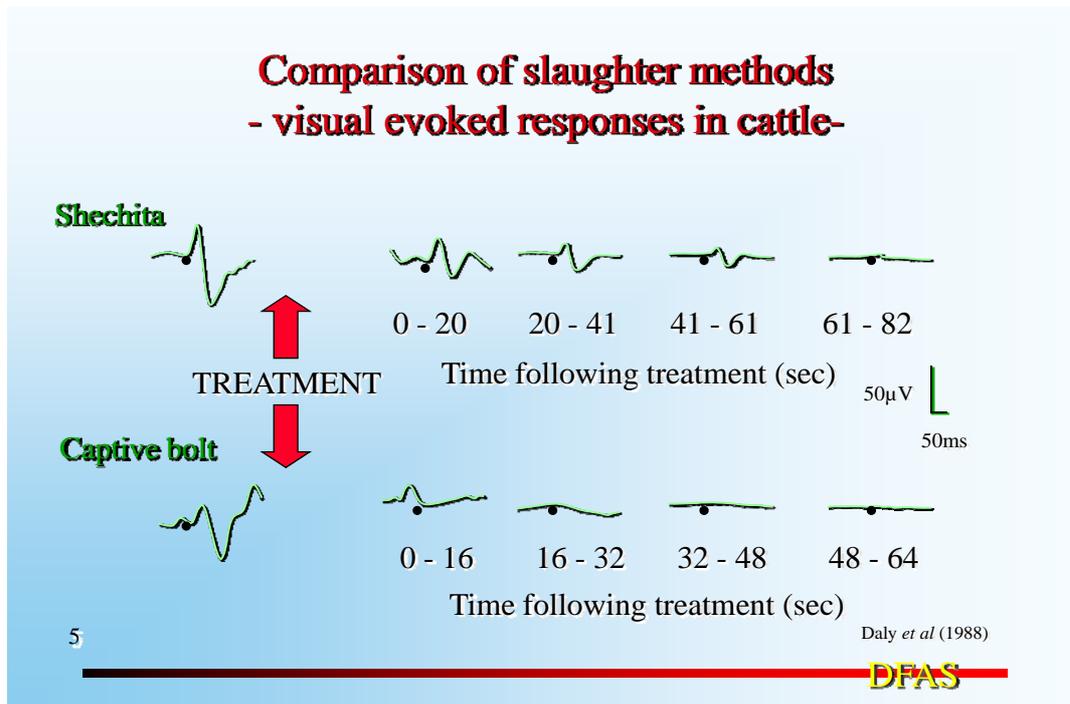


Figure13. Comparative effects of different slaughter methods on visual evoked responses (VERs)

4.4 Death

Death is described as a state where physiological respiration and blood circulation have stopped as a result of their centres in the brain stem permanently losing function due to lack of oxygen and energy (EFSA, (2004).

In terms of stunning and slaughter correct application should result in sufficient loss of blood to the brain and cause irreversible loss of vital functions (Michiels, 2004; Rosen, 2004; Pallis, 1982a,b,c,d).

4.5 Exsanguination or bleed out

Slaughter implies exsanguination by severing blood vessels in the neck or chest so that death is induced.

Although for conventional slaughter trachea and oesophagus can be left uncut there are exemptions for religious slaughter.

4.6 Loss of blood and blood pressure

Of the circulating blood volume, 8% of body weight, 18% of cardiac output flows perfuses the brain (EFSA, 2004). Following effective cuts 40 to 60 % of blood volume is lost in similar patterns and rates in different species (Warriss and Wilkins, 1987). This rapid loss should result in a dramatic drop in blood pressure leading to inadequate perfusion of tissues and a state of shock and failure of the system's compensatory mechanism (Gregory, 2004).

It is claimed that immediate loss of blood pressure after neck cutting results in rapid loss of consciousness due to ischemia reduction of cerebrospinal fluid pressure (Rosen, 2004; Levinger, 1995; Levinger, 1976).

Blood pressure loss can be very disturbing to humans (Hamlin and Stokhof, 2004) and probably to animals of other species (EFSA, 2004).

In cattle following exsanguination it takes a certain amount of time for blood loss to reach critical levels. It is estimated that 50 per cent of total blood volume is lost during exsanguination. Levinger (1995,1976) reported that 33 *per cent* of total blood loss was reached after 30 seconds, whereas Anil et al (2006) found 25 *per cent* was bled out after 17 seconds.

In sheep however, the time period is much quicker with 50 *per cent* being lost after 14 and 90 *per cent* after 56 seconds (Anil *et al*, 2004).

The critical low levels of blood pressure can be reached earlier, e. g. in sheep after about five to six seconds (Levinger, 1976) but not in all animals, e.g. cattle. Due to anatomical differences occlusions of the arteries in cattle can lead to recovery episodes in blood pressure in calves, however blood pressure fell sooner when no occlusion occurred (Anil *et al*, 1995b).

4.7 Cerebral perfusion after neck cutting

The brain of ruminants is perfused with blood from a vascular network called “rete mirabile” that receives branches from the carotid and vertebral arteries. In cattle there are extra anastomosis that may bring in blood to rete mirabile and brain sometimes even after exsanguination, whereas in sheep and goats this is not the case (Baldwin and Bell, 1963a,b).

Although perfusion is possible and demonstrated it is argued whether that is sufficient to maintain consciousness. Rosen (2004) claimed that the cerebral blood flow after a neck cut would not be sufficient to supply the brain. Anil et al (1995a) found that carotid occlusion delayed the time to isoelectric ECoG in calves. In the same study when carotid occlusion occurred, vertebral artery blood flow was maintained at about 30% of its initial level for up to three minutes and in some animals it increased substantially following sticking.

Similarly, Shaw et al. (1990) ligated the vertebral arteries in calves, looked at ECoG and concluded that other factors contributed to the delays in time to loss of electrocortical activity after slaughter in calves.

In sheep, severing both the common carotid arteries and the external jugular veins is the quickest method of abolishing brain responsiveness compared to cutting only one carotid artery, only the jugular veins or cardiac ventricular fibrillation (Gregory and Wotton, 1984a,b; Newhook and Blackmore, 1982b).

Sharpness of the knife and performing a complete uninterrupted cut could influence other factors such as vasoconstriction, clotting, ballooning known also as carotid occlusion or false aneurysms (Gregory *et al*, 2006; Anil et al., 1995a,b). Gregory et al. (2008) found a prevalence of large false aneurysms in 10 percent of cattle slaughtered by Shechita and Halal with implication for sustained consciousness during religious slaughter in cattle.

4.8. Time to loss of consciousness after exsanguination

Following exsanguination it is imperative that consciousness is lost rapidly. This duration depends on a number of factors such as the method of restraint, quality of the cut as well as species differences. Time to loss of brain function has been studied by various researchers who examined electrical activity of the brain such as EEG, evoked responses as well as

animal reactions and reflexes. Under laboratory conditions they found variations. Review of results showed using time to flat EEG/ECOG from 10 seconds to more than a minute (Newhook and Blackmore, 1982a; Kallweit *et al*, 1989); loss of evoked responses from 10 seconds up to 2 minutes (Gregory and Wotton, 1984c); loss of coordination up to 47 seconds (Blackmore, 1984). In contrast, abattoir investigations showed even longer durations before collapse was observed between 19.5 and 265 seconds after Shechita and Halal slaughter (Gregory *et al*, 2010).

In regard to sheep however, similar studies obtained much shorter durations between 2 and 43 seconds (Newhook and Blackmore, 1982b).

The implications of above findings are that following neck cutting delays in time to loss of consciousness would be serious welfare problems. However, some of the studies used do not necessarily prove presence of consciousness, rather showing residual brain function with possibility of feeling sensation. Nevertheless, ideally immediate loss of brain function should be aimed at for optimum welfare.

4.8.1 Clinical signs during the post cut period

Physical signs observed during and after the cut need to be evaluated with care, as some may indicate conscious or involuntary reactions such as reflexes. Physiological reactions to blood loss after Shechita have been described by Rosen (2004) and Levinger (1995) who claim that the heart will beat for a few minutes, then lack of venous return would lead to diminished cardiac contraction.

Gregory *et al*. (2010) described the loss of posture of adult cattle after slaughter without stunning occurring on average 19.5 seconds post cut.

Blackmore (1984) reported sheep lost ability to stand up after four seconds, whereas calves took 40 seconds after satisfactory neck cutting.

Brain stem activity manifested by positive eye reflexes could be present for significant periods. However, these as well as respiratory gasps/gagging reflexes alone only indicate residual brain stem activity.

The following can be significant indicators:

- attempts to rise or to regain normal body posture
- reactions to cuts or manipulation of the wound
- eyes being able to follow stimuli from the surrounding with concomitant blinking
- vocalisation
- response to threatening movements

4.9 Post neck cut stunning

Stunning after neck cutting also called “post-cut stunning” is regarded by some as an improvement to animal welfare, compared to slaughter without stunning. This approach shortens the time during which possible sensations, if no preslaughter stunning is used, may be experienced, especially in cattle (Caspar and Koepernik, 2010).

Post cut stunning is used in some European countries applying a captive bolt. In the UK captive bolt stunning used to be acceptable and applied in cattle after Shechita, but later abandoned and rejected by Shechita Boards.

5 Effects of religious slaughter on quality

5.1 Carcass and meat quality

The main potential effects of stunning and slaughter on carcass and meat quality have already been referred to in previous chapters (see 1.2). These are carcass defects such as haemorrhages, bruising, broken bones and more importantly rate and total bleed out, particularly in relation to religious slaughter without stunning. As discussed, haemorrhages can be related to inappropriate preslaughter handling, electrical stunning using high voltages with currents and sometimes due to possible nutritional or unknown factors such as blood splash in sheep. These defects and resultant downgrading can occur during slaughter with and without stunning. If electrical stunning is used before religious slaughter as long as sticking is done early enough, rising blood pressure may not be a problem. Neck cutting in sheep and lambs while the heart is still pumping should result in 75 to 85% of total blood being lost in the first 60 seconds (Blackmore & Newhook, 1976). Therefore, during the powerful clonic phase, the carcass should have lost half the blood to be exsanguinated. Therefore blood pressure, under normal circumstances, should not be responsible for haemorrhages. Another factor is ensuring an uninterrupted flow of current during stunning (Kirton & Frazerhurst, 1983) to avoid carcass haemorrhages.

If the cause is electrical stunning parameters then this can be addressed by modifying electrical frequency, such as using high frequency stunners with square waveform instead of the conventional 50Hz frequency with sinusoidal waveform. Effects on blood loss have already been mentioned and will be discussed further especially in relation to religious slaughter..

In regard to religious slaughter and meat quality Kirton *et al* (1980; 1981) reported that haemorrhages are less common in unstunned sheep carcasses. In addition to early sticking (Kirton *et al* 1978), the neck cutting technique used can also affect the bleed-out rate (Blackmore and Newhook, 1976). Other factors such as stress and restraint are also important and should be considered (Jemmi, 1984).

Velarde *et al* (2003) studied comparative effects of electrical stunning versus no stunning on meat quality in lambs. They found no significant differences in colour (L^* , a^* , b^*), muscle ultimate pH (pHu), chilling losses and carcass weights after 45 min and 24 h were not significantly different between treatments. The only effect observed by Velarde *et al* was petechial haemorrhages in hearts caused by electrical stunning with 250 volts for 3 seconds. No carcasses with petechial haemorrhages, ecchymosis, haematomas or broken bones were found in either treatment. They concluded that meat quality and the incidence of haemorrhages are unaffected by head-only electrical stunning. This is in agreement with other studies by Anil *et al* (2004) who also examined meat quality parameters as well as packed cell volume and carcass weights in lambs after religious slaughter without stunning or slaughter with electrical stunning in lambs. Comparing captive bolt stunning with Halal slaughter without stunning Anil *et al* (2006) also found no differences in packed cell volume and meat quality parameters between treatments in cattle. In an earlier limited study Anil *et al* (1993) reported effects of preslaughter handling and Halal slaughter on quality parameters including packed cell volume, pH and colour in sheep and cattle. There were some increases

in pH and packed cell volume values probably due to long transport and preslaughter handling but no change in muscle colour.

However, with the recent significant increase in religious slaughter with and without stunning, there is a need to carry out further studies specifically looking at carcass and meat quality effects in more detail under current practices that vary within and between European countries. This can be attributed to variation of skills of slaughtermen who carry out religious slaughter, in particular Halal, and standards being reflected in the final product.

5.2 Blood loss and retention

It is of utmost importance to expel as much blood as possible to meet religious requirements of Halal and Shechita slaughter. In addition to consumption of blood being forbidden, there are two beneficial reasons put forward, firstly harmful blood constituents would be excluded and secondly keeping quality of meat would improve. The basis for better keeping of meat was that blood would provide a good medium for bacteria to grow. Another consideration is that if blood is left in vessels, after cutting, it could produce an unsightly appearance. However, it has been shown that minced meat mixed with blood and inoculated with bacteria showed no more growth of included bacteria than meat that had no added blood (see Gregory 1998). Nevertheless, although it is impossible to rid a carcass of its blood completely as there will be some retention of blood, efforts need to be made.

It was often claimed that stunning would adversely affect bleed out rate and total loss and that neck cutting without slaughter improved blood loss. The first study that directly compared blood loss between stunning and slaughter with that of neck cutting without stunning was carried out by Anil et al (2006; 2004) who examined exsanguination and compared stunning and slaughter versus slaughter with no stunning in sheep and cattle. Rate and total blood loss after neck cutting with electrical and captive bolt stunning or without stunning were measured and results corrected for differences in carcass and visceral organ weights in sheep and cattle. They found no differences in both bleed out rates measured every 10 seconds and total blood loss after complete exsanguination. These results were later confirmed by the study of Gomes Neves et al. (2009). Velarde et al. (2003) carried out similar studies in lambs and found a slight increase in blood loss after electrical stunning, rather than an improvement in blood loss by slaughter without stunning. The most recent investigation by Khalid (2011) compared exsanguination following three Halal slaughter treatments: electrical stunning, no stunning and neck cut as well as post-cut electrical stunning using a v-restraining conveyor. Both experimental and commercial trials were carried out in 440 sheep slaughtered in upright or horizontal position. They found no statistically significant differences in carcass weight and by-products as well as loss of blood confirming earlier results with addition of V-restraining and also post-cut stunning to treatments tested.

Earlier reported studies measured blood haemoglobin content in different muscles as an indicator of bleed out quality. Kallweit et al (1989) determined that haemoglobin did not differ in muscles of sheep and calves that were subjected to captive bolt stunning or Shechita. Levinger (1995), in his book on Shechita also reviewed experiments in which blood parameters, colour and pH were measured in different species slaughtered by Shechita or Halal or conventional methods showing no difference. However, Levinger concluded that sticking and blood loss could still be better after Shechita because of the very sharp knife used and efficacy of cut. Based on existing studies and available results it is reasonable to

suggest that regardless of whether preslaughter stunning is used or not blood loss is not likely to be different.

6 National and international legal aspects

6.1 UK and European Union

European Union places emphasis on Animal Welfare and agreed to protect animals at the time of slaughter by a directive entitled *Council Directive 93/119/EC on the protection of animals at the time of slaughter or killing (1993)* (European Community, 1993) This piece of legislation is now in the process of being amended by the 2009 regulation (European Community, 2009) that will come into force in January 2013. As previously, the EU provides a certain degree of subsidiarity to member states for the implementation of EU directives. To this end, UK government has in force the Welfare of Animal at Slaughter and Killing Regulations (WASK 1995). This legislation has since been amended a few times the latest being in 2007 (<http://archive.defra.gov.uk/foodfarm/farmanimal/welfare/slaughter/>). UK legislation lays down rules regarding abattoir construction and facilities, preslaughter treatment of meat animals as well as requirements for stunning and slaughter methods. Most of these rules cover both conventional as well as religious slaughter. However, UK, like other member states, allow certain derogations for religious slaughter/

In Europe religious slaughter has been practiced for centuries, however, objections on welfare grounds started in the 19th. Consumers in Europe now have more concern for food quality and safety as well as animal welfare.

Some EU members, such as Sweden, have banned slaughter without stunning in recent years. Nevertheless, *Council Directive 93/119/EC* (European Community, 1993) of the European Union allows derogations so that Member States can authorise religious slaughter without pre-slaughter stunning in their own territory. However, it is also required that welfare of animals slaughtered by religious methods shall be protected and a mechanical form of restraint be used to prevent injury when the animal is killed.

Dialrel project has collected national legislation documents on religious slaughter from European Countries and prepared a report on this issue (Ferrari and Bottoni, 2010) showing existing gaps and differences. The new 1099/2009 (European Community, 2009) regulation is aimed at bringing in further important changes. Some examples are:

- Individual restraint of bovine and ovine animals if slaughtered without stunning and checks on recovery
- A report on systems restraining bovine animals by inversion to be submitted before 2013 (This method is banned in the UK)
- Ban on hoisting and clamping legs of animals (other than poultry) before slaughter
- Requirement for training slaughterman

7 Codes of practices and recommendations

Dialrel project concluded its activities with a set of recommendation for improved practices to be adopted during religious slaughter. This document was the result of detailed discussion between project partners, advisory board members, and representatives of the meat industry, religious organisations, groups and individuals. Although it does not impose legal

requirements, it is hoped that the recommendations are observed up as much as possible with a view to protecting animal welfare as much as possible in practice. The following are extracts from the final document posted on the Dialrel website:

GENERAL OUTCOMES AND RECOMMENDATIONS

The document proposes good animal welfare practices during religious slaughter, including restraining, neck cutting and post-cut management. As reversible stunning is also accepted by some religious communities, recommendations for pre- and post-slaughter stunning are also included.

This document does not aim to discuss religious rules. The recommendations are intended as a proposal to improve animal welfare during religious slaughter, taking into account existing legislation and religious slaughter requirements in the general context and in the case of specific incidents.

Best methods must be employed to ensure calm animals/birds are made ready for slaughter. The management of animals during transport, unloading, lairage, restraining, reversible stunning or slaughter must follow the approved standard operating procedures to ensure the welfare of all the animals. These should include clear management objectives, participation of the responsible persons, appropriate modus operandi, measurable criteria of success, as well as regular monitoring of procedures and recording of outcomes.

For failures in meeting standards, appropriate corrective actions should be defined.

All facilities should develop effective working and training procedures.

One person should be designated within the religious authority as being the responsible person for ensuring compliance with religious slaughter requirements and, in addition, or optimizing animal welfare protocols within those requirements.

Specific training of slaughtermen and abattoir staff, including management in key areas (such as animal handling, restraint, knife sharpening, animal physiology, signs of stress and pain, times to unconsciousness and signs of loss of consciousness), is vital to ensure good animal welfare.

RESTRAINING METHODS

MAIN OUTCOMES

Restraint (design, construction, operation and maintenance) has a marked impact on animal stress, which will in turn impact on the qualities of the cut, bleeding and the time to loss of consciousness.

In cattle, the use of an upright pen can reduce the duration of restraint required until neck cutting is applied and allows the animal to be slaughtered in a natural standing position.

However, this position may require greater skill in achieving an appropriate cut and managing the post-cut period.

In cattle, a rotatable restraint might facilitate neck cutting. However, this type of restraint may lead to increased stress. Dorsal recumbency (animal turned on the back) is an unnatural posture and might also cause discomfort. Turning to positions between upright and lateral recumbency (e.g. 45° or 90°) has the potential to decrease stress.

Sheep and goats can be restrained in either an upright position, lying on their side or lying on their back (rotating to angles other than 90° or 180° are also used). Systems depend on slaughter equipment and slaughter speed.

RECOMMENDATIONS

Ruminants

1. Animals must be restrained only when slaughter can be performed without any delay, and it must be performed without any delay.
2. The restraining device, including both the body and head restrainers, or method must suit the size, species and type of animal slaughtered.
3. Due care must be taken during loading the animal into the restraining system to minimize stress and injury. Effort should be made to avoid use of any electric prods. The restraint device and surrounding area must have adequate lighting (lighting should be designed to encourage animals to naturally enter the restraint device), flooring should be non-slip and the parts in contact with the animal should have smooth, rounded surfaces. These surfaces should be inspected at least daily to ensure that worn-out and protruding parts are replaced promptly.
4. All restraining devices should use the concept of optimal pressure. The device must hold the animal firmly enough to facilitate slaughter without struggle or undue delay. Excessive pressure that would cause discomfort to the animal should be avoided. All moving parts of the restraint device should have a smooth, steady movement and jerky motion should be avoided. All mechanized parts of the restraint apparatus that press against the animal should be equipped with pressure limiting devices that will automatically prevent excessive pressure from being applied to the animal. Optimal pressure might be assessed by the absence of struggling behaviour and vocalization during the restraint, and the absence of any injuries and bruises caused by the restraining method.
5. The head restraint must be such that it provides good access to the neck for effective neck cutting and bleeding out and it must be such that it is set with the proper amount of neck tension to optimize slaughter.
6. The head restraint must be designed to avoid mechanical stimuli (such as physical contact or scraping) and chemical stimuli (such as contamination with stomach content) on the surface of the wound during the conscious period that would be assessed according to Recommendation 4 of the 'Post-cut Management of Animals Slaughtered without Stunning' section (Chapter 4).
7. The design of the head restraint must not obscure the front of the head and should also allow good access to the eyes to check for signs of reflexes and sensibility and must not obscure the front of the animal's head.
8. When rotary pens are used, the head of the animal must be restrained before the start of the turning process. The turning operation should proceed smoothly and quickly without interruption to reduce as much as possible the period of animals being restrained in unnatural positions.
9. To restrain the head of cattle, ropes could only be used if slaughter speed is very slow (e.g. maximum four animals per hour) as long as it is ensured that cattle are handled with necessary care.
10. During neck cutting, the head of sheep and goats (and small calves) may be stretched manually in addition to the mechanical restraining of the body. However, to maximize blood loss and minimize mechanical impact (scraping or touching) on the wound following the cut, until the animal is unconscious, it is recommended that the head continues to be supported during the early stages of bleeding.
11. When using an upright restraint for cattle the belly plate, if used, must be operated according to the concept of optimal pressure to support the animal without lifting it off the ground.

12. During bleeding, the animals shall be held secure but as relaxed as possible, e.g. the head holder and rump pusher should be partially released immediately after the throat cut but not to an extent where blood flow is impeded.

NECK CUTTING WITHOUT STUNNING

MAIN OUTCOMES

Incision of the neck tissues can result in noxious stimuli that can be perceived as pain in conscious animals. However, the issue is controversial, as there are differences in cutting method and variations in the times to loss of brain function between reported studies. In addition, wounds or actions that involve scraping of exposed tissues, large or multiple cuts are more likely to elicit pain sensation.

RECOMMENDATIONS

1. The slaughter person must be ready to perform the cut before the animal is restrained.
2. The neck cut must be performed without any delay.
3. Both carotid arteries and both jugular veins must be cut without touching the bones of the spine (vertebrae) with the knife.
4. Each animal should be neck cut by a single swift or continuous back and forward movement of the knife without interruption.
5. The knife used must be sufficiently long for each type of animal to minimize the need for multiple cuts. Ideally, the length of the knife blade should be at least twice that of the width of the animal's neck.
6. The knife must be sharp for each animal. The knife should be checked by the slaughtermen (Shochetim for Shechita) as frequently as required for nicks and bluntness and sharpened accordingly. Emphasis on training slaughter persons to improve their knife sharpness is recommended.
7. Neck breaking must not be performed together with the cut.

POST-CUT MANAGEMENT OF ANIMALS SLAUGHTERED WITHOUT STUNNING

If not pre-slaughter stunned, the animal becomes unconscious when brain perfusion becomes insufficient after the neck cut.⁶ The time taken for unconsciousness to supervene varies between animals.

Some studies on neck cutting in cattle have shown that delays in time to loss of consciousness can vary from a mean of 20 seconds (sd \pm 33) to up to more than 120 seconds in exceptional cases.

Most sheep and goats seem to lose consciousness within 2 to 20 seconds after ventral neck cutting, but sheep can show signs of recovery for longer times in exceptional cases.

Most chickens lose consciousness after between 12 and 15 seconds, but signs of recovery/consciousness are possible for up to 26 seconds after the cut.

However, as time to loss of consciousness varies between animals, clinical signs are necessary to recognize unconsciousness.

Several clinical signs have been suggested to recognize unconsciousness:

- Complete loss of posture.
- No attempts to regain or to retain upright body posture.
- No reactions (e.g. retraction) to mechanical impacts on the wound (e.g. contact of the wound to parts of the head-holder or pen).
- Absence of tracking by the eye of movements in the vicinity often accompanied by spontaneous closure of the eyelid.
- Absence of response to threatening movements (e.g. rushing the hand towards the eyes leading to closing of the eyes or moving the head backwards does not occur).

These are the clinical signs of brain death:

- Permanent absence of cardiac activity (e.g. pulse or heart-beat) when bleeding has ceased.
- Permanent absence of brain stem reflexes such as pupillary light reflex, corneal reflex, rhythmic breathing and gagging.

RECOMMENDATIONS

1. There must be no interference with the wound until the animal is unconscious, except for procedures involved with checking the adequacy of the cut. Mechanical and chemical stimuli on the wound must be minimized.
2. The cut should be inspected carefully for complete sectioning of both carotid arteries and both jugular veins, and for the efficiency of bleeding through the strong flow and seeing the pulsating effect of the heart-beat on this flow. When inspecting the wound, unnecessary contact with the severed edge of the skin must be avoided. Thus, visual inspection is preferable. It is understood that at times, the shochet may have a religious responsibility to carry out a physical inspection on the cut, and a visual inspection will not suffice. If the inspection is done by the shochet, they need to be trained to minimize or totally avoid touching skin surfaces.
3. The animal must be assessed to be unconscious by the slaughter persons (or the shochet) before it can be released from the restraint. It is suggested that the signs of unconsciousness are checked at least twice, for cattle between 30 and 40 seconds post-cut, and for sheep between 15 and 25 seconds post-cut. The following clinical signs should be used as a guide for monitoring:
 - No attempts to regain or retain upright body posture.
 - No reactions (e.g. retraction) to mechanical impacts on the wound (e.g. contact of the wound with parts of the head-holder or pen).
 - Absence of tracking by the eye movements in the vicinity often accompanied by spontaneous closure of the eyelid.
 - Absence of response to threatening movements (e.g. rushing of the hand towards the eyes leading to closing of the eyes or moving of the head backwards does not occur).
4. In the event of inefficient bleeding or prolonged consciousness being exhibited during repeated checks after neck cutting, animals should be stunned with a suitable method as soon as possible, even if this requires the religious authorities to declare the animal as non-kosher or haram. Optimally, this should be done within 45 seconds post-cut for cattle, or within 30 seconds for small ruminants and poultry.
5. As prolonged consciousness is an indicator of poor procedures, in the event of prolonged consciousness, the problem should immediately be investigated and necessary corrective action taken. Records of failure should also be documented for monitoring purposes.
6. Further dressing or scalding or electro-stimulation shall only be performed after brain death of the animal has been verified as indicated above.
7. When the cut is performed in a 180° inverted position in cattle, it may be preferable to turn the box to a position between 180° and 90° directly after the cut for better access to the head of the animal and a more relaxed position.

See Council Regulation (EC) No. 1099/2009 of 24 September 2009 on the protection of animals at the time of killing, Art 5, 2: ‘Where, for the purpose of Article 4(4), animals are killed without prior stunning, persons responsible for slaughtering shall carry out systematic checks to ensure that the animals do not present any signs of consciousness or sensibility before being released from the restraint and do not present any sign of life before undergoing dressing or scalding’.

REVERSIBLE STUNNING

MAIN OUTCOMES

Effective stunning before slaughter induces unconsciousness in animals.

Stunning for religious slaughter requires animals to be alive at the time of slaughter.

Reversible stunning methods induce temporary loss of consciousness and rely on prompt and accurate neck cutting procedures (bleeding out) to cause death.

After effective stunning, the presence of a heart-beat can indicate the reversibility of Unconsciousness if the animal is not slaughtered.

RECOMMENDATIONS

1. The animal must be introduced in the restraining device only when the slaughter person is ready to stun the animal, and stunning must be performed without any delay.
2. Correct stunning should induce loss of consciousness without pain before, or at the same time as, the animal is slaughtered.
3. The criteria for monitoring the loss of consciousness need to be applied according to the stunning system and species, to ensure that the animal does not present any signs of consciousness or sensibility in the period between the end of the stunning process and death.

Signs of a successful mechanical stunning in ruminants:

- Immediate collapse.
- Immediate onset of tonic seizure (tetanus) lasting several seconds.
- Prompt and persistent absence of normal rhythmic breathing.
- Loss of corneal reflex.

Signs of a successful electrical stunning in ruminants:

- Immediate collapse of free-standing animals (not applicable to animals held in a restraining conveyor).
- Immediate onset of tonic seizure (tetanus) lasting several seconds, followed by clonic seizure (kicking or uncoordinated paddling leg movements).
- Apnoea (absence of breathing) lasting throughout tonic–clonic periods.
- Upward rotation of eyes.

Indicators of ineffective stunning are escape behaviour often with vocalizing, absence of the typical tonic or clonic muscle activity, resumption of rhythmic breathing, vocalization during and after the current application or righting attempts and eye tracking of movements often with spontaneous blinking after the current application. In poultry, return of eye reflexes and rhythmic breathing are useful indicators of early return of brain function after electrical stunning. During bleeding, vocalization and wing flapping must be absent

4. Animals must be checked for the signs of unconsciousness before and after neck cutting.
5. The heart function can be recognized from the pulsating¹³ flow of the blood and the rate of blood loss when the cut is made.
6. The stun–stick interval must be sufficiently short to induce death through blood deprivation in the brain before the animal recovers from the stun.
7. Animals showing signs of consciousness following stunning need to be effectively re-stunned without any delay, using an appropriate back-up method.
8. Non-stuns, or mis-stuns, should be recorded. Management should monitor and take action if non-stuns or mis-stuns occur.
9. The equipment used for stunning should be maintained, regularly tested, and operated properly in accordance with the manufacturer’s recommendations, in particular with regard to the species and size of the animal, and a back-up stunner should be available.

POST-CUT STUNNING

MAIN OUTCOMES

Post-cut stunning shortens the time to unconsciousness, i.e. the time when the animal can feel anxiety, distress and/or pain as a result of restraint or neck cutting.

RECOMMENDATIONS

1. Post-cut stunning should be performed immediately and at the latest 5 seconds after the neck cut, without further manipulation of the animal between the cut and the stunning application (except if manipulation is required to enable relaxed bleeding position).
2. When a post-cut captive bolt stun is used, the gun must be placed in the correct position using the correct captive bolt/cartridge combination for that animal type.
3. Post-cut stunning must induce immediate loss of consciousness.

8 Conclusions and outstanding issues

This report has reviewed current methods employed in the UK for slaughter of cattle and small ruminants from animal welfare, legislative and meat quality points of view. In relation to conventional stunning and slaughter, more research has been carried out than for religious slaughter methods making considerable number of publications available. Cattle can be effectively slaughtered following application of captive bolt or electrical methods meeting legislative requirements whilst maintaining animal welfare when correctly employed. The former technique generally results in lesser problems such as haemorrhages and other meat quality defects leading to downgrading, if appropriately used. Similarly, small ruminants can also be stunned using the same methods. However electrical stunning is the preferred method for these species. In addition to stunning and slaughter, prior handling of animals can also have adverse effects on animal welfare, meat quality as well as public health. A recent EU legislation to come into force in January 2012 will bring in changes relating to handling, stunning and slaughter methods. In particular cattle restraint method and devices used during slaughter are being reviewed by the EU commission and this could have changes in practices.

This review was also aimed at collating published information relating to conventional and religious slaughter methods and their effects on quality, animal welfare, legislative requirements and public health. As indicated in the title, although particular reference to meat quality was sought to be made, it has become apparent that in relation to religious slaughter methods there is insufficient information. The main reason for that could be that most research until recently has been on conventional slaughter. However, with the increase in production of meat from religiously slaughtered animals due to consumer demand and bigger market share, especially of Halal products, in the last two decades, there is a need for research in this area. The following lists the gaps in understanding research needs for certain areas and issues:

1. Meat quality effects of current religious slaughter practices in cattle and sheep
2. Reasons for variations in slaughter standards carried out especially in Halal meat production
3. Factors affecting occurrence of carotid occlusions (ballooning) during religious slaughter and quality consequences
4. Preslaughter handling of sheep for religious slaughter, legislative and throughput problems
5. Preslaughter restraint of cattle in specialised devices and relative effects on welfare, quality and operator safety
6. Hygiene implications of religious slaughter both in abattoirs and during distribution
7. Halal meat certification, audit standards and illegal meat
8. Training of slaughtermen

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