11. Animal Welfare, Ritual Slaughter and Slaughter Floor Operations

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Learning objectives

By the end of the chapter you should be able to:

- describe the steps in the slaughter chain from lairage to by-products.
- discuss the operational issues within the slaughter process
- debate the benefits of different technologies on the slaughter chain

11.1 Introduction

Abattoir slaughter and dressing procedures have evolved from early practices which were relatively slow, unpleasant and unhygienic by to-days standards, which are efficient, clean and hygienic components of the meat supply chain. This lecture provides an overview and basic understanding of what happens pre-slaughter and on the slaughter floor of an abattoir—stunning, exsanguination (bleeding) and carcase dressing procedures. The criteria for humane slaughter and ritual slaughter are also outlined.

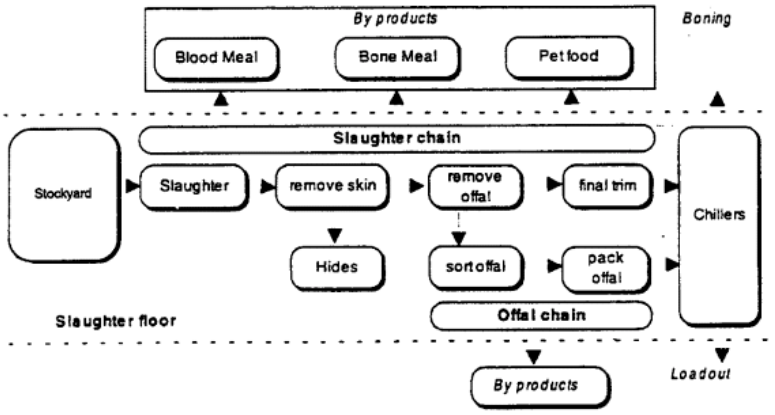
Figure 11.1. Pig slaughter chain (Photo JM Thompson).

The major tasks undertaken in a processing works can be grouped into five key areas:

1. Lairage operations (from animal receival to the knocking box)
2. slaughter chain and offal chain
3. fabrication
4. chilling and freezing
5. by-product production.

Fabrication, chilling and freezing will be covered in later lectures.

Figure 11.2 Major tasks on a slaughter chain
Source: Industry Commission Report No. 38 Meat Processing. Copyright Commonwealth of Australia; reproduced by permission.



11.2 Pre-slaughter procedures

Lairage
Lairage and handling should minimise stress and discomfort. Electric prodders should not be used. The optimum amount of rest required prior to slaughter depends upon climatic conditions, distance/time of travel, method of transport and general health. There is no point in prolonging a rest period if there are no obvious commercial advantages (**this is discussed in more detail in replenishment of glycogen reserves).**

Figure 11.3. Cattle in lairage (Photo JM Thompson).

Cattle usually arrive at an abattoir 1–2 days prior to slaughter. A number of abattoirs are reducing the time in lairage so that cattle are yarded, transported and slaughtered in the one day. Tailgating is when cattle are slaughtered soon after delivery to the abattoir. This reduces the need for extensive yards and facilities at the abattoir and reduces the stress of yarding and mixing and so minimise depletion of glycogen prior to slaughter. Mixing of animals prior to slaughter can often impose great stress on individual animals as they stress to establish there social position within the new 'group' (This is discussed in more detail in the section on lairage stress**).**

Stock begins to empty out after being yarded off pasture or the feedlot. They tend to lose weight in an exponential fashion with greater weight loss directly after being taken off feed, compared with 2 days off feed. The rumen contents comprises 20-30% of the live weight of cattle, although this will vary due to the type of feed, its digestibility and the rate of passage of digesta through the animal. Typically cattle will lose up to 8% of bodyweight in the fist 24 hours off feed. Carcase weight loss in cattle is thought to begin around 24 hours after being taken off feed (Wythes and Shorthose 1968). Access to electrolytes during lairage may reduce weight loss.

Animals are not fed during the 24-hour period prior to slaughter. Animal welfare legislation demands that when cattle are kept off feed prior to slaughter they must have access to water. The weight loss prior to slaughter is known as 'shrink'.

11.3 Ante-mortem inspection

This is carried out in lairage the morning of slaughter. The inspector (usually the works veterinarian) looks for symptoms of any disease that could transmit disease to humans or other animals and render the meat unfit for consumption. No animals appearing to suffer from such a disease could be slaughtered for human consumption. Any animal that is injured, fatigued, or stressed is required to be rested for 24 hours and inspected again before it can be slaughtered.

Cattle are usually washed prior to the ante-mortem inspection.. If cattle are considered dirty then they must be washed to the veterinarian's satisfaction. In cold environments the washing procedure can impose stress on the animal and deplete glycogen reserves. The value of washing pre-slaughter as a means of reducing microbial contamination of the animal and subsequently the carcase is debatable. A recent study in Victoria examined the relationship between cleanliness of the live animal and cleanliness of the carcase. Surprisingly, the cleanliness of live animals pre-slaughter had little effect on the microbiological quality of the resultant carcase under the processing criteria for Australian plants. From these results it was apparent that Australian slaughter processes are conducted at standards that enable removal of contaminants from the hide and prevent cross-contamination to the carcase.

Figure 11.4 Cattle are generally washed prior to slaughter to remove loose dirt and faeces from the coat and therefore decrease carcase contamination. (Photo JM Thompson)

11.4 Stunning and slaughter

Criteria for a good slaughter include:

- animals must not be treated cruelly;
- animals must not be unnecessarily stressed;
- bleeding should be rapid and as complete as possible;
- carcase damage must be minimal; and
- process should be hygienic, economical, and safe for the workers.

Except in approved ritual slaughter procedures, animals should be stunned and rendered unconscious, with death resulting from loss of blood.

The steps in the slaughter process are

A. Stunning

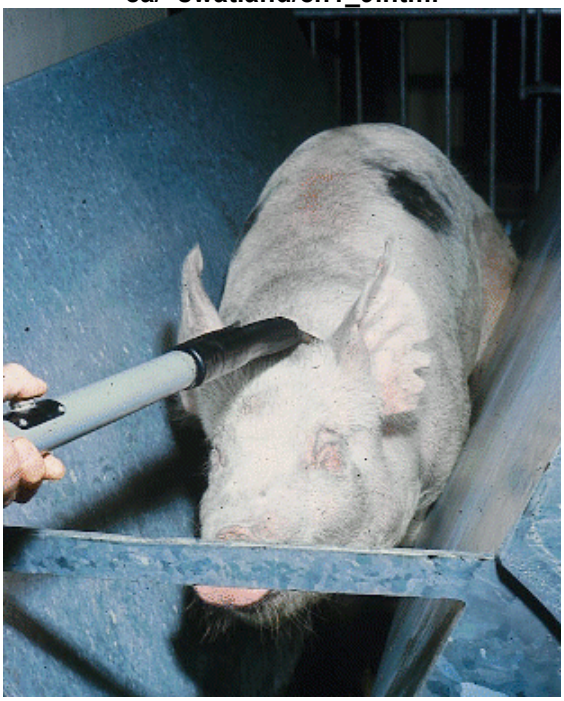
Concussion
This may be induced by penetration of the skull by a bullet or a bolt. A captive bolt pistol is commonly used. This device uses a blank cartridge to propel a cylindrical bolt against the skull, on the midline above the brow ridges of the eye sockets. An alternative site is behind the poll. Penetration may be minimal. Non-penetrating stunners have a mushroom shaped head and are generally used on cattle for a halal kill.

Figure 11.5. A captive bolt gun being used. Source: Thompson, (2006).

Electrical
Animals can be stunned by passing an alternating electrical current through the brain. Current is applied for only 1–2 seconds, and some systems involve a 'heart stop'. Electrical stunning is common with pigs and may be manual or automatic. It is also used on poultry.

Carbon Dioxide (CO_2)
Pigs are stunned in some countries by placing them in an atmosphere which contains at least 65% CO_2. This is done in a pit or tunnel containing the CO_2 which is heavier than air. Automatic ferris wheel systems are available and stunning requires about one minute. It is also used for turkeys. CO_2 stunning is not feasible for sheep because the wool absorbs the CO_2. The volume required for cattle would make the costs of CO_2 prohibitive.

Figure 11.6. Electrical Stunning in pigs. Source: http://www.aps.uoguelph.ca/~swatland/ch1_9.htm.



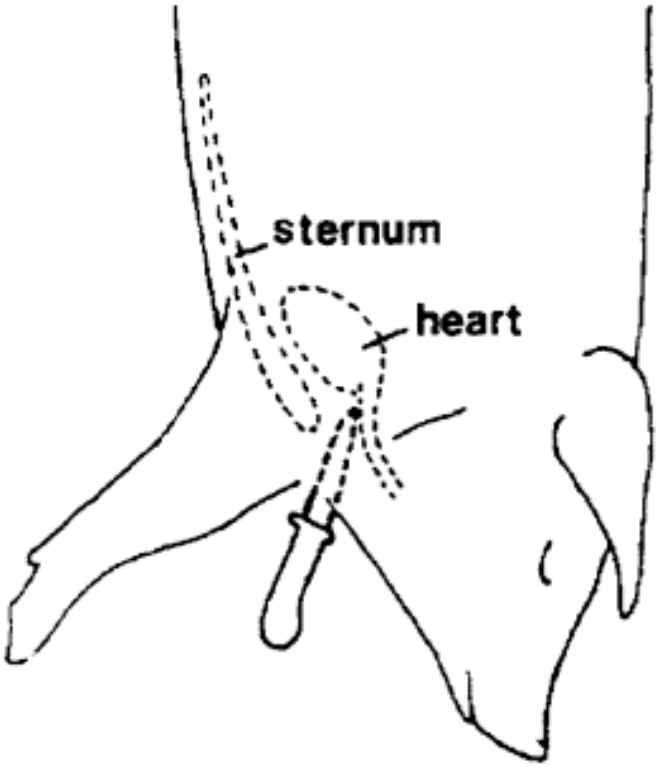
B. Bleeding

Cattle, sheep and pigs are usually exsanguinated by a puncture wound that opens the major blood vessels at the base of the neck. The carotid arteries and the jugular vein are severed (see Fig 11.7). In the industry, this is called sticking. If sticking is inaccurate, exsanguination (bleeding) may be slow. Damage to large areas of tissue can cause the formation of blood clots. Similarly, if the trachea is severed by the wound, blood may be drawn into the lungs. Poor sticking procedures may result in the need for carcase trimming to remove blood and clots.

The knife between the forelimbs is angled so that it cuts the major blood vessels along the heart, just near the anterior edge of the sternum (Swatland 1994).The sticking knife must be kept clean otherwise bacteria might be introduced into the venous system and spread through the otherwise relatively sterile muscles of the carcase

Electrical stunning of pigs may stop cardiac activity so that, at the start of exsanguination, the blood escapes by gravity rather than being pumped out. In pigs, cardiac arrest does not affect the rate and extent of exsanguination. After exsanguination has started, the heart usually re-starts and attempts to pump, until it runs out of energy. Thus, in many cases, there is no reason why animals such as pigs and sheep cannot be killed by electrocution rather than being merely electrically stunned. In cattle stunned by concussion, more or less complete exsanguination may be obtained without ventricular pumping.

Figure 11.7 Sticking of a pig. Source: Swatland (1994).



Blood loss as a percentage of body weight differs between species:

- Cows 4.2 to 5.7%
- Calves 4.4 to 6.7%
- Sheep 4.4 to 7.6%
- Pigs 1.5 to 5.8%

Blood content as a percentage of live weight may decrease in heavier animals since the growth of blood volume does not keep pace with increase in live weight. Approximately 60% of blood is lost at sticking, 20–25% remains in the viscera, while a maximum of 10% may remain in carcase muscles.

It is traditionally maintained that poor bleeding leads to dark meat with poor keeping qualities due to microbial spoilage and rancidity. However, there is little scientific evidence in support of this view, and it may be false, even in animals which retain massive amounts of blood in their carcases. Delayed exsanguination of cattle may lead to a slight reduction in the amount of blood removed so that the carcase and spleen are slightly heavier. The effects on meat quality, however, are negligible. For further reading a good article by Temple Grandin from Colorado State University which compares the different stunning (electrical, CO2 and concussion) techniques can be accessed at http://www.grandin.com/humane/rec.slaughter.html.

Stimulation systems that mimic the action of the heart are being developed to improve the bleeding. This is expected to have a beneficial effect on both meat and fat colour.

Humane slaughter
In research situations, neuromuscular response to stunning is often measured using electroencephalography (EEG). Stunning should induce a situation where there is no EEG activity. It is very difficult to determine whether prior suffering is associated with stunning in a commercial abattoir and there has been much research into attempting to ensure that slaughter is as humane as possible.

One of the most important aspects is the duration of unconsciousness, because animals must be fully bled before they recover consciousness. Pigs lose consciousness within 60–75 seconds but the duration is not long and bleeding must be commenced within 30 seconds of the pig leaving the stunner. Drugs cannot be used because unacceptable residues could remain in the meat.

Ritual slaughter
The Jewish and Muslim religious laws specify procedures for slaughter of red meat animals and poultry.

Kosher Slaughter (Jewish Ritual Slaughter)
Animals, which must be fully conscious, are placed on their backs and their throats are cut. The resulting meat is put through a process of covering the surface with coarse salt for one hour at room temperature, then rinsing well with water. Only animals that have split hooves may be eaten—cattle, sheep, goats, deer, camels. Pork is prohibited.

Halal Slaughter (Moslem Ritual Slaughter)
This procedure is similar but it does not require the animal to be on its back. In both religions, meat from animals or birds of prey is not permitted. Eating animals killed by hunting is similarly excluded. Blood must not be eaten. The basis of these procedures was to prohibit meat from dead animals entering the human food chain. The persons performing the slaughter must be specially trained and accredited. A prayer is said for each animal. These ritualistic processes are intended to protect slaughter animals from cruelty and humans from eating 'unclean' food.

The Halal slaughter process requires the first penetration of the body to be the slaughterman's knife. Therefore percussion stunning must be used for Halal slaughter as the captive bolt would penetrate the skull. The knife cut must be across the neck to sever arteries, veins (and the oesophagus). At this stage an oesophageal clip cannot be put on and a bung must be pushed into the oesophagus to minimise the chance of rumen contamination. Many abattoirs now kill all stock using Halal kill so that it does not exclude the cuts or offal from any Muslim markets

11.5 Carcase dressing procedures

Slaughter procedures are extremely variable, and methods common in one locality may be unheard of in another. The introduction of equipment, such as a hide puller, may lead to a significant reorganisation of the slaughter line. The main objectives of a slaughter procedure are to get the job done neatly, hygienically and quickly. One possible method for beef carcases is described below. The other species of meat animals are treated in a corresponding manner, except for the head, feet and hide. With calves, the skin may be left on until the eviscerated carcase has been chilled.

Figure 11.8. An oesophageal plug being pushed up the oesophagus of a carcase after knocking, for a halal kill. Source: Thompson, (2006).

The steps in the carcase dressing procedure are:

1. immobilisation
2. shackling and hoisting
3. removal of horns, feet, udder and pizzle
4. clearing of shanks and neck and dropping the bung
5. removal of hide
6. evisceration
7. carcase splitting
8. carcase washing and inspection
9. carcase weight and measurements
10. electrical stimulation may be applied to the carcase at some stage of the slaughter chain/dressing procedure, although in itself it is not part of the dressing procedure. It is not used by all abattoirs, nor for all classes of stock in any particular abattoir.

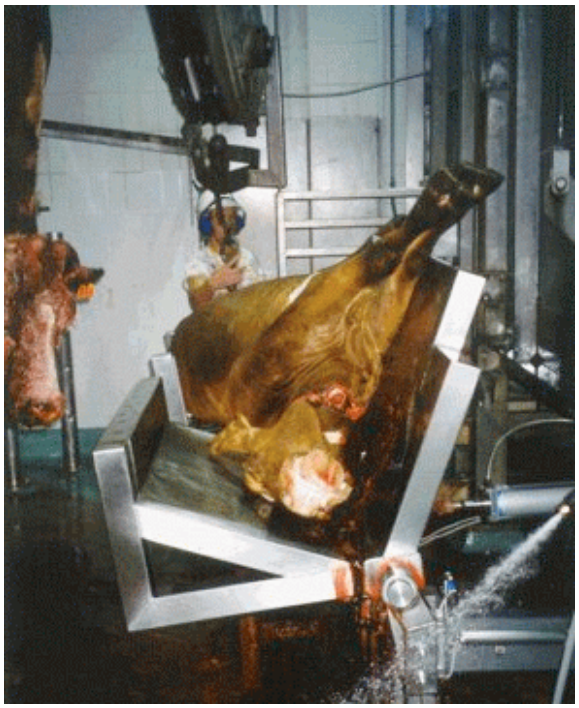
Immobilisation and shackling

Bodies are often immobilised after stunning and sticking to reduce the risk of kicking during the shackling and hoisting stage (Fig 11.9) . A problem that occurs is that often the duration of immobilisation is dependent upon how quickly cattle are shackled and hoisted onto the rail. Therefore the duration of immobilisation can vary widely between animals. This becomes a problem since low voltage immobilisers are most effective at low frequency (about 45 Hertz, which causes the greatest muscle tetany) which in turn initiates glycolysis. This then becomes a problem if electrical inputs are being controlled to manage the pH/temperature window. Beef carcases are first shackled with a chain around the foot, but before the feet are removed, the carcases are re-suspended from a hook under the Achilles tendon at each hock.

Electrical Stimulation

Electrical stimulation is the application post-slaughter of an electrical current to the carcase. In practice, low voltage stimulation is applied immediately after slaughter, whilst high voltage stimulation is applied anywhere from 20 minutes to one hour after slaughter. Extra low voltage stimulation (ca. 45V) is applied immediately after shackling, within 5 minutes of bleeding. Current application is by a low voltage passing between the nose (nostril) and anus and effectively involves the nerves in the current pathway. The voltage is typically between 40 -80 V peak.

Figure 11.9. Immobilisation of a body in the sticking cradle. Note the legs are extended and in muscle tetany. (Photo JM Thompson).



High voltage stimulation (ca 700V) is effective for up to one hour after bleeding, but it is dangerous for workers and must be done in a secure area. It is usually applied after hide removal and evisceration.

Figure 11.10. Low voltage stimulation being applied immediately post slaughter. Low voltage current being applied by nostril clamp and an anal probe. Notice the tetany of the front legs (compare with those of other carcases). (Photo JM Thompson).

An alternative is mid level stimulation, which can be applied at the end of slaughter chain before the sides go into the chillers. The voltage involved does not pose as much of an occupational health and safety issue as does HVES. Research is currently underway to use MVES to "top up" electrical inputs taking into account the weight and fatness of individual carcases, and the electrical inputs they have already received via the immobiliser and rigidity probe.

Preparation for hide removal

- Any horns are removed, the head is skinned and the skull and lower jaw removed, leaving the whole of the neck and the skin of the head hanging on the carcase. The head is put on a separate chain for inspection.
- Each foot and the distal part of each limb is removed by cutting through the joint immediately proximal to the long cannon bone.
- A long incision is made through the hide in the midline of the chest and abdomen, and continued along the medial face of each of the limbs, and the legs cleared of hide. The pizzle or udder is usually removed at this stage.
- A circular cut is made around the anus (in females this includes the anus and vulva).The freed rectum is covered with a plastic bag to prevent contamination of the carcase with faecal matter and dropped into the abdominal cavity for removal during evisceration.

Figure 11.11. Using a pneumatic cutter to remove the feet (Photo JM Thompson).

Removal of the hide

The hide is removed using an electric or pneumatic hide puller, powered flaying knives or curved hand knives. Hide pullers can be upward or downward pulling. When a downward-pulling hide puller is used, cuts are made inside the shanks of the rear legs, allowing the hide to tear so that it can be peeled off downwards, leaving the clean carcase behind. A rigidity probe is usually used with a downward hide puller to stiffen the backbone whilst the hide is being removed

Figure 11.12 Clearing the legs prior to bagging and removing the bung and taking off the hide (Photo JM Thompson).

from the shoulders and poll. When an upward-pulling hide puller is used, incisions are made around the neck and inside the shanks of the forelegs so that the hide can be peeled off in an upward direction. The downward-pulling hide puller causes less contamination of the carcase, so is the preferred option.

Figure 11.13. An upward hide puller (Photo JM Thompson).

Note the foreshanks need to be anchored. This generally results in a better dressing procedure than a downward hide puller which can tend to tear more fat of the loin and hindquarter regions.

Figure 11.14. Downward hide puller (Photo JM Thompson).

Figure 11.15. Rigidity probe being used with a downward hide puller (Photo JM Thompson).

A rigidity probe is used to stiffen the body as the hide is pulled over the shoulders and poll (Figure 11.15).

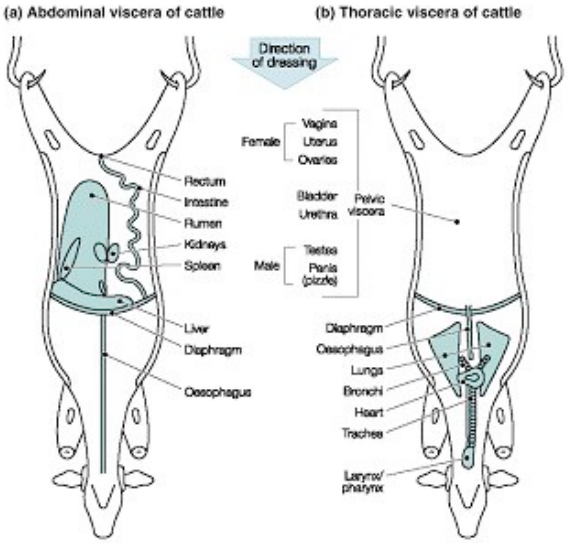
Evisceration

Evisceration is the process of removing the internal organs, or offal, from both the thoracic and abdominal cavities. These are dropped into a tray for inspection and further processing of offal components. The offal falls into two categories:

- Green offal. Those organs which still contain faecal matter
- Red offal. The remainder of the organs, a large part of which can be used for human consumption, including the heart, liver and kidneys. That portion not separated and packed for human consumption is incorporated with other offal for rendering.

Figure 11.16. Abdominal and thoracic contents being dropped into a tray during the dressing procedure (Photo JM Thompson).

Figure 11.17. The offal components that are removed during dressing
Source: Gracy J.F. Meat Plant Operations



Carcase splitting
The carcase is split using a bandsaw. It is necessary that the blade be sterilized between carcases.

Figure 11.18. Carcase splitting (Photo JM Thompson).

Carcase inspection and washing
The purpose of post-mortem inspection is to detect and eliminate abnormalities, including contamination and disease, thus ensuring that only meat fit for human consumption is passed for food. All parts of the carcase in which any lesion is found, or any other condition or adulteration suspected, are retained for further inspection and labelled accordingly until the final inspection is completed. Identification of all severed parts of the carcase is maintained in case it is condemned.
There are 3 stages of post-mortem inspection:

- Inspection of the head comprises examination of the tongue, eyes, lymph glands and the inside of the mouth.
- After evisceration, the internal organs are examined on the gut conveyor inspection table. Inspection involves a combination of visual examination, palpation (examination by touch) and incision of the various organs.
- The dressed carcase is examined for such things as the state of nutrition of the animal, efficiency of bleeding, colour, cleanliness, odours, evidence of bruising or haemorrhage, lesions and any other abnormalities.

Figure 11.19 The head being trimmed prior to inspection (Photo JM Thompson).

At this stage the head can be related to the carcase and offal components on the gut conveyor

Figure 11.20. Inspection of organs on the offal line (Photo JM Thompson).

Before going to the chiller the dressed carcase sides are washed with hot water, weighed and standard carcase measurements taken. Labels are attached to each half, giving lot number, body number, weight and fat depth.

Readings

The following readings are available on web learning management systems

1. Meat and Livestock Australia (MLA) 2001 Novel Products from the meat industry.

Summary

Summary Slides are available on web learning management systems
The slaughter chain has evolved to a rapid and efficient processing chain in the modern abattoir. The major tasks undertaken to produce a dressed carcase are:

- Lairage operations (from animal receival to the knocking box)
- Stunning and bleeding
- Removal of appendages and hide
- Removal of organs
- Splitting the carcase into half
- Inspection of head, offal and carcase to make sure they are fit for human consumption
- Washing the carcase
- The carcase may also be electrically stimulated (optional)

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