

21. Lairage – Beef, Sheep and Pigs

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Learning objectives

At the end of this topic you should be able to:

- Be able to identify and describe the different phases of the pre-slaughter period.
- Understand how livestock management during the pre-slaughter period can affect food safety, animal welfare, meat yield and meat quality.
- Appreciate the differences between the different livestock species (pigs, cattle and sheep) in relation to the pre-slaughter period.

Key terms and concepts

Curfew, Transport, Lairage, Pre-Slaughter Stress, Dehydration, Yield, Meat Quality, Animal Welfare Muscle glycogen

21.1 Introduction

The pre-slaughter period consists of the period of time from when animals are organised into a consignment, on the property where they have been “finished”, to the time when they are slaughtered at an abattoir. This period consists of a number of phases which will be discussed below and can be a critical period affecting carcase yields and ultimate meat quality.

21.2 Phases within the pre slaughter period

The pre-slaughter period can be thought of as consisting of a number of different phases. These phases will depend on whether livestock are sold directly from farm to abattoir or indirectly from farm to abattoir via a saleyard.

When livestock are consigned directly from farm to abattoir the phases of the pre slaughter period include:

- farm curfew,
- transport
- abattoir lairage.

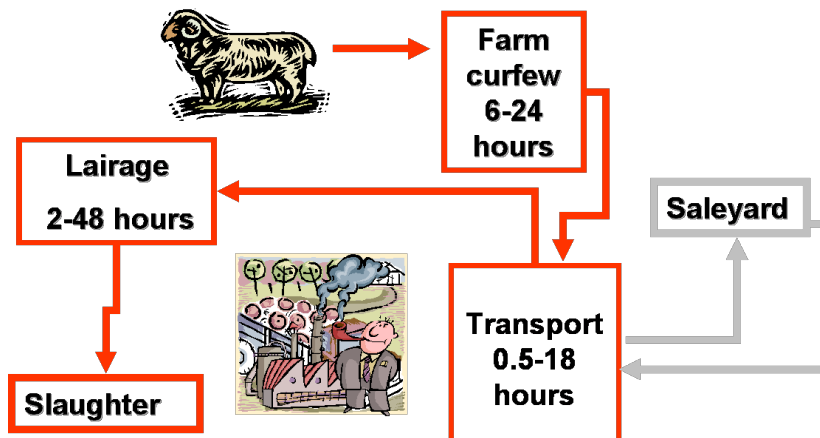
A recent study of vendor declaration forms collected from an abattoir in Western Australia found that the average time for the pre-slaughter period of lambs consigned directly from farm to abattoir was 42.8 ± 4.35 hours (mean $\pm$ sem) for the farm curfew, transport and lairage periods combined. On average the farm curfew period was 14.6 ± 2.61 hours (mean $\pm$ sem).

When livestock are sold via saleyards the pre-slaughter period includes:

- farm curfew,
- transport,
- saleyards,
- transport,
- abattoir lairage.

Indirect consignment can be longer in time and potentially more strenuous for livestock than direct consignment.

Figure 21.1 The movement of livestock from farm to slaughter. Source: Jacob, (2006).



The different parts of the pre-slaughter period can often be managed by different people. A common scenario is that the farmer on the source property will manage the farm curfew period, the transport contractor will manage the transport period and the lairage manager will manage the abattoir lairage period. Decisions during one phase can therefore be made independently of decisions during a previous phase. The time spent in lairage is not necessarily altered to cater for the time in farm curfew to achieve a standard total time off feed for example.

Farm curfew

The purpose of farm curfew is to prepare livestock for transport and specifically to reduce the volume of the gastrointestinal tract and the urinary bladder contents prior to transport. Farm curfew generally begins after livestock have been organised into a consignment or 'line' for sale and slaughter. This process generally involves assessment of the animals for weight and fatness in some way, either subjectively by visual appraisal of liveweight and manual palpation of body fatness or objectively using liveweight scales and ultrasound measurement for body fatness. In the case of sucker lambs and vealer cattle, weaning from the animals mother will coincide with consignment for sale and commencement of the farm curfew period.

A farmer may organise a consignment alone or with the assistance of a professional live animal assessor and/or selling agent. The animals that satisfy the liveweight and fatness requirements for slaughter form the consignment and those that do not are directed elsewhere for further finishing or perhaps to an alternative market such as live export. Once the consignment has been formed, farm curfew may begin immediately or be delayed for a short period of time to coincide more closely with transport. Generally farm curfew involves confinement at a high stocking density, such as in a shearing shed in the case of sheep.

For sheep and cattle, both feed and water are withheld during the curfew period on farm and this reduces the volume of the gastrointestinal tract and the urinary bladder contents prior to transport. The length of the farm curfew period will often be dictated by recommendations from the transport contractor and or processor. Recommendations can be flexible and may depend on the feeding system under which the livestock have been run. For example one processor recommends that animals grazing lush pasture be fasted for 12 hours and animals grazing dry feed be fasted for 4-6 hours before loading onto transport (Mulcahy 1998). Meat and Livestock Australia have a standard recommendation of 12 hours (Anonymous 2005).

For pigs water is not withheld during the farm curfew period which tends to be very short, as they are more susceptible to dehydration and stress than sheep and cattle.

A recent study of vendor declaration forms collected from an abattoir in Western Australia found that in most cases the water deprivation periods were compliant with the guidelines set out in the Codes of Practice. However in some consignments dehydration was prevalent and further research is required to understand the causes of dehydration in sheep particularly.

Transport

Transport from farm to abattoir under Australian conditions, generally involves road transport. Although important in the past, rail transport is rarely used for livestock currently. On some routes in Australia, notably from Kangaroo Island to the mainland in South Australia and from Tasmania to Victoria, transport will include a short sea voyage whereby the truck loaded with livestock is carried on a vehicle ferry.

The length of transport will vary according to a number of factors including the distance from farm to abattoir, the need to collect other consignments on neighbouring farms to fill a truck, and the time of arrival in relation to the opening time of the lairage. Lairage yards may be closed during the night so if a truck arrives after closing time, the livestock will be kept on the truck until the lairage opens the following morning. When this occurs the period of confinement on the truck will be longer than the travelling time.

Both food and water are withheld during the transport period. The recommendation in the code of practice for transport is that livestock should not be transported for more than 24 hours without being unloaded and rested.

Many studies have demonstrated that transport elicits a physiological stress response in travelling livestock, namely an increase in the serum concentrations of adrenaline, noradrenaline and cortisol. Motion sickness, fasting, mixing, high

stocking density, maintaining balance, noise, temperature extremes, and water deprivation (Gregory 1996) are factors during transport that contribute to a stress response.

However this hormonal response to transport tends to occur mainly at the beginning of the journey and livestock become acclimatised to transport. Short journeys may therefore be just as stressful as long journeys. Fell and Shutt (1996) showed that the cortisol response of lambs to transport depended on the nature of the transport. Thirty minutes of stop-start transport gave significantly higher salivary cortisol levels than 1 hour of steady highway transport. Age of the animal breed may also be important for the magnitude of the stress response to transport.

Abattoir lairage

Holding livestock in abattoir lairage yards prior to slaughter is done for a number of purposes. To rest animals after transport, to further reduce the volume of contents in the gastrointestinal tract before slaughter, to facilitate a continuous supply of animals to the slaughter floor throughout a working day, and to allow resorting of animals into lines consistent with the markets available to the meat processor.

In Australia, food is withheld but water is made available during abattoir lairage unless the lairage period is planned to extend beyond 24 hours. In this event the animals should be released to holding yards where food and water can be supplied.

Lairage yards are often covered and designed to keep the animals as clean as possible. Floors vary from solid earth or concrete to wooden slats or metal mesh. Lairage yards in the case of sheep are often raised to facilitate removal of manure. Stocking densities are high and yards may be large. Group sizes in abattoir lairage tend to be smaller for cattle than for sheep. Lairage yard specifications depend on AQIS regulation when the abattoir is licensed to sell meat for export.

21.3 Impact of the pre-slaughter period for meat

Adverse management of livestock during the pre-slaughter period can induce negative physiological responses in the live animal which can lead to changes in meat. Importantly changes that occur during the pre-slaughter period generally cannot be reversed within the time frame of a normal commercial pre-slaughter scenario, as events occur in a one way sequence and end with slaughter.

There are 4 key areas in which the pre-slaughter period can have an impact on meat production.

- Food safety
- Animal welfare
- Meat yield
- Meat eating quality.

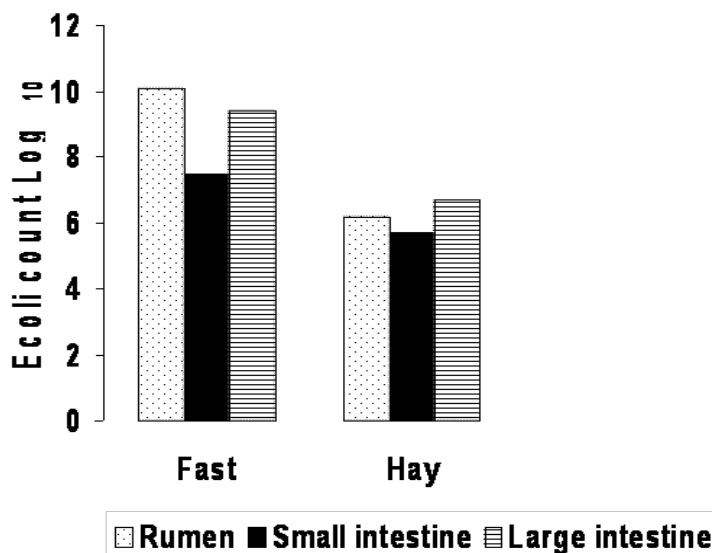
Management that is optimal for one area may not be optimal for another area. A good example of this is the practice of “swimming” sheep prior to slaughter. This is a rare practice in Australia, but is still practised in New Zealand. Sheep are made to swim in a water bath to wash them prior to slaughter. This involves exercise which can reduce muscle glycogen concentration and a high pHu (dark cutting) hence is detrimental to meat quality. Another example would be very long farm curfew times which may reduce faecal soiling during transport but reduce carcass weight when the total fasting period lasts for an extended period of time prior to slaughter.

Food safety

Meat is required to be free of harmful contaminants including physical, chemical and microbiological pathogens. Soiling of the skin with faeces and urine during transport can lead to microbiological contamination of the carcass during processing. Cattle are considered to be the main source of *E. coli* O157:H7, and the disease in humans has been primarily associated with ground beef (Vanselow, Krause *et al.* 2005).

If animals arrive at the abattoir with excessive faecal soiling they may be rejected by the AQIS inspector. Prevention of soiling is particularly important for sheep as pigs and cattle can be washed more easily prior to slaughter than can sheep. Whilst extended fasting prior to slaughter may reduce the volume of gut contents it may increase other risks for food safety. Gut contents become more watery in consistency (Gregory, Jacobsen *et al.* 2000), rumen pH increases and the growth of pathogenic bacteria such as *E. coli* and *Salmonella spp.* may increase with fasting (Figure 21.2). Extended fasting is therefore not favoured for food safety reasons.

Figure 21.2 The effect of fasting on bacterial populations in the gut
(adapted from Gregory *et al.* (2000))



Animal welfare

During the pre-slaughter period livestock will experience different environmental conditions and management to what they have become used to on the property where they have been reared. Contact with humans, dogs, unfamiliar surroundings, temperature extremes, physical exercise, mixing with unfamiliar animals, food deprivation and water deprivation are some of the unfamiliar experiences livestock are likely to encounter during the pre-slaughter period.

Codes of practice

Codes of practice provide guidance for the management of livestock during the pre-slaughter period. These codes and the legal status of the codes vary between states although steps are currently being made to harmonise standards within different states with national codes.

In some states, such as South Australia, the codes of practice are written into law and provide for penalties when violated. In other states, such as Western Australia, the codes are not laws as such and do not provide penalties for specific actions mentioned in the codes. However in the case of the W.A. code of practice, evidence that a code of practice has been followed may be used to support the defence of a person who has been accused of mishandling livestock during the pre-slaughter period and vice versa. Even when codes are harmonised it is likely that interpretation and implementation of the codes will be controlled at a state level and this may vary between states.

Codes of practice can be found at the following web site:

<http://www.publish.csiro.au/nid/22/pid/367.htm>

Meat yield

Bruising

Bruised meat is trimmed on the slaughter floor and this reduces the weight of the carcase. Yard design, yard maintenance, animal temperament and absence of horns are important parts of bruise prevention. Muzzle guards for farm and lairage dogs are essential to prevent bruising associated with bite wounds particularly in the hock area of sheep.

Muscle weight changes

Liveweight loss

Liveweight loss is particularly relevant for estimating the value of livestock when they are sold live rather than “over the hooks” as carcasses. Livestock valuers may impose a curfew period before weighing animals for valuation purposes to reduce liveweight variability due to gut fill.

Liveweight loss occurs due to a reduction in the weight of the gastrointestinal tract (gut fill) as well as carcass weight loss. Over a 48 hour pre-slaughter period losses in live weight of up to 15% can occur depending on conditions. Thompson et al (1987) attributed the loss during transport to feed and water deprivation rather than stress.

Carcass weight loss

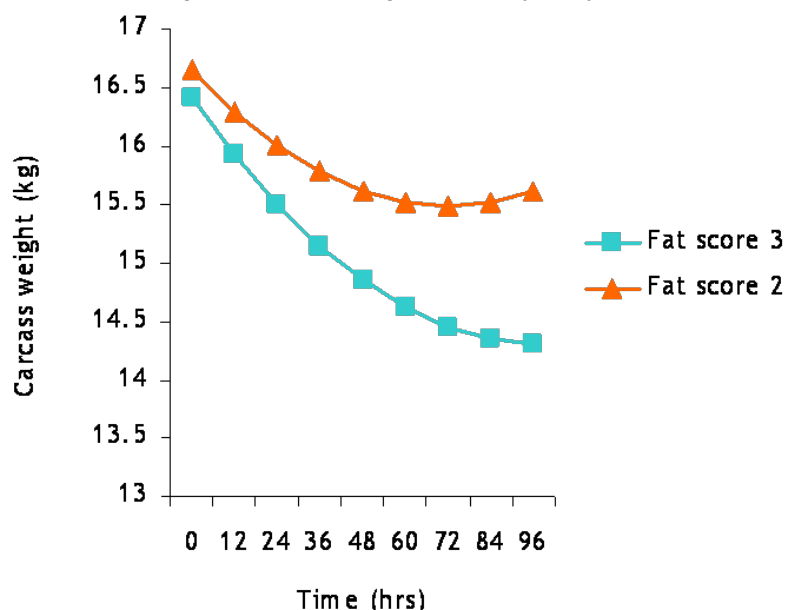
Carcass weight loss is more significant than liveweight loss in terms of the value of the meat harvested. When sold over the hooks the farmer rather than the processor will bear the cost of carcass weight loss.

Meat and Livestock Australia recommend the following benchmarks (Anonymous 2005) for estimating the effect of time off feed on dressing percentage:

- 1% after 4 hours off feed,
- 2% after 12 hours off feed, and
- 4% after 24 hours off feed.

Carcass weight loss can be due partly to tissue mobilisation to satisfy the energy requirements of the animal but dehydration is also important. Thompson et al (1987) attributed the loss during transport to feed and water deprivation rather than stress.

Figure 21.3 The effect of fasting on carcass weight loss.
Adapted from Thompson et al (1987)



Dehydration causes a loss of fluid from muscle tissue which decreases muscle weight, muscle volume, carcass weight, condition score as estimated by GR tissue depth, and dressing percentage (Jacob *et al.* 2005). After a 48 hour period of water deprivation, carcass weight loss due to dehydration may be in the order of 2-3% for lambs.

Recent studies have shown that under commercial conditions dehydration occurs mainly in sheep and not cattle. This species difference is thought to be due to differences in water intake during the lairage period due to group size and accessibility to water. Sheep tend to be kept in large group sizes and cattle in small group sizes during lairage. However there may be other factors that require further investigation to find a solution to the dehydration problem in sheep.

One study at 2 commercial abattoirs estimated that about 50% of lambs are dehydrated at the time of slaughter. Inadequate water intake during the lairage period appears to be the key reason for dehydration in lambs at the time of slaughter rather than ambient air temperature extremes. Factors that predispose lambs to dehydration during the pre-slaughter period include:

- Long farm curfew times,
- Lamb age - sucker lambs are more susceptible than carry over lambs,
- Time of the year - lambs slaughtered in winter are more susceptible to dehydration than lambs slaughtered in summer, and
- Location - lambs in cool locations are more susceptible than lambs in warm locations.

Meat quality

Muscle glycogen concentration

At the cellular level, muscle glycogen breakdown is mediated through adrenaline and glucocorticoid hormones that activate the messenger cAMP, causing activation of glycogen phosphorylase and inhibition of glycogen synthesis (Murray *et al.* 1996). Cortisol inhibits glycogen synthase (Bergman 1983) and induces gluconeogenic enzymes. Adrenaline injection causes an acute reduction in muscle glycogen concentration and has been used experimentally to model muscle glycogen depletion (Monin 1981). Exercise increases the demand for energy and stimulates the release of adrenaline once the anaerobic threshold has been reached. Anaerobic exercise has also been used to model the stress response in relation to dark cutting (Pethick *et al.* 1991).

Exercise and stress can reduce muscle glycogen concentration but fasting per se has little effect unless there is exercise at the time of fasting. Repletion of glycogen will not occur unless livestock are fed for at least 48 hours and the rate of repletion is proportionate to their metabolisable energy intake. So rest alone is not sufficient to restore muscle glycogen concentration to levels that existed prior to a depletion event.

The effect of the pre-slaughter period on muscle glycogen concentration is highly variable. Studies have shown that glycogen loss can occur during the farm curfew and transport periods in the case of sheep (Jacob *et al.* 2005a,b) but this effect is dependent on consignment factors and can often be negligible. Factors that predispose lambs to muscle glycogen loss during the farm curfew and transport periods include; long curfew time, breed (merinos are more susceptible than crossbreds) and very high muscle glycogen concentration prior to transport. When glycogen loss occurs during the farm curfew and transport period the reduction can be in the order of 30% of the starting level (Jacob *et al.* 2005a,b).

Marketing livestock through saleyards may increase muscle glycogen loss compared to direct consignment (Walker *et al.* 2000) When muscle glycogen loss does occur during the pre-slaughter period the effect is greatest in glycolytic type muscles such as the *M. semitendinosus* (silverside), and is less common in oxidative type muscles such as *M. semimembranosus* (topside).

Lairage has little effect on muscle glycogen concentration in sheep (Jacob *et al.* 2005a,b) presumably because sheep do not engage in physical activity during this time. For cattle and pigs care must be taken when mixing animals in lairage as this may cause fighting and muscle glycogen loss. In particular the penning of bulls or boars together and heifers on heat need to be avoided during the lairage period.

There is evidence that stress immediately prior to slaughter may have an effect on the processing of meat. Very short lairage periods (kill on arrival) may increase pHu and cause dark cutting. Use of electrical prodders to move animals from the lairage yard to the slaughter point may increase the rate of pH decline post mortem and cause heat shortening or Pale Soft Exudative (PSE) meat in the case of pigs (D'Souza *et al.* 1999).

Meat colour

Low muscle glycogen concentration causes high pHu and the condition known as dark cutting. This effect occurs in all species and is part of the payment system for beef. Jacob (2004) found that lairage time may have an effect on meat colour independently of pHu and intramuscular fat concentration but was unable to determine either the cause or the potential for this effect to influence consumer acceptance of lamb meat. Dehydration may cause meat to be darker in colour and this may have been involved.

Eating quality

Apart from the effects on muscle glycogen concentration the effects of management during the pre-slaughter period on eating quality characteristics including tenderness, flavour, liking of flavour, juiciness and overall liking, are thought to be relatively small. However there is some evidence that lairage period may affect tenderness in lamb meat such that 1 day is the optimal lairage time for lamb meat eating quality (Jacob *et al.* 2005c).

Readings

The following readings are available on CD and WebCT:

MLA factsheets

1. Lamb and meat eating quality: Outcomes of the R&D program
2. Maximising sheepmeat eating quality : A guide for retailers, foodservice and wholesalers
3. Sheepmeat eating quality: A guide for Australian producers
4. Maximising lamb and sheepmeat eating quality : A guide for Australian lamb and sheepmeat processors
5. Managing glycogen to improve quality in lamb and sheepmeat
6. The effect of pH on beef eating quality
7. MSA requirements for handling cattle
8. Preventing dark cutting in livestock- On farm guide, Meat processor guide

Australian Model Codes of Practice for the welfare of animals

1. Land transport of sheep
2. Land transport of cattle
3. Land transport of pigs
4. Livestock at Slaughtering establishments

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Activities



Available on WebCT

Multi-Choice Questions



Submit answers via WebCT

Useful Web Links



Available on WebCT

Assignment Questions



Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCt

Summary

Summary Slides are available on CD

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Glossary of terms

Term	Definition
Farm curfew	A period that livestock are confined on farm without feed and water prior to transport
Lairage	The holding of livestock at abattoirs prior to slaughter.
Glycogen	The principal storage form of glucose in animal cells .
Eating quality	A measure of the acceptability of meat to consumers in terms of tenderness, juiciness, flavour liking of flavour and overall liking
Fasting	No access to food
Water deprivation	No access to water
Ultimate pH	The pH at which chilled meat stabilises once post-mortem glycolysis has ceased.
Dressing percentage	The weight of a carcass divided by the liveweight of the animal prior to slaughter expressed as a percentage
Dark cutting	Meat with an ultimate pH greater than 5.8

