Chapter 10

Feeding silage

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In this chapter

The authors

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The Key Issues

- Planning an efficient feeding system must take account of the farm production goals, number and class of livestock to be fed, location of the silage storage and feedout sites, current facilities and equipment, and the potential for investment in improved silage handling equipment.
- An efficient system must minimise losses caused by aerobic spoilage and wastage at feedout. Feedout losses have a major effect on the success and profitability of silage in a farming system.
- Management of the silage face will have a major impact on aerobic spoilage. Aerobic spoilage can be reduced or eliminated by:
  - removing a minimum of 15-30 cm of silage per day; and
  - minimising disturbance of the silage face, to reduce air penetration.
- Wastage at feedout can range from a negligible amount to >50%. Wastage can be minimised by:
  - using barriers to prevent animals from trampling, camping, defecating or urinating on the silage.
  - feeding regularly and only in quantities that the animals can consume within a short period.
- Feedout management aimed at reducing wastage could be the most important factor affecting silage profitability.
- Accessibility of the silage to livestock may influence intake, and therefore animal production. This may only be important in production feeding situations.

Section 10.0

Introduction

The silage-feeding process is made up of three interlinked operations:

1. Removal of silage from the pit, bunker or stack.
2. Transport of silage to the feeding site.
3. Feeding silage to the animals.

Each activity uses considerable capital and labour resources so it is important that it is done efficiently, minimising feedout losses and with a focus on the feeding cost per tonne of DM fed.

The anaerobic storage stage ends when the sealed silage is opened to begin feeding. Silage is a perishable product and aerobic spoilage begins as soon as it is exposed to air. The first sign of spoilage is heating of the silage.

The rate of spoilage depends on a range of factors, including the speed at which the silage is removed from the silage face, the equipment used to remove silage and operator technique (see Chapter 2, Sections 2.2.3 and 2.5.3). Aerobic spoilage and wastage, during removal from storage and at the feeding site, are the factors determining feedout losses.

Another important issue is the accessibility of the silage to the animals. This may be important in production feeding situations and is likely to be influenced by the type of feedout system used.

Safety first

Silage feedout involves the use of a range of machinery including tractors, shear grabs, mixer wagons and front-end loaders.

Make sure you obtain, read and fully understand any information provided by the manufacturer on the safe operation of the machinery.

There have been a number of serious accidents and fatalities in Australia when people have been feeding out silage and other feeds. Examples of the potential areas of risk with silage feedout systems are:

- Stability of baled silage. Stacks of bales have been known to collapse. Bales have fallen off the trucks and front-end loaders on which they are being transported.
- Mixer wagons pose a particular hazard. Caution is essential when working close to the augers used to mix the silage with other feed ingredients, and to deliver the silage to the animal.
- Tower silos are sealed spaces that can contain trapped gases. Care must be taken when entering these structures.

Seek advice from Workcover, or the relevant State authority, to ensure all feedout equipment and practices are safe and meet recommended guidelines, and that all necessary regulations are complied with.

Section 10.1

Planning a feeding system

As discussed in Chapter 1, long-term management goals and the role for silage on the farm must be clearly defined when planning a silage-feeding system.

It is essential to identify the number of animals that are to be fed, the likely period of feeding and the quantities of silage that need to be handled.

Deciding the type of feedout system is usually, but not always, the first step in the silage planning process. The harvesting and storage systems are then designed around it.

The design of the feedout system is dependent on the scale of silage feeding and the form of the silage. Where large quantities of silage are fed, efficient, high-throughput systems are essential. Small quantities, often fed as a supplement, only require basic facilities.

There are many feeding systems (see Section 10.3) that are often 'customised' to suit the circumstances on individual farms. Common criteria that can be used to assess a system at the individual farm level are:

- cost ($/t DM fed);
- feedout losses; and
- labour use efficiency (labour units/t DM fed).

Feeding costs for the same (or similar) system can vary considerably from farm to farm (see Chapter 11, Section 11.2.8).

Factors influencing the choice of a feeding system

- Cost is the most important consideration. Producers should assess the cost of their current system and investigate options for reducing costs (see Chapter 11). This will provide a firm basis for decisions on investing in new feeding equipment.
- Feedout losses can be due to aerobic spoilage of the silage during feeding and wastage during unloading and during feeding. Losses can vary considerably between feedout systems.
- When costing the various feedout systems, farmers must take into account the difference between the amount of silage fed and the amount actually eaten by the animals.
- The scale of the feeding operation depends on the number of animals to be fed, whether they will be fed large amounts of silage for production feeding purposes or smaller quantities as a supplement, and the time available for feeding. Consider these requirements when determining the need for capital investment.
- Producers may decide to expand the scale of an existing feedout system or change to a new system. Costs can be kept down if existing facilities can be adapted.
- The labour required to feed each tonne of silage DM is an important consideration in many feeding systems, particularly on farms where labour is a limiting resource.
- The most efficient feeding systems are usually those where the feeding site is close to the silage storage.
- Where silage is fed in the paddock, wet weather can result in extensive pugging around the feeding site(s), impair vehicular access, and increase wastage during feedout.
- If access time is at all limited or the silage is difficult for the animal to access, silage intake may suffer. This could be important in a production feeding situation, where high intake is required to sustain high levels of animal production. It will not be as important in maintenance feeding situations, where limited silage is fed.

Section 10.2

Removing silage from storage

Removing silage from storage is the first step in the feedout process. When selecting equipment, producers should not only take into account the cost and efficiency of this operation, but also the impact of management of the silage face on the silage's aerobic stability and wastage. This is particularly important with chopped silage stored in a pit or bunker, but can also be important with baled silage stored in bale stacks.

More specialised equipment is required to remove silage from pits and bunkers while producers feeding out baled silage can often use the same equipment that is used to load the bales into the bale stack at the time of ensiling.

What does it mean?

Aerobic spoilage – the loss of DM and nutrients that occurs during prolonged exposure to air, not only during feedout, but also during storage if the silage is sealed inadequately or the seal is damaged. Heating is the first sign of aerobic spoilage.

Aerobic stability – term given for the time taken for the silage to begin heating on exposure to air.

The stability of the silage after opening will be influenced by the crop type, DM content, silage density, type of fermentation, quantity of residual spores of spoilage organisms present from the initial aerobic phase (e.g. yeasts and moulds), ambient temperature during feeding, rate of feedout and removal technique.

Feedout rate – the speed at which silage is removed from the feeding face, for example, 15-30 cm/day, or the number of days to remove one layer of bales from a bale stack.

10.2.1

Reducing aerobic spoilage

Aerobic spoilage at feedout begins when silage is opened and exposed to air. Losses can be significant under warm Australian conditions, particularly for silages prone to aerobic spoilage, such as maize, sorghum, whole crop cereal or wilted temperate grass silages.

The first obvious sign of this process is heating at the silage face or in the feed trough. The silage's inherent susceptibility to aerobic spoilage, and how quickly it develops, is influenced by both silage characteristics and the conditions prevailing during feedout. The influence of these factors on aerobic spoilage is discussed in Chapter 2 (Sections 2.2.3 and 2.5.3).

If the silage is unstable, aerobic spoilage can significantly increase feedout losses (DM losses can be as high as 30%), lower nutritive value (lower ME and heat damage to protein) and reduce palatability, resulting in a reduction in intake. There are management steps that can eliminate or reduce an aerobic spoilage problem:

- Good management during silage making – including rapid filling, good compaction and effective sealing for bunker or pit silage (see Chapter 2, Section 2.2.1). In baled silage this includes high bale density and rapid and effective sealing.
- Use a silage additive specifically developed to improve silage stability where aerobic spoilage is a potential problem (see Chapter 7, Section 7.7).
- Ensure good silage management during feedout. The two important principles here are a sufficiently high feedout rate, to avoid heating at the silage face, and minimum disturbance of the feeding face, to minimise air penetration.

Feedout rate

The rate of silage feedout determines the time the silage at and near the feeding face is exposed to air. It also determines the extent of aerobic spoilage losses.

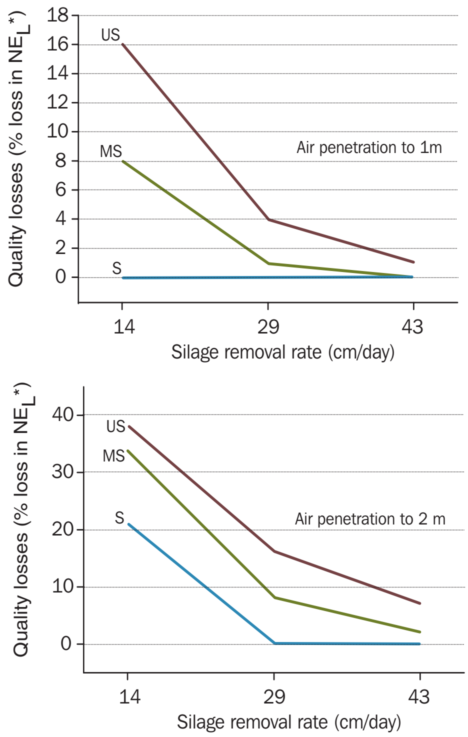
A German study investigated the effects of rate of feedout and silage porosity on the loss of nutrients from silages of varying susceptibility to aerobic spoilage (see Figure 10.1). DM losses and losses in nutritive value (the loss in net energy for lactation, MJ/kg DM in this case) were combined to calculate the total loss in nutrients (%) due to aerobic spoilage. Nutrient losses calculated in this way were 40-70% higher than the DM losses. The silage temperature results for this study are given in Chapter 2 (see Figure 2.10). Both temperature and nutrient losses increased as air penetration increased and when feedout rate was slower.

Where significant heating of the silage occurs, DM and quality losses can be high (see Figures 10.1 and 10.2). In both European and American studies, DM losses of up to 3.5-4.0% per day have been observed. Studies on dairy farms in the United States have confirmed that losses are higher when feedout rate is slow.

With good silage management during filling and removal, a feedout rate of at least 15 cm/day will usually minimise aerobic spoilage losses in bunkers and pits. However, a rate of at least 30 cm/day is recommended with unstable silages, such as maize. This may need to be increased during warmer weather. This higher rate is certainly justified by the results in Figure 10.1.

The surface area of the feeding face required to achieve the target feedout rate can be calculated from the quantity of silage fed per day and the density of silage in the bunker or pit. For baled silage stored in stacks, producer experience indicates that the removal of one layer of bales from

Figure 10.1

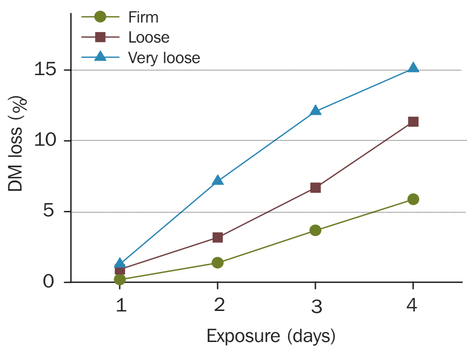


Effects of air penetration and rate of silage removal on nutrient losses from silages varying in aerobic stability, under German conditions.

* NE_L is the net energy available for lactation.
US: Unstable – stable for only 1 day.
MS: Moderate – stable for 3 days.
S: Stable – stable for 7 days.

Source: Honig et al. (1999)

Figure 10.2



Effects of management of the silage face and duration of exposure to air on the DM losses during the feeding of maize silages stored in bunkers.

Source: Roth and Undersander (1995) citing the results of Zublena et al. (1987)

Silage stability and recommended minimum feedout rate for chopped silage.

		Feedout rate (cm/day)
Unstable	Stable for 1 day	>30
Moderately stable	Stable for 3 days	25
Stable	Stable for 5 days	20
Very stable	Stable for >7days	15

Plate 10.1a

Poor management of the silage face. Disturbance of the face and buildup of loose silage at the base of the pit. *Photograph: F. Mickan*

Plate 10.1b

Good management of the silage face. Silage removed cleanly without disturbance. *Photograph: F. Mickan*

the feeding face over two days will usually minimise aerobic spoilage. Calculations that can be used to determine the dimensions of the feeding face are given below.

Disturbance of the silage face

Minimising disturbance of the silage face during feedout will reduce air infiltration into the silage stack and keep aerobic spoilage losses down. The level of disturbance of the silage face is affected by the equipment used to remove the silage and the operator's skill, as well as the type of forage ensiled, its DM content, the chop length and degree of compaction. All these factors affect the handling properties and porosity of the silage.

The results in Figures 10.1 and 10.2 show that aerobic spoilage losses are significantly increased where poor management allows significant air penetration into the silage face. This has been confirmed by on-farm studies in the United States, which have shown that where the silage face was poorly managed and significant loose silage was allowed to accumulate at the floor of the silo, aerobic spoilage and DM losses increased, and silage quality decreased.

Calculating the maximum surface area of the feeding face to minimise aerobic spoilage losses

$$\text{Area of feeding face [width x height, m}^2\text{]} = \frac{\text{Quantity of silage fed per day (kg fresh weight)}}{\text{Silage density (kg/m}^3\text{) x Rate of removal (m/day)}}$$

- ➤ The target rate of removal should be at least 0.15 m/day, rising to at least 0.30 m/day with unstable silages.
- ➤ Silage density is kg fresh silage/m^3. Silage densities can be highly variable, so it is best to use actual densities measured on-farm for the appropriate type of silage. For wilted pasture and maize silages, typical average densities are 575 and 650 kg/m^3, respectively. (Chapter 8, Section 8.3.1, contains an equation to calculate the density of fresh silage.)
- ➤ The calculated result is the maximum area of the silage face that will allow the silage to be fed out at the desired rate. If the area of the feeding face is greater, the feedout rate will be too slow. The appropriate width and height of the silage face can be estimated from the area.

Example: 250 cows are fed 6.5 kg DM/day of a maize silage with a 37% DM content. To minimise aerobic spoilage losses, the desired rate of removal from the whole face is 0.30 m/day. Assumed density is 650 kg fresh silage/m^3.

Silage removed/day (kg fresh weight) = (250 x 6.5) x (100 ÷ 37) = 4,392 kg/day

Required area of feeding face (m^2) = 4,392 ÷ (650 x 0.30) = 22.52 m^2

The area should be no more than 22.52 m^2. If the height of the silage is 2.5 m, the maximum width of the bunker would be: 22.52 m^2 ÷ 2.5m = 9.0 m.

The best implements for removing silage – including shear grabs, block cutters or similar machinery – leave a firm face and minimise wastage. A front-end loader with bucket can remove silage with minimum disturbance of the face if it is operated carefully. Use the edge of the bucket to pull the silage down the face. The silage can then be scooped from the floor and loaded into the feedout wagon or cart. A variation of this procedure is to first remove a section at the base of the face, then pull down sections above it, making it easier to scoop up and load silage from the floor of the silo.

Although it is tempting to drive the bucket into the silage face and lift up to remove the silage, it is not advisable. This action opens fissures in the silage face and allows a large amount of silage to loosen. This, in turn, allows air to penetrate deep into the silage face.

Aerobic spoilage after the silage has been removed from storage

Moderately unstable silage may not heat while it remains in storage during the feedout period, but may heat once removed from storage. This situation often arises where silages are processed before feeding. Processing by machines such as mixer wagons, feedout carts or bale choppers usually results in significant aeration of the silage.

While good management during silo filling and during removal of the silage from storage, and more frequent feeding will help alleviate this problem, unstable silages can still heat in the feed trough or feeder. In these circumstances, silage additives applied at the time of ensiling and designed to inhibit aerobic spoilage can be useful (see Chapter 7, Section 7.7). Additives can also be added at the time of feeding to overcome an aerobic spoilage (as in the study shown in Table 10.1).

Although this strategy was successful in this example, it needs further evaluation. Applying an aerobic deterioration inhibitor at the time of ensiling would be a more practical approach.

Management of plastic cover

When feeding silage from a bunker or pit, or from a stack of baled silage, the plastic top cover should be rolled back just far enough to expose an area that will meet the silage requirements for the next 2-3 days. The rest of the top cover should remain firmly anchored to the top surface of the silage.

Under most circumstances, it is recommended that the top cover should be pulled back over the exposed face after removing each day's silage requirement.

It has been argued that this can create a hot, humid microenvironment between the top cover and the silage face during warm weather, and that this may increase aerobic spoilage in some silages. In these circumstances, it may be better to leave the face exposed, unless a strong wind is blowing directly into the face. There are insufficient research results to resolve this issue.

Resealing will be necessary if feeding is stopped. It is important to trim back the face so that it sufficiently even to maintain good contact between the plastic cover and the silage face. Effective sealing is essential to minimise losses.

Table 10.1

*Effect of a sulphite additive applied at the time of feeding on aerobic stability and milk production from a total mixed ration (TMR).**

	Untreated	Treated
Silage temperature (° C)	22.2	13.0
DM intake (kg/day)	20.4	21.4
Milk production (kg/day)	26.9	28.0
Milk protein content (%)	3.56	3.68
Milk fat content (%)	4.56	4.83

* *TMR (DM basis): maize silage 50%, grass silage 13%, cracked wheat 21%, molasses 5%, concentrates 21%.*

Source: R.H. Phipps (personal communication)

10.2.2

Equipment for removing silage from bunkers or pits

Tractors with hydraulically powered front-end loaders are commonly used to empty pits/bunkers. Attachments vary in complexity from a fork with a set of horizontal tynes that are forced into the heap and raised to tear out the silage, through to loaders with some form of cutting mechanism (e.g. shear grab or block cutter).

Front-end loaders fitted with a fork or bucket tend to leave a disturbed silage face, and require careful operation to minimise air penetration. Table 10.2 gives the results of a comparison of alternative equipment for removing a lucerne/pasture silage (30-150 mm chop length) from a silage pit with face dimensions of 12 m wide by 2.5 m high. This study confirmed that estimated losses were lower with the equipment that cut silage from the face, and left it relatively undisturbed. Further studies, covering a range of silages and weather conditions, are required to more accurately quantify losses for various silage removal methods.

Tractor-mounted shear grabs and block cutters are efficient implements for removing silage and leave a relatively undisturbed face. Shear grabs are the cheaper option and provide satisfactory work rates, influenced by the grab's capacity and the distance from the stack to the feeding site (see Figure 10.3).

Block cutters can be front- or rear-mounted. They have a set of tynes that are driven into the silage and knives, either reciprocating or on a continuous chain, cut vertically down the surface removing a block of silage.

The weight of the block removed varies from 300 to 1000 kg, depending on the type of machine used. Some block cutters have guards to prevent the silage from spilling in transit, while others have clamps that hold the block firmly to the

Plate 10.2

A tractor-mounted shear grab, used correctly, will leave the silage face relatively undisturbed.

Photograph: D. Stanley

Table 10.2

A comparison of alternative tractor-mounted equipment for removing lucerne/pasture silage from a silage pit.

	Bucket	Silage grab	Shear grab	Block cutter (horizontal)	Block cutter (vertical)
Capacity (m³)	0.4	0.6	0.95	2.5	1.5
Attachment*	F	F	F	T	T
Maximum operational height (m)	4	4	4	3	2.3
Operation time (seconds for each load)	10	10	15	90	90
Face condition	loose & uneven	loose & uneven	uneven	firm & even	firm & even
Estimated losses, aerobic spoilage + wastage (%)	10-20	10-15	0-5	0	0
Temperature 15 cm behind the face after 6 days (°C)**	38	38	17-38	14	14
Approximate price (1994)	$1,200	$2,700	$5,700	$13,000	$11,800

** F = front-end loader; T = three point linkage.*

*** Ambient temperature 14°C.*

Source: Anon (1994)

tynes. Because the blocks are, in effect, an undisturbed part of the stack, air penetration is minimal and the block tends to remain aerobically stable well into feedout.

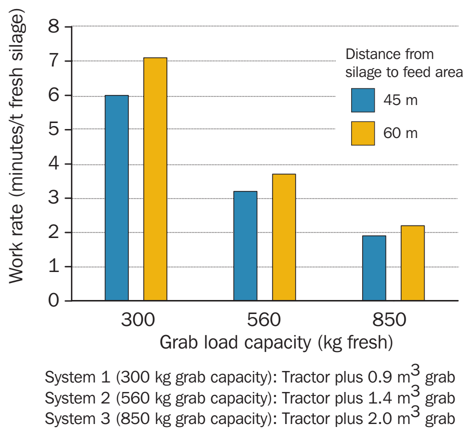
More sophisticated pit/bunker unloaders, with rotating cutters, are available for operations that handle large quantities of silage. The silage is transferred into a wagon or truck for feedout.

A rotating drum cutter is a common design, which has a rotating drum, about 30 cm in diameter, fitted with small knives (see Plate 10.3). The drum is carried on a boom attached to a tractor. The drum can swing in an arc up and down the face, the silage falls onto a conveyor belt and is delivered into a wagon or truck. This type of unit shaves the silage off the face, leaving it relatively undisturbed. Care must be taken to ensure the unloader is moved sideways regularly so the silage face does not become irregular.

The Australian market for silage-handling equipment is expanding rapidly as the amount of silage produced increases. Producers intending to buy equipment should seek information on the machinery that is available, and the work rates of various machines, from machinery dealers.

Any capital investment in equipment and facilities should be based on sound business principles, i.e. careful consideration of the costs and benefits.

Figure 10.3



Effect of shear grab capacity and distance from the silage to feedout on work rates.

Source: Forristal (2000)

Plate 10.3

Maize silage being removed from a bunker using a rotating drum cutter.

Photograph: N. Griffiths

Section 10.3

Delivering silage to the animal

10.3.1

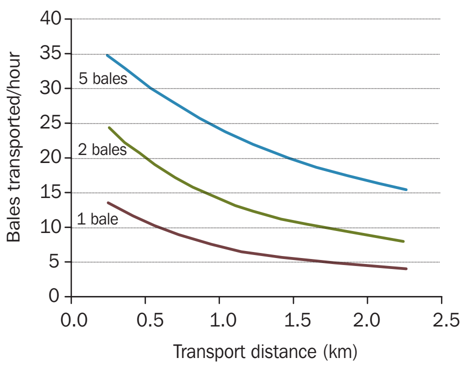
Feedout systems available

Feedout systems can be very basic and low cost, from self-feeding from a pit (with no transport component), feeding whole bales in the paddock, through to expensive integrated systems used on large feedlots or dairy enterprises.

Advantages and disadvantages of the more common feeding options are presented on pages 265 to 267.

Figure 10.4

Difference in number of bales transported per hour either by tractor (1 or 2 bales) or trailer (5 bales) for a range of distances.



Source: Adapted from Forristal (2000)

Transporting the silage to the animals

Baled silage

Baled silage is usually removed from the storage site using forks or a spike mounted on the front of a tractor (front-end loader) or to the three-point linkage. One or two round bales can be carried at any time with these attachments. If there is a reasonable distance between storage and feedout, using a truck or trailer to increase the number of bales carried will substantially improve the work rate. This will save time, particularly when a large number of bales need to be fed, in several paddocks.

The relatively large farm sizes in Australia make efficient delivery systems essential, particularly if silage is being fed to several groups of animals.

An Irish study compared transporting one or two bales with a tractor or five bales on a self-loading trailer to find the number of bales that could be transported in an hour. Figure 10.4 shows the work rate benefit from the increased transport capacity and

Comparing Feeding Systems

Feeding system	Capital investment*	Labour efficiency*	Feeding losses	Accessibility to the animal
Chopped silage in a pit or bunker:				
A1. Self-feeding	Low	High	High	Restricted
A2. Fed on the ground in a paddock	Medium	Medium	High	Easy
A3. Fed on the ground under an electric wire	Medium	Medium	Medium	Easy
A4. Fed in a paddock in a trough, self-feeder or off trailer	Medium	Medium	Low/medium	Easy
A5. Fed in a specialised feeding area (feedlot, feed pad)	High	High	Low	Easy
Baled silage:				
B1. Fed out as a whole bale on the ground in a paddock	Low	Low	High	Restricted
B2. Unrolled or fed as biscuits on the ground in a paddock	Low/medium	Low	High	Easy
B3. Chopped and fed out on the ground in a paddock	Medium	Medium	High	Easy
B4. As for B2 but under an electric wire	Low/medium	Low	Medium	Easy
B5. As for B3 but under an electric wire	Medium	Medium	Medium	Easy
B6. Whole bale fed in the paddock in a self-feeder or off a trailer	Medium	Low	Medium/low	Restricted
B7. Chopped and fed out as for B6	Medium/high	Medium	Low/medium	Easy
B8. Chopped and fed out in a specialised feeding area (feedlot, feed pad)	High	High	Low	Easy
B9. Whole bale fed out on a feed pad	High	Medium	Low/medium	Restricted

* *Within a system, differences in the equipment used, the numbers of animals fed and the distance travelled will influence the ratings for capital investment and labour efficiency (labour units/t DM fed).*

For more detailed information on various feeding options, see pages 13-15.

the penalties associated with increasing transporting distance. While trucks and trailers can be used to efficiently transport bales, they have the disadvantage that separate equipment is needed to feed out the bales once they are delivered to the feed site.

There is equipment available that is specifically designed to chop round and square bales at the time of feedout. The chopped silage is then delivered into a windrow, trough, pad or bale feeder.

The advantage of this system is the reduced particle length and increased accessibility (feeding space). Chopping aims to increase animal production by increasing intake. However, because the chop length is still relatively long (similar to that produced by a forage wagon) any advantage is likely to be greater for cattle than for sheep. Any improvement in sheep production will probably be due to increased accessibility. The effect of chop length on sheep intake and production is discussed in Chapter 15, Section 15.2.5.

Anecdotal evidence from studies at Cowra, NSW, suggests that baled silage, chopped just before feeding may be less aerobically stable than unchopped bales or fine chop silage produced from the same material. The most likely reason is the increased rate of aerobic spoilage caused by vigorous aeration of the silage during chopping. More details on factors affecting aerobic stability are covered in Chapter 2, Section 2.2.3, and Section 10.2.1.

Chopped silage

Silage removed with a shear grab or block cutter holds together as a block and it can either be fed out whole, similar to a large square bale, or fed out through a mixer wagon or forage wagon.

Forage wagons or feed carts are used for feeding out chopped silage. They have moving floors and convey the forage to one end where the silage can then be fed out in a windrow or into a trough through a side delivery chute. They are not designed for feeding mixed rations.

Feed mixer wagons are used when mixed forage-based diets are fed. There are essentially two designs:

- horizontal mixer wagons – these are usually V-shaped and have three or four augers running the length of the body in banks of one or two, and
- vertical mixer wagons – usually conical shaped with a single auger.

Plate 10.4

Forage wagon used for feedout. Photograph: K. Kerr

Plate 10.5

Mixer wagon being loaded by a front-end loader. Photograph: M. Martin

Mixer wagons vary in capacity and handle chopped silage from pits, bunkers and tower silos. They can be mounted on either a tractor-drawn trailer or a truck. Some models contain a series of blades along one or more of the augers that are capable of chopping baled silage and hay. The augers mix the roughage with the other feed ingredients, usually concentrates. Mixer wagons can be fitted with load cells so that the correct quantity of different feeds can be monitored. The silage or mixed ration is then delivered into a trough or windrow.

In highly mechanised and intensive feeding systems, the transport of silage from the storage to troughs or feedbunks can be fully mechanised. A series of augers transport the silage or mixed ration, unloading at the appropriate location. These systems combine well with tower silos where the silage is mechanically removed from the bottom of the silo.

Plate 10.6

Internal auger system of a mixer wagon. *Photograph: M. Martin*

Feeding options

There are a number of ways that baled and chopped silage can be presented to the animals. In many cases, the feeding option is only limited by the imagination of the producer and available material. The advantages, disadvantages and management strategies for a range of feeding options are given on the following pages.

Self-feeding from the silage face

Plate 10.7

Cows feeding from the silage face, with electric wire limiting access.

Photograph: F. Mickan

Suitable for chopped pit and bunker silage. Not recommended for baled silage because wastage is high.

Requires a barrier or electric wire to keep animals off the silage.

Pros

- No machinery or labour required to remove the silage from the pit or bunker and deliver it to the animals.
- Low capital cost to construct barrier.

Cons

- Number of animals that can feed is limited by face width.
- Wastage can be high in wet weather, unless the floor is made of concrete and well sloped.
- Floor needs to be scraped clean regularly to remove faeces and waste silage.
- Barrier needs to be moved regularly to ensure continuous access.
- Depth (height) of the silage face needs to be restricted to suit animal type.
- It can be difficult for stock to extract long silage particles, particularly if it is very well compacted.

Management tips

- Most suitable when the chop length is uniform and about 50 mm or less.
- Silage should not be more than 1.5 times the height of the animal so the silage is not eaten out underneath, collapsing onto animals and the barrier.
  The major risk is that collapsing silage can kill smaller livestock, in particular sheep. Face depth should be no more than about 2 m high for mature cattle, 1.5 m for weaner cattle and 1.2 m for grown sheep. With deeper bunkers, the silage can be cut out and thrown to the stock but this is very labour intensive.
- If the silage is very densely compacted the animals will have difficulty removing the silage. The silage will be more tightly packed at the bottom of the face.
- Fences need to be secure to ensure that animals cannot get on top of the pit and damage the plastic.
- Regularly clean the floor of the bunker at the silage face to minimise ‘bogging’ and wastage.

Self-feeding from flat-top trailer

Plate 10.8

Cows feeding from flat-top trailers.

Photograph: A. Kaiser

Can be used for chopped and baled silage. Trailer design will vary with silage type and the class of livestock to be fed.

Pros

- Trailers are relatively inexpensive to construct and maintain.
- Able to transport silage in bulk for several groups of animals, simply hook up the trailers and drop them off into the appropriate paddocks.
- Can move feedout point regularly to reduce damage to surrounding pasture/soil.
- Can be used for pit or baled silage.

Cons

- Tall or wide trailers are unsuitable for smaller stock, such as sheep.

Management tips

- Trailer size needs to vary to reflect animal sizes.
- Accessibility will depend on the number of trailers.
- Monitor silage wastage, ensuring animals do not drag much from the trailer. It may be necessary to install feeding barriers to minimise wastage.

Windrow on ground in paddock

Plate 10.9

Square baled silage being chopped and trailed out in a windrow.

Photograph: J. Piltz

Suitable for fine chop and chopped bale silage, round bale silage that has been unrolled, or square bale silage fed in biscuits.

Pros

- Requires no expenditure on feed troughs or pads.
- Feeding sites are well-distributed – little damage to pastures/soil.
- Good accessibility.

Cons

- Will need specialised equipment to make a silage windrow.
- Wastage can be very high if animals trample, camp, urinate and defecate on the silage.
- Uneaten silage will be contaminated by soil, particularly in wet weather.

Management tips

- Running a single or double electric wire along the top of the windrow can reduce wastage due to trampling and fouling.
- Avoid overfeeding to reduce wastage. It is better to feed less silage more frequently.

Bale silage fed whole in the paddock

Plate 10.10

Baled silage fed whole in the paddock – low cost, high wastage.

Photograph: K. Kerr

Suitable for round and large square bales.

Pros

- Little capital cost.
- Feedout location can be varied to reduce pugging and damage to surrounding pasture.

Cons

- Wastage is high due to camping, trampling and fouling by animals. Under most circumstances this method of feeding will result in the greatest amount of wastage.
- Competition for access may limit intake.

Management tips

- Avoid overfeeding to reduce wastage. It is better to feed less silage more frequently. This is sometimes a compromise between providing enough bales to allow reasonable access for a number of animals – may need to provide 2-3 days silage at a time to ensure intake is not limited. Silage may then become unstable (heat) over time, increasing wastage and reducing intake.

Bale silage fed whole in a feeder

Plate 10.11

A bale feeder will reduce the amount of wastage caused by trampling and fouling.

Photograph: R. Inglis

Suitable for round and large square bales, and chopped silage.

Pros

- Very small capital cost.
- Eliminate wastage due to trampling and fouling by animals.
- Feedout location can be varied to reduce pugging and damage to surrounding pasture.

Cons

- Competition for access may limit intake.

Management tips

- Will require different feeders for different classes of livestock – sheep are unable to use some feeders designed for cattle, and weaner cattle may not be able to reach the centre of the bale. With sheep a circle of mesh may be a better option – as the bale is eaten, the sheep can push the circle of mesh around to get at the remaining silage.

Feed trough

Plate 10.12

Feed troughs should be deep enough to avoid spillage. *Photograph: J. Piltz*

Appropriate for fine chop or chopped bale silage. Can vary from inexpensive homemade troughs to permanent concrete feed bunks.

Pros

- Reduces wastage during feedout because – the silage is kept off the ground, preventing contamination by dust and mud, and – animals are not able to trample, urinate or defecate on the silage unless they stand or jump in the trough.
- Suitable for a range of feeds – silage and mixed rations (including dry rations).
- Portable units can be moved to reduce paddock damage.

Cons

- Any aerobically spoiled or uneaten silage must be cleaned out to prevent contamination of fresh silage.
- May need expensive equipment to deliver silage to the trough.

Management tips

- Avoid overfeeding to reduce the need to clean out troughs.
- A bar or cable over the top of the trough will prevent animals from standing in the silage.
- Permanent troughs are more common on dairy farms, feedlots and some beef properties. They should be located near the silage storage site to reduce transport time and must be easily accessed by machinery for feeding and cleaning surrounding area.

Feed pads

Plate 10.13

Feed pads are permanent feeding stations commonly used on dairy farms. *Photograph: M. Martin*

Permanent feeding stations, usually associated with dairy farms and beef feedlots. Feed pads can vary enormously in cost of construction, depending on size, roofing, etc. May be used for feeding for a limited time (e.g. after milking) or allow access throughout the day.

Pros

- Reduces wastage during feedout because
  – the silage is kept off the ground, preventing contamination by dust and mud, and
  – animals are not able to trample, urinate or defecate on the silage.
- Suitable for a range of feeds – silage and mixed rations.
- Allows cattle to be fed in a relatively clean environment, irrespective of weather conditions.

Cons

- Any aerobically spoiled or uneaten silage needs to be cleaned out to prevent contamination of fresh silage.
- Expensive to construct.
- Requires expensive equipment to deliver silage to the pads.

Management tips

- Avoid overfeeding to reduce the need to clean pads.
- A physical barrier, usually an iron bar or cable, is used to keep cattle from getting into the feed.
- Feed pads should be centrally located, e.g. next to the dairy and the silage storage site, to reduce feeding time.
- Should be designed to allow for easy machinery access at feeding and for cleaning surrounding area.

10.3.2 Accessibility

Accessibility refers to how easily the silage can be reached or approached (available feeding space) as well as how easily it can be removed and eaten (depends on the physical form of the feed).

In most Australian systems, silage will be fed either as a supplement to pasture or as part of a ration in a full feeding situation, such as a feedlot. It may be fed separately or mixed with other feeds such as grain.

Animal production is usually highest when DM intake (consumption) is not limited by the amount of feed provided or by the animal's ability to access that feed. Depending on the production system, most producers will want to maximise an animal's silage intake over a day or achieve a target intake within a set period. The two major factors that can restrict silage intake are:

- the ability of the animal to physically access the feed; and
- the physical form of the feed.

Factors affecting animals' space requirements at the silage

Animal factors that affect space requirements at the silage are:

- Type of animal.
- Pregnancy or lactation status.
- Age and size.
- Dominance ranking or hierarchy within the herd.

Management factors that affect space requirements are:

- Amount of time that the animals have to access the silage. Restricting time will effectively reduce the space available for each animal.
- Quantity of silage available – fed *ad lib* or as supplement.
- When fed as a supplement, usually to grazed pasture, the quantity and quality of other feed available will influence an animal's requirement for silage.
- Accessibility – baled or loose; long or short chop.

There is little information available on how various feedout systems and the physical form of the silage affect accessibility. In a number of cases the information is for hay, but the principles should be similar even if the expected level of production is different. Species (sheep versus cattle), age, stage of lactation and quality of the silage are also likely to affect accessibility.

Physical access to the silage

Physical access refers to the space available for the animals to position themselves to consume the feed offered (in this case silage or diets containing silage). In the simplest terms, the greatest access is when an animal can stand and feed from a trough, windrow or bale, *when they want to and without any disruption*. This depends on available space per animal.

Space available for each animal is calculated by dividing the length of windrow or feed trough, or the circumference of a bale, by the number of animals (see Example 1 on the next page). If there is a barrier, which is divided into sections, between the silage and the animal, the number of sections and the size of the animal will determine how many animals can feed at any one time (see Example 2).

Ad lib feeding is when animals have continuous access to silage throughout the day. The number of animals eating at any one time under *ad lib* feeding systems is usually 20-40%. The animals rest and ruminate for the remainder of the day.

Using horizontal barriers with sheep can reduce backjumping and aggressive behaviour compared to vertical divisions (tombstone barrier type). The horizontal barriers allow the sheep to move sideways to accommodate other animals.

Guidelines for feeding space needed for animals to access silage from a pit or feed trough

Dairy cows

- *Ad lib* feeding – 24 hr access – 15-23 cm per cow.
- Limited access (controlled feeding) – 30-45 cm per cow when access is restricted to a period after milking. Can increase to 80 cm per cow if all animals are to be fed at once.

Beef cattle

- *Ad lib* feeding – 24 hour access – 15 cm for young stock, increasing to 20 cm for mature cattle. May need to be increased where silage or a mixed silage diet forms more than 75% of the ration. The space allocation may need to be increased, even doubled, for these animals when being introduced to this type of feeding regime.
- Limited access (controlled feeding) – 25-40 cm for young animals, increasing to 30-50 cm for mature stock.

Sheep

- 9 to 11 cm per mature sheep for *ad lib* feeding.
- Increase to 15 cm for lambs or pregnant ewes.

Note: There are so many variables that affect accessibility, it is impossible to make blanket recommendations.

Example 1: Calculating available space per animal

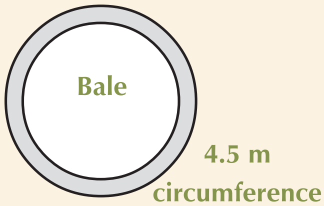
Assuming 25 steers have access to the silage:

Trough or windrow (feeding from 1 side)

6 m row ÷ 25 steers ≈ 0.25 m per steer (25 cm per steer)

Trough or windrow (feeding from 2 sides)

6 m row x 2 ÷ 25 steers ≈ 0.5 m per steer (50 cm per steer)

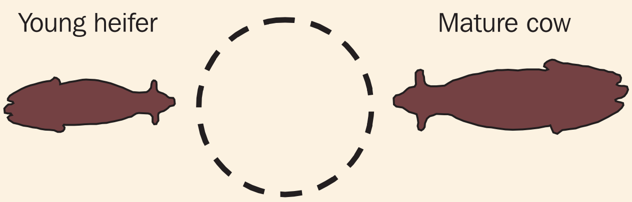


Round bale (access all around bale)

4.5 m circumference ÷ 25 steers = 0.18 m per steer (18 cm per steer)

Note: The total number of feeding positions that are available on a round bale ring feeder will determine the available access space.

Example 2: Calculating the number of animals that can consume silage at the same time, when the barrier is divided into sections.



Round bale ring feeder with spaces for 14 animals.

Young heifer: Room for one heifer per feeding spot – can fit 14 heifers at one time

Mature cow: Only room for one cow every two places – can fit only 5 to 6 cows

Where cattle are allowed to self-feed from the silage face, an electric wire can be used to prevent animals trampling the silage. They are not as cumbersome to move as solid barriers. However, in order to maintain high intakes, animals must be able to reach the silage without making contact with the wire. This may mean moving the wire more than once daily, which may not be practical.

A barrier must also take account of access by horned sheep or cattle, and the risk of animals being trapped.

Four studies of dairy heifers in the UK showed that restricting access to maize silage directly reduced intake (see Figure 10.5). In these experiments, heifers self-fed from the silage face with either a tombstone barrier or electric wire used to control wastage.

The different restrictions in access were achieved by either limiting the time the heifers were allowed to feed or limiting available space for each animal. (Limiting space effectively limits time available for each animal to feed.) Behavioural interactions between the heifers were observed in two of the studies.

The following observations were made:

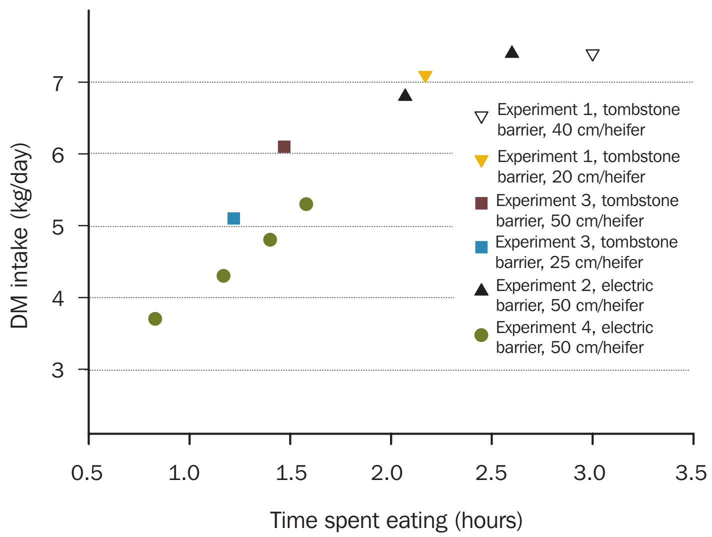
- Reducing access time reduced the amount of time individual heifers spent eating.
- Reducing time spent eating reduced DM intake.
- Heifers increased the rate at which they ate when access to the silage was reduced. Therefore the drop in DM intake was not proportional to the reduction in time spent eating.
- Dominant (top-ranked) heifers ate 11% more silage than bottom-ranked heifers, even though bottom-ranked heifers spent more time at the silage face.
- Bottom-ranked heifers had less visits to the silage, but these were longer, and they consumed silage more slowly.

Physical form of the feed

Physical form refers to the way the silage is delivered (loose or in a bale) as well as the length of the silage (long versus short chopped). The potential impact of chop length on animal production is covered in Chapters 13, 14 and 15. The various physical forms in which silage is delivered to animals are shown in Figure 10.6.

Figure 10.5

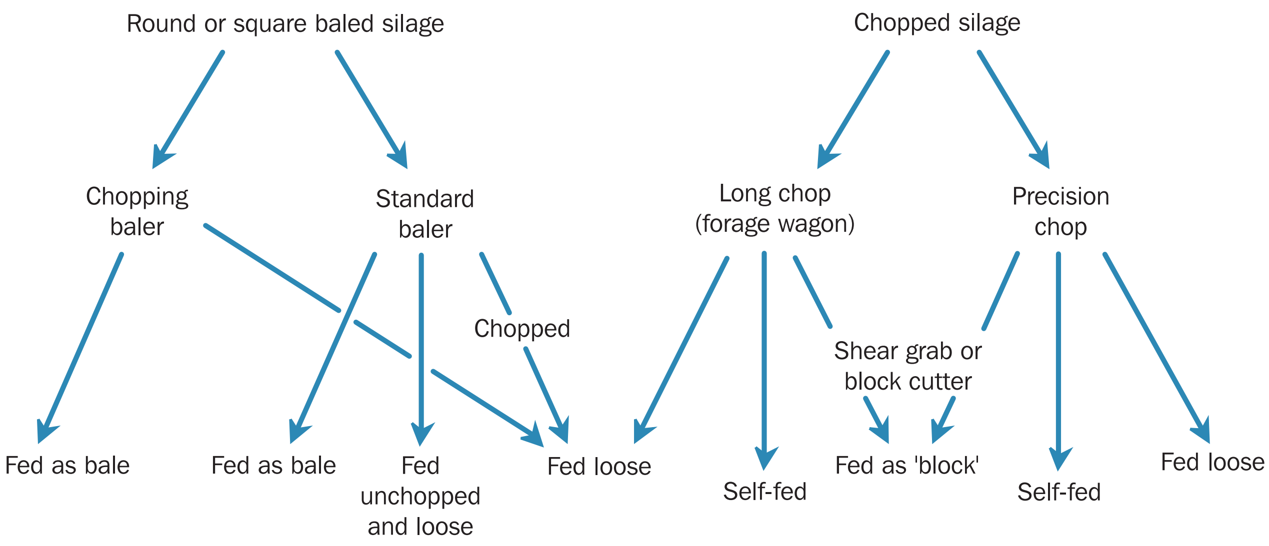
Effect of time spent eating on DM intake of maize silage by heifers self-feeding from the silage face, using either tombstone barriers or electric wire. Heifers also received 0.9 kg of a 18% crude protein supplement.



Source: Adapted from Leaver and Yarrow (1977); Dominance effects reported in Leaver and Yarrow (1980)

Figure 10.6

Various forms in which silage may be presented to animals.



The relative intakes and potential animal production of the various systems, for silage produced in Australia, is not known.

The two extreme forms, in terms of ease of access, are likely to be:

- baled silage made without chopping; and
- fine chop silage fed in a trough.

Long chopped forage and chopped bales are essentially the same physical form and likely to support the same level of animal production. Intake of the silage made with a chopping baler may be higher than the unchopped bale because animals are able to remove the material from the bale more easily.

In a study of dairy cows and heifers in Queensland, soybean silage was fed in a round bale ring feeder either as whole bales or after chopping to 15 cm using a bale chopper. As Table 10.3 shows, the cows receiving the chopped silage consumed more, although the difference was not statistically significant. Several overseas studies have shown improved intakes when silage is available in an 'easy-feed' system. An easy-feed system is one where the silage is in the loose form.

Table 10.3

Effect of chopping baled soybean silage before feeding on the intake of silage by dairy cows.

Treatment	Silage DM content (%)	Stem length (cm)	Proportion rejected (%)	Silage intake (kg DM/day)
Unchopped	47	56	20	9.6
Chopped	52	14	14	12.5

Source: Ehrlich and Casey (1998)

Table 10.4

Intake and change in body condition score of pregnant mature ewes and hoggets fed baled or double-chop silage.

Source: Grennan (2000)

	Baled silage		Double chop silage	
	DM intake (g/day)	Condition score change	DM intake (g/day)	Condition score change
Mature ewes	1,051	-0.22	904	-0.45
Hoggets	882	-0.06	684	-0.42

It is possible that even when good-quality, baled silage is fed *ad lib*, in self-feeders, growth rates may be disappointing due to low intake as a result of:

- competition for space; and
- animals having to work harder, compared to loose silage, to remove the silage from the bale.

The impact of competition for space is likely to be greater for bale feeding compared to loose silage because animals are less able to adjust feeding time or eating rate. Research is required to clarify this.

In a number of overseas studies, the production from sheep fed long chopped silage has been inferior to that of sheep fed short chopped silage. In these studies, the silages were fed loosely, in feed troughs, and intake of the shorter chopped silage was higher. As a result, the general recommendation has been to provide short material to sheep (and young cattle) to improve intake and production.

In studies at Cowra, NSW, the growth rate of lambs fed round bale silage was the same as when fed precision chopped silage, produced from the same forage (see Chapter 15, Section 15.2.5).

The results seen at Cowra need follow-up research to understand why the response was different to the overseas experiences. Some possible explanations include:

- Sheep are able to 'graze' bales, in a manner similar to pasture and they are able to reduce the length of the silage as it is bitten off.
- Sheep are able to selectively 'graze' the higher quality leaf fraction of baled silage. Selection is more difficult with very finely chopped silage.

This conjecture is supported by a five-year study in Ireland, shown in Table 10.4, where pregnant mature ewes and hoggets were fed either baled or double-chopped silage. Double-chopped silage still has relatively long particles, longer than precision-chopped silage. The baled silage supported higher growth rates and better animal production than the double-chopped silage.

Further research is needed on the impact of access and the form in which silage is delivered to the animal.

10.3.3

Wastage

There is very little information available to quantify feedout losses (wastage) under different practices; most that is available relates to hay. Wastage at feedout can be due to:

- aerobic spoilage;
- wastage due to animals trampling, camping, urinating or defecating on the silage; and
- silage which the animals refuse to eat.

Losses caused by aerobic spoilage are discussed in Section 10.2. Aerobic spoilage during feedout may have begun at the storage site. Silages that have started to heat before feedout will be less stable and need to be fed regularly to avoid wastage due to increasing unpalatability.

Baled silage

Losses are likely to be greatest with baled silage. Bales are usually consumed over two or more days. The longer bales are left uneaten, the greater the losses due to trampling, fouling and aerobic spoilage. The longer fibre in the bales means that more material is dropped and remains uneaten. This is subsequently trampled and spoilt. In wet weather, losses increase when the silage becomes caked in mud and it is more easily trampled into the ground.

In a Western Australian study of weaner steers and heifers grazing dry, low-quality summer pastures, the animals were supplemented with hay, fed either on the ground or in a ring feeder. A visual assessment of the amount of waste hay was 15% for that fed on the ground compared to 5% in a ring feeder. Table 10.5 gives the hay consumption and liveweight responses in this study. The total amount of hay offered was 16% less for the ring feeder, which suggests that the animals with access to hay in a ring feeder actually consumed 6% less hay.

Plate 10.14

Excessive wastage will occur if stock are allowed unrestricted access to whole bales fed in the paddock.

Photograph: K. Kerr

Table 10.5

Effect of supplement type and method of feeding on cattle production.

	Hay (on ground)	Hay ('Waste-not' ring feeder)
Number of animals	34	31
Final liveweight (kg)	283	301
Liveweight gain (kg)	38.5	57.4
Supplement (kg/head)	350	295
Supplement costs ($/head)	35.00	29.50
Costs/gain (¢/kg liveweight gain)	91	51

Source: Tudor et al. (1994)

Table 10.6

Wastage and intake of hay fed to beef cows either in racks or on the ground.

Source: Adapted from Parsons et al. (1978)

	Hay fed in racks	Hay fed on the ground			
Amount of hay offered per cow at each feeding (kg)	–	9	18	36	72
Wastage (%)	4.7	10.9	24.9	31.0	34.3
Relative amount of hay fed (%)	100	112	133	145	152

The hay fed in a feeder produced high liveweight responses. When the increased gain and the lower supplement costs are considered, there was a substantial economic advantage in using the feeder. Losses due to trampling also increased substantially after rain for the hay fed on the ground, but not the hay fed in a feeder.

Plate 10.15

Electric wires will reduce wastage when silage is fed onto the ground in windrows.

Photograph: A. Kaiser

In a study in the United States, round bale hay was fed to beef cows either in hay racks or on the ground. The cows fed on the ground were offered 9, 18, 36 or 72 kg at each feed. Additional hay was provided once the cows had consumed all of the available hay that they would eat. The rejected hay was wasted. As Table 10.6 shows, wastage was less for hay fed in racks. When hay was fed on the ground the level of wastage increased with the amount of hay fed at each time.

Although these studies were not conducted with silage, the message is quite clear and likely to be directly applicable to baled silage systems.

Chopped silage

There have been no studies quantifying the levels of wastage Australian producers are likely to experience when feeding chopped silage. Much of the chopped silage fed overseas is to sheep and cattle that are housed indoors. In these situations, the silage is presented to the animals either in a trough or on a feed pad. The animals are kept separate from the silage to prevent trampling and contamination from faeces and urine. Silage is fed at regular intervals and the amount offered can be accurately controlled to ensure all the silage is consumed before the next feeding. In these systems, wastage should be negligible, and consist mainly of mouldy pieces that animals will not eat.

When silage is fed outdoors, which is usually the case in Australia, wastage would be higher, particularly if fed on the ground and animals are allowed to trample and camp on it. The factors that influence the level of waste are likely to be the same as for baled silage, although the levels of wastage may differ. Management considerations to reduce wastage include:

- Prevent animals trampling and camping, and defecating and urinating on the silage.
- Quantity and regularity of feeding:

  – When silage is fed loose, on the ground and unprotected from trampling and fouling, wastage will be greater if more silage is provided than can be consumed in a short time. Wastage will increase as feeding interval increases, for example, when more than one day's silage ration is provided at a time.

  – If the silage is aerobically unstable, wastage will increase when silage is not provided fresh at regular intervals, due to spoilage and increasing unpalatability.
- Wastage increases in wet weather if silage is fed on the ground and as a result of water-logging if it is fed in undrained troughs.
- If the silage is aerobically unstable spoilage increases with ambient temperature.

The potential wastage during feedout of silage can range from almost negligible amounts for well-managed systems, using troughs or feed pads, through to >50% for silage fed on the ground in poorly managed systems. The results of the New Zealand study in Table 10.7 clearly demonstrated this. When pasture silage was fed in troughs, wastage was 6%, compared to 23% when fed on the ground.

Further research is needed to quantify actual losses for a range of systems under Australian conditions. Improved feedout management to reduce wastage will significantly affect the profitability of silage feeding.

Table 10.7

Effect of feedout system on the wastage (% DM) of pasture silage offered to dairy cows.

Silage fed on the ground (in paddock)	Silage fed in a trough (in a yard)
23.0	6.1

Source: Wallace and Parker (1966)