Use of ensiled forages in large scale animal production systems

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Summary

Incorporating silage into large scale feeding systems is often a matter of reallocating resources, rather than introducing totally new resources, and it is consistently more difficult to show a profit from reallocating resources than from introducing new ones. It is therefore imperative that the purpose of incorporating silage be clear. These purposes are defined as, drought feeding, production increases, an aid to pasture or crop management, utilisation of excess growth, balancing nutrients in the diet, and the storage of wet feed products. A general financial model is proposed for assessing the financial benefits of incorporating silage.

It is concluded that silage is most likely to be profitable when used to increase productivity or balance nutrient content of the diet. Special purpose crops such as maize and legumes will normally be used in these roles, and their use in the feeding program will be integrated with other demands on modern production systems, such as quality assurance and sustainability.

Introduction

Large scale and intensive systems of ruminant production are relatively new to tropical and subtropical zones. Though traditional systems of feeding were often intensive, utilising hand harvested forages and crop by-products; it is only recently that herds are being aggregated together in large-scale production units. This has been made possible by improvements in pasture and forage crop technology, or the availability of crop by-products from centralised processing facilities.

Silage has played an uneven role is these developments. There has been a tendency to equate the role of silage in these systems with that in temperate zones, and consequently much of the attention has been on the harvesting and storage of excess growth in the growing season for subsequent feeding during the dry season. The results of this practice have generally been disappointing. More recently attention has focused on the ensiling of special purpose crops, using these to increase productivity of the land, and this approach shows more promise. Ensiling has also been a convenient way of storing some wet by-products, such as pineapple skins and brewers grains.

Over the past 20 years there have been major advances in the technology of making and feeding silage (O'Kiely and Muck 1998). Much of this development has occurred in temperate zones, and there are needs for further research in tropical zones, in areas such as manipulation of microbial fermentation and the development of grass and legume crop silage. In general, however, the technology is adequate, and the difficulties are in integrating silage into profitable feeding systems.

This paper attempts to provide some guidelines to assist in integrating silage into feeding systems. Much of the information will be drawn from the experiences of dairy production systems in tropical and subtropical Australia.

Uses of silage

In large scale farming the use of silage is a business input. As with any business input it is essential to understand clearly the purpose of this input, and the likely consequences of its use. With silage the question is somewhat complicated by the fact that it is often a rearrangement of inputs already in the feeding system, rather than an additional input. It is consistently more difficult to demonstrate a profitable outcome from the rearrangement of inputs compared with an additional input (Cowan 1997).

The purpose for using silage has often been poorly defined. Very few feeding systems experiments have been done, and the bulk of the literature is on the making and feeding of silage. The introductions to these reports are dominated by reference to surpluses or gross deficiencies of forage at particular times of the year, and it is assumed that overcoming these will be advantageous to the farm business.

The advantages of using silage have generally been grouped under the following headings.

- As a drought reserve; where silage is made from pasture or crop in times of plenty and stored for a period of 1 to 20 years. The silage is fed to animals only in times of extreme feed deficiency.

- To increase productivity; where silage is routinely made as a means of increasing the amount of feed available to cows. The storage period is consistently less than 1 year, and the practice is often associated with a change from pastures to crops as a form of land use.

- To aid in the management of pasture or crop; where the pasture or crop is removed as silage to enable benefits to be accrued from other management practices. Examples are the increased tiller density and production of temperate pastures when excess growth is removed early in the growing season, and the removal of a crop to enable the earlier planting of a subsequent crop.

- The use of excess growth; where the rationale is that it is a waste to allow excess growth to mature and decay *in situ*, and it should be harvested for use in the future.

- To balance the nutrient content of the diet; where the silage is made with the intention of feeding it to provide nutrients lacking in feeds available at that time. Examples are the use of legume silage to feed with maize silage, maize silage to feed with grazed legume pastures, or silage of relatively high fibre content to feed with pastures of low fibre content.

- To enable storage of potentially unstable material; where the ensiling process ensures the feed can be used over an extended period. An example is the ensiling of wet by-products. This use is similar to that in the preservation of feeds through the addition of chemicals or exclusion of air from feeds such as high moisture grains.

All of these have the underlying assumption that it will be profitable to use silage in the feeding system.

Financial model

Given the wide array of potential types of silage and purposes of use, it is important to have an overall framework for the financial assessment of incorporating silage into the feeding system (Cowan and Kerr 1984). The model below allows at least the main sources of revenue and cost to be taken into account in planning for a silage program.

Net financial benefit =	increased income during feeding	+ indirect benefits	- penalty during silage making	- costs of silage
	Additional L milk, by price/L	e.g. extra days crop growth, or improved pasture growth	Loss of production, by price/L	Operating costs. Labour costs. Capital costs.

The key parameters influencing additional income during feeding are the quantity of silage fed and the quality of the silage in relation to the other feeds available to the animal at that time. The increased income must be substantial for the practice to be profitable, and to achieve this a large quantity of silage must be fed. In northern Australia, many farmers found that making small amounts of silage did not improve their financial position. Costs do not reduce in direct proportion to the amount of silage made, and a small advantage in milk production at one time of the year does not generate sufficient income to cover these costs. For example, farmers with herds of around 100 cows found that making in the order of 100 to 300 tonnes of maize silage did not provide a net benefit. These farmers have quickly separated into those who stopped using silage and those who make larger quantities, in the order of 1000 tonnes.

The quality differential is very important in intensive production systems. Though silage is normally fed during periods when alternate feed supply is low, poor quality silage can further reduce intake of paddock feed and give only a small net gain in milk output. This has been most obvious in attempts to use tropical grass silage in dairy feeding programs. The quality of the tropical grass silage is relatively low, with dry matter digestibility in the order of 55%, and it is usually fed during winter when the quality of the scarce feed resource is high. In northern Australia this is often grazing oats, irrigated ryegrass pasture, or tropical grasses which are growing slowly at this time but are of a higher quality. The net effect has been a very modest increase in milk yield during the feeding period, which did not cover the costs of silage (Davison *et al*. 1984; Cowan *et al*. 1991).

In contrast, the feeding of maize silage in combination with grazed clover or lucerne pastures has given substantial increases in milk output (Stockdale and Beavis 1988; Cowan *et al.* 1991). The combination of high energy content in the maize and high protein content in the legume enabled these feeds to be complementary.

The estimation of indirect benefits is often specific to the farm, although the 2 cases referred to above occur relatively widely. Fulkerson and Michell (1985) found that by removing the early growth of a temperate pasture they achieved an increase in milk yield per cow over the spring to autumn period. By removing a maize crop as silage rather than grain, farmers are able to obtain an additional 50 days active growth from land by using it for another crop.

There is often a penalty to milk production during the silage making period, where silage is made from tropical pastures or crops that are being grazed, as the removal of paddocks from the grazing rotation reduces the selection differential available to the animal. Cows select strongly for leaf material and restrictions in the area allocated for grazing can reduce the selection ability (Cowan and Lowe 1998). In this situation cows consume a higher proportion of stem in the diet, and consequently the dry matter digestibility of the diet is reduced.

There may also be an indirect penalty, through less time being available for tasks such as pasture management and fertilisation, ration formulation and cow health care during busy periods of silage making.

There is a large volume of local data on the operating costs of silage. These analyses show the main variable inputs, such as land preparation, seed and fertiliser, casual labour and harvesting costs. Sensitivity analyses show that variations in crop yield and harvest and storage losses have the greatest impact on cost, rather than differences in the cost of the above inputs (Brennan 1992). However the commitment in terms of capital and the farm managers time are invariably undervalued. Often the feed-out costs are also omitted. There are virtually no total farm analyses of the cost of silage when used as a component in a feeding program based on grazed pasture or forage. By contrast there are total farm costs for feedlot operations (Nixon 1992), which invariably show a higher cost than the marginal cost often quoted for silage in grazing systems (GRM 1997).

Drought feeding

There have been consistent difficulties in justifying the use of silage as a drought reserve in intensive feeding systems. The investment in silage is often made a number of years before the silage is fed to cattle, and so the opportunity cost of the feed is high. In other words the money could have been used to pay for a more direct input to production. Secondly, the object of drought feeding is only to maintain animals, so the additional milk or beef output is very small. In large scale and intensive feeding systems there are unlikely to be substantial numbers of cattle deaths during drought, and so silage is unlikely to be used to keep cattle alive. The net effect is a very small increase in income during feeding, and a high cost of conservation.

Increasing production

A more positive use for silage in the tropics is as a means of increasing land productivity (Cowan *et al*. 1993). There is a continuing increase in the pressure to use natural resources more effectively, primarily land and water. Associated with this pressure are demands for greater control over the production system, to meet quality assurance targets, ensure animal welfare and facilitate sustainable land management practices. It can be argued that each of these goals is more likely to be achieved in a system of feeding which has a high reliance on conserved crops.

In northern Australia a typical dairy farm has 100 milking cows and uses an area of 100 ha. However, on average, two thirds of the milk production from the farm in produced from 20 ha. This is the highly fertile and irrigated land. In other countries it is the total farm area that is limited (Simpson and Conrad 1993). In many areas irrigation is used to grow high quality feed for cows, and the efficient use of water is a high priority. The combination of cropping and conservation increased dry matter production per hectare compared with pasture systems, and achieved a higher ratio of feed production to water input (Kerr *et al*. 1987).

The cropping activity developed must use crops that can be efficiently used in the feeding system. Feeds such as maize, barley, and lucerne have high conversion rates to milk production, soybeans and sorghums are intermediate, and Napier (or elephant) grass *(Pennisetum purpureum)* and sugarcane are low. Napier grass has been shown to produce very high yields of dry matter and high water use efficiency, but because of the low digestibility cannot be used in systems producing in excess of 15 L /cow/day (Anindo and Potter 1986). By contrast maize and lucerne are capable of supporting levels of production in excess of 40 L/cow/day. In northern Australia, dairy production systems have made increasing use of maize, lucerne and forage sorghum silage to complement grazed pasture, and maintain production levels in the order of 25 L milk /cow/day (Ashwood *et al.* 1993; Cowan 1997). In 1994-5, an average of 0.4 t DM /cow was fed as silage (Kerr *et al.* 1996). A similar development, using a pasture and crop rotation for dairy production, was described for Uruguay (Wallis 1997).

Kerr *et al.* (1991) used time series analyses to evaluate the effects of incorporating maize silage into a grazing system on the productivity of a dairy farm, and two further cases were reported by Cowan *et al.* (1991). Productivity increases were 21,000 to 150,000 L milk/ farm/year above the previous system based solely on grazed pasture. Much of this extra production occurred during autumn and winter, a period when there are increased price incentives for milk production. It has been consistently shown that those dairy farms which persist with using maize silage have larger herd sizes (by 40 to 60 cows), higher milk production per cow (by 600 to 2000 L), and greater total milk output (by 300,000 to 700,000 L/year), than farms not using silage (Cowan *et al.* 1991; Kaiser and Evans 1997). In a separate survey, Kerr and Chaseling (1992), observed an increase in milk yield of 0.73 L for each kg hay or silage dry matter used in the feeding program.

Trends in the development of feeding systems in subtropical Australia indicate an increasing input of conserved forage (Figure 1). The development of intensive irrigation and conservation has resulted in a decline in the proportion of milk being produced from grains and tropical grasses, and it is projected these trends will continue. Much of the silage is made from crops during summer, and fed in the autumn and spring periods when pasture supply is normally low. This has resulted in a relatively stable pattern of production throughout the year (Figure 2).

In feedlot operations there has been an increase in the amount of silage, particularly maize, in the diets of beef and dairy cattle (Kaiser *et al.* 1993; GRM 1997). High quality silages are capable of supporting the high levels of animal production demanded in such operations, are often lower in cost than grains and hay, enable higher productivity from land, and maintain a more stable rumen environment (GRM 1997). Kaiser and Simmul (1992) and Kaiser *et al.* (1998) measured daily liveweight gains of 1.0 kg for steers given diets of grain to maize silage ratios of 0:100, 54:46, and 80:20.

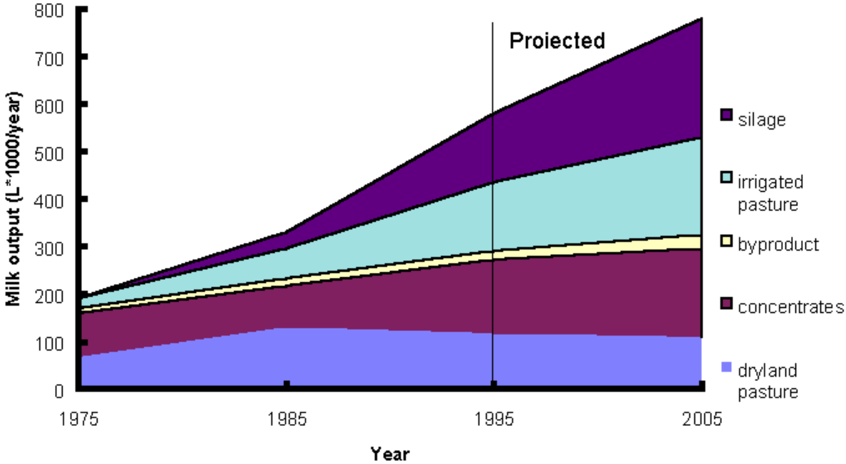

Figure 1. *Past estimates and projections of the milk output from feeds on a typical Queensland dairy farm (from Cowan et al. 1998).*

The increasing level of control needed over the production system is also influencing the move towards conserved crop systems. Farmers need to be confident they can produce a certain level and quality on a specified date. This is difficult to manage under many grazing systems, and farmers in northern Australia have adapted a combination of grazing and crop conservation to enable this control. The management of stress on the cow, from heat, parasites and walking, is sometimes a consideration.

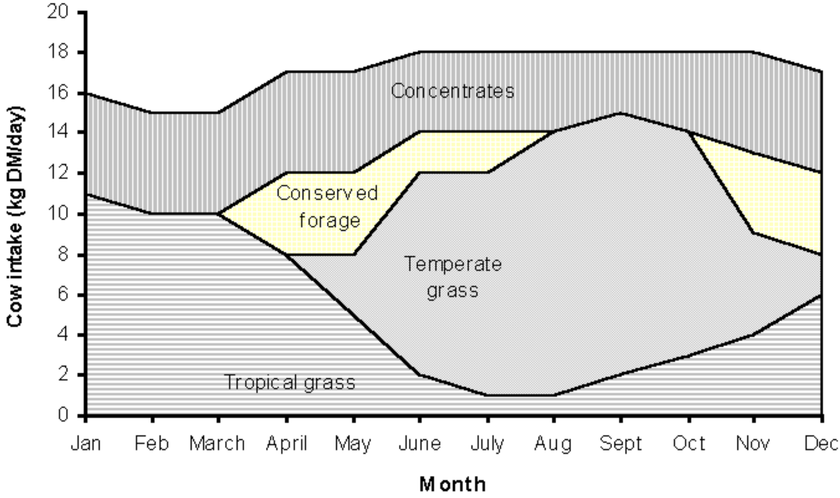

Figure 2. *Seasonal change in feed intake for a dairy cow producing 5200 L milk annually in a typical feeding system in northern Australia (from Cowan and Lowe 1998).*

There is increasing importance being placed on the sustainability of intensive ruminant production systems, and measures taken to enhance this may restrict cow movement to certain paddocks. For example the use of creek banks for shade and grazing may not be possible, and tree-planting schemes to address salinity may preclude grazing those areas by cows. However those areas could still be used to produce conserved fodder.

Management of land and pasture

This aspect of forage conservation has received considerable interest in pasture grazing systems in temperate areas. Removal of the early growth encourages greater tiller density and subsequent dry matter production (Fulkerson and Michell 1985).

Such an effect has not been shown for tropical grasses, and frequent cutting almost always leads to reduced dry matter production (Blunt and Haydock 1978).

The benefits in cropping systems can be significant. As referred to above, a silage crop can be taken some 30 to 50 days before a grain crop, thus increasing the number of days on which another crop can potentially be grown. As the land is often used for 2 or more crops annually, there is an increase in potential growth in the order of 30%.

Use of excess growth

In the modern business approach to farming the idea of ensiling an excess of forage growth simply because it is there may seem illogical, but it is often used as the justification for research and development. Davison *et al.* (1984) conserved the excess growth in a green panic based pasture in each of 3 years, and fed this back to cows during the dry season. Though the pasture was conserved as a stable and palatable silage, a result in common with other experiments (Moss *et al.* 1984), the net effect on milk production was zero. This was largely attributed to the low digestibility of such silage, and the low milk production response when it is fed to cows.

By contrast, silage made from temperate pasture, such as ryegrass (*Lolium* spp.) grown with irrigation during winter, has a high quality differential when compared with the grazed pasture on offer to cows during summer and autumn. The milk response to feeding this silage is likely to be high, and in northern Australia dairy farmers place high priority on conserving any excess of this pasture, rather than conserving the much greater excesses of summer pasture.

Recent experiments have attempted to enhance the digestibility of conserved Rhodes grass *(Chloris gayana)* by "ensiling" with sodium hydroxide (Chaudhry *et al.* 1999). The treatment was shown to cause a significant increase in digestible dry matter intake of very mature grass, but no improvement with young grass. The dry matter digestibility of treated grass was 60 and 65 % respectively; levels which are unlikely to provide a positive quality differential compared with grazed summer and winter pastures.

Balance nutrients in the diet

In northern Australia there has been a rapid adoption of irrigated temperate pastures for provision of grazing during winter and spring (Kaiser *et al.* 1993). These pastures are high in digestibility, very high in crude protein concentration and often contain a high percentage of legumes, although the quantity is usually insufficient for the total forage requirements of the herd. The supplementation of these pastures with maize silage has shown substantial benefits. Moss *et al.* (1996) showed this combination removed the need for protein supplementation of the diet unless very high levels of maize silage were being fed, and the use of maize silage in this way reduced the excessively high ammonia levels in the rumens of cows. Stockdale and Beavis (1988) demonstrated an additive effect of this combination of feeds.

Recently, there has been increasing interest in the use of legumes for ensiling in the tropics. Legumes such as lablab *(Lablab purpureus)*, cowpeas *(Vigna unguiculata)* and soybeans *(Glycine max)* have been shown to be compatible with sustainable land management practices, including zero tillage, and to conserve as silage of acceptable digestibility (Ehrlich *et al.* 1999). Dry matter yields of soybean silage was 6 t/ha, containing 17% crude protein and 42% leaf, and dry matter intakes of up to 12.5 kg daily were recorded (Ehrlich and Casey 1998). The high crude protein concentration is an advantage in tropical feeding systems, where many of the grass forages are low in protein. The legume silages are also relatively high in mineral concentration, and have a high buffering capacity. The potential benefits of these characteristics are presently being investigated (David McNeill, personal communication).

Storage of wet by-products

There are substantial quantities of vegetable and fruit waste produced from centralised food processing facilities. Much of this material is fed to dairy cows. Because of the uneven nature of supply, it is often ensiled in trenches in the ground, for subsequent use as feed. Pineapple skins were found to fall to a pH of 3.5 within 2 days of delivery, and remain at that level with no apparent reduction in feeding value (Cornack 1995).

Conclusion

The record of development of silage in tropical regions has been characterised by unclear objectives in making silage, a lack of a whole farm approach to silage evaluation, and a preoccupation with utilising excess pasture growth during the growing season.

It is concluded that where silage is considered appropriate to the feeding system, the activity should concentrate on using crops, making large amounts for individual properties, combining feed sources to enhance efficiency of nutrient use, and integrating feed planning with other demands on modern production systems, such as quality assurance and sustainability.

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