

Dairy Farm Production

Improving Forages for Dairy Cows



by Edward Cox

2010 Nuffield Scholar

March 2011

Nuffield Australia Project No 1010

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Foreword

Western Australia has a largely domestic base for the sale of dairy products. Dairy processors are demanding a flatter supply curve for the white milk market as it results in more efficient factories and a steady supply for the supermarkets. Subsequently, dairy farmers are increasingly required to produce a constant supply of milk throughout the year, regardless of the season. This combined with lower milk prices means that it is vital that farmers improve their feed efficiencies to maintain a consistent milk supply and reduce feeding costs.

Whilst it is acknowledged that Australians are world leaders in pasture based grazing systems (one of the lowest cost methods of feeding cows), research indicates that these systems combined with partial mixed rations (PMR) and a low level of concentrates will result in improved milk production and utilisation of pasture (Bargo, Muller, Delahoy, Cassidy 2002). The implementation of a pasture based grazing system in isolation will leave the cow with an effective shortage of energy due to relatively low total dietary intakes. In Australia, this shortage of energy is counteracted by feeding the cows high starch cereal grains in the dairy. When high quantities of these gains are fed in addition to quality pasture from grazing, this can often lead to subclinical acidosis costing the dairy industry millions of dollars every year.

The fundamental aim of this study project is to research cow feeding efficiencies and the maximisation of milk production from feeding a combination of pasture and total mixed ration systems. The findings of this study project were based on information obtained from visiting a number of progressive global dairy farming operations in the United States, Canada, United Kingdom and Ireland and through research provided by agricultural specialists in this area. The research underlying this report supports the idea that in order for cows to maximise milk production and profitability for the farmer, it is necessary to implement a variety of forage options and concentrates to supplement our predominately grass based system.

This report is focused on advocating processes that produce particular forages that will improve feed conversion efficiencies of cows, hence increasing milk production and overall profitability for the dairy farmer. These processes include; ensiling whole crop cereals (silage), grain tempering, and ammoniated forage (alkalage™).

Acknowledgements

Nuffield provides a truly unique experience and one that would not be possible without the dedication and hard work from the Nuffield team who provide skilled and passionate mentors such as Jim Geltch to guide us through the always exciting and occasionally arduous Nuffield journey!

In addition I would like to acknowledge my sponsors Dairy Australia and the Australian Dairy Conference, I hope I can provide some positive outcomes for the future of dairy farming in an industry that is currently facing many challenges.

My thanks to those international Nuffield scholars who showed such outstanding hospitality and opened not only their homes but also their address books full of useful contacts. My thanks to Malcolm Graham and Alan Sayle from FiveF consultancy, United Kingdom.

My gratitude also must go to my farm manager Ove and my staff who did a brilliant job of running the business in my absence. Every farmer knows how indispensable capable staff are and nothing tests this more than when you have to leave your business in their hands for an extended period of time.

I must also acknowledge my global focus tour group who are an amazing group of people all achieving inspirational outcomes in their own fields of primary production. These are friendships borne out of a common interest and passion that will last a lifetime.

Lastly, but of course most importantly thanks and gratitude to my family Kate, Bonnie, Lucinda and Claudia for allowing me to take this journey, one that I am sure will reap benefits for years to come.

Abbreviations

AUD	-	Australian Dollar
FCE	-	Feed Conversion Efficiency
GM	-	Genetically Modified
PMR	-	Partial Mixed Ration
TMR	-	Total Mixed Ration
UK	-	United Kingdom
US	-	United States

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Executive Summary

The climate in south Western Australia is predominately Mediterranean and as a result the winter rainfall provides for grass growth in the months of June through to November. However, there is a resulting shortfall in grass growth for the remaining months of the year which must be addressed. This is particularly significant for dairy farming as the grass growth is not adequate to feed a cow for her entire lactation. Alternatives such as irrigated pasture are limited due to competition for scarce urban water supplies and the increasing energy costs of pumping water. In addition, irrigated pasture will encounter a certain disparity in its growth caused by variations in the summer temperature and water availability which make it difficult to match cow numbers with the amount of pasture available.

It is acknowledged that good pasture growth can be attributed to good management, but there are also a number of factors to be taken into consideration that are beyond the control of the farmer. These main factors include rainfall and temperature. Ensuring that the entire dietary requirements of the cow are met is paramount to optimising milk production and hence, profitability. Therefore, it is vital that dairy farmers become increasingly proactive in minimising the uncertainties in pasture growth and availability and become more focused on producing forages that can be preserved and utilised when pasture is not readily available.

When pasture is limited, grain and concentrates are easy fillers but can be expensive and its use must be managed in regards to animal health. The majority of dairy farms in Australia currently process grain by using the method of 'dry-rolling'. This is a process where grain with 10-12% moisture content is shattered and then fed to cows. The 'shattering' of the grain increases its surface area which speeds up the rate of digestion in the rumen. In many other parts of the world such as the United Kingdom, grain is also 'dry-rolled' but with much higher moisture content of 15%. This can cause potential storage issues, due to the higher risk of mould occurring, however it reduces the speed of digestion and as a result lessens the risk of acidosis.

Subclinical Acidosis is a condition triggered when the pH in the rumen drops below 5.8 (Russell & Wilson 1996). The rumen will function at an optimal level when the pH is 6.2 – 7.2. Whilst cows are able to naturally increase the pH of their rumen by providing a salivary buffer flow, they are not able to completely compensate for a diet extremely low in pH.

Pasture has a pH of 7, which is neutral. However, starch digestion from low fibre grain results in acid build up, thus lowering rumen pH. To maintain healthy rumen the diet of a dairy cow requires adequate amounts of physically effective fibre. Physically effective fibre is obtained from feed such as hay, silage and other forages. Farmers must be cautious when adding silage to the diet as it has a naturally lower pH of 4.5 due to the fermentation process. As a result many feed rations may be inadvertently lowering rumen pH to the detriment of milk production.

Alkalage™ which can be described as an ammonia treated whole crop has a high pH of 8.5, with good effective fibre. These ammonia treated whole crops also contain high starch levels, perfectly complementing pasture which is high in sugar. The benefits of adding alkalage™ into the diet of a cow include; reducing the risk of acidosis, improving rumen function, minimising storage losses, lifting protein and delignification of the crop. The benefits of these crops will be discussed in more detail in the body of the report.

The importance of grass preservation techniques such as silage should also not be overlooked. Grass pasture silage produces a feed that is both cost-effective and of maximum nutritional value. However, grass pasture silage also contains a negligible level of starch. The consequence of lower starch in the silage combined with less grain being fed due to higher grain prices is less starch in the overall diet. This problem can be rectified by utilising maize as a high starch forage crop in the dairy feed ration.

In North America maize is widely utilised due to the suitability of the climate and advances in Genetically Modified (GM) technology which assures consistency of the crop. In areas where conditions for growing maize are not suitable or irrigation is not possible, other crops containing high levels of starch such as barley and wheat offer good substitutes. These crops are not harvested until they reach a late “milky dough” stage of maturation so that the levels of starch are maximised.

In addition to advocating the use of alkalage™ and targeting specific crops for silage making, a further method of feed processing is tempering grain. It is commonly used in cattle feedlots throughout Australia, Canada and the US, where water and surfactants are added to the grain to increase the moisture from 10% to 20%. This effectively ‘flakes’ the grain and thus vastly improves the digestible quality of the grain. The adoption of this process would prove to be extremely cost-effective for the dairy industry.

Finally, to produce an optimal Feed Conversion Efficiency (FCE) for cows and maximise returns, it is vital to combine good rumen function with good nutrition. This report supports the idea that to realistically achieve this goal, dairy farmers should utilise their pastures as a high quality forage base. If and when there is a necessity to supplement the feed ration with higher levels of starch and/or forages, the alternative aforementioned processes could also be undertaken.

Introduction

Western Australia has an 85% manufactured domestic product base for the sale of dairy products (Wilson, 2011). Dairy processors are demanding a flatter supply curve for the white milk market as it results in more efficient factories and a steady supply for the supermarkets. Subsequently, dairy farmers are increasingly required to produce a constant supply of milk throughout the year, regardless of the season. This combined with lower milk prices means that it is vital that farmers improve their feed efficiencies to maintain a consistent milk supply and reduce feeding costs.

The climate in Western Australia is predominately Mediterranean and as a result the winter rainfall from May to August provides for grass growth in the months of June through to November (Figure 1). However, there is a resulting shortfall in grass growth for the remaining months of the year which must be addressed. This pattern of grass growth is not adequate to feed a cow for her entire lactation. Alternatives to grass growth such as irrigated pasture are limited due to competition for scarce urban water supplies, the increasing energy costs of pumping water, and high land costs. In addition, irrigated pasture will encounter a certain disparity in its growth caused by variations in the summer temperature and water availability which make it difficult to match cow numbers with the amount of pasture available.

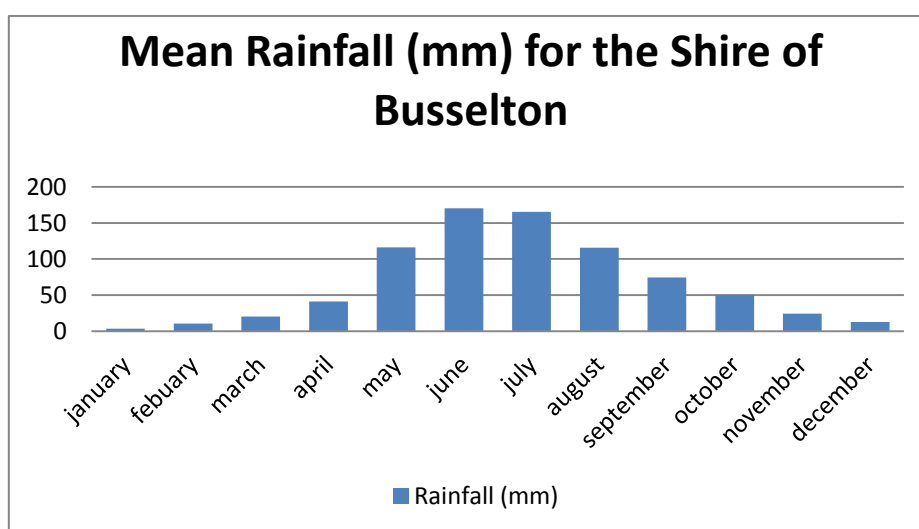


Figure 1: Mean annual rainfall for the Shire of Busselton (Source: Bureau of Meteorology Australia)

Successful dairy cow management requires matching the quality and supply of feed with the cow's nutritional requirements as efficiently and profitably as possible. Therefore, it is vital that dairy farmers become increasingly proactive in minimising the uncertainties in pasture growth and availability and become more focused on producing forages that can be preserved and utilised when pasture is not readily available.

This report is focused on advocating processes that produce particular forages that will improve feed conversion efficiencies of cows, hence increasing milk production and overall profitability for the dairy farmer and the dairy industry. These processes include investigating; ensiling whole crop cereals (silage), ammoniated forage (alkalage™) and grain tempering.

Objectives

The overall objectives of this Nuffield Scholarship were:

- To investigate high input dairy feeding systems and examine alternative forage options that could be easily integrated into the Australian dairy industry.
- To gain further knowledge of Feed Conversion Efficiencies (FCE) – Is it more than just rumen function?
- To explore silage making techniques.
- To investigate the benefits and application of ammoniated forages.
- To review existing ruminant feeding systems e.g. beef feedlots to gain a better understanding of grain processing systems (grain tempering).

Improving Dairy Farm Production

In the global dairy farming arena, Australia and New Zealand are at the forefront of low cost dairy production. This competence can be largely attributed to cost effective production systems, quality pasture and the ability to milk cows without having to house them in sheds. In Australia we are able to combine our cost effective pasture based system with a more intensive partial mixed ration (PMR) system to produce high levels of cow productivity. Irrigation systems in the Southern States of Australia are coming under closer scrutiny, and the price and availability of water is becoming more and more uncertain. To counteract the higher price of water and its further restriction, plant water use efficiency will become an ongoing issue. This can be achieved through the use of C4 type plants such as maize and sorghum, which possess a higher water use efficiency than C3 plants or rye grass pasture type plants.

Western Australia has a minimal amount of irrigated water available and is currently experiencing, longer, drier summers. It is therefore inevitable that cows eating preserved forages will gradually move towards an increasingly Total Mixed Ration (TMR) feed and at the shoulder of the season a Partial Mixed Ration (PMR). It makes sense therefore, to thoroughly investigate the methods for providing cost effective home grown forage options for feeding cows in the future.

Feed Conversion Efficiency (FCE)

Feed Conversion Efficiency (FCE) can be defined as the volume of milk produced by the cow per kilogram of feed consumed by the cow and acts as an accurate indicator of the effectiveness of the feed ration. A fundamental aim of the dairy farmer is to maximise this ratio. Optimising rumen function is the first step towards achieving a favourable FCE. The passage and rumination of the feed ration can be determined by faecal consistency. Faecal consistency can be rated on a scale of 1-5 with a score of 1 indicating watery faeces and 5 stiff faeces. The ideal score is around 2.75 – 3.5, which presents as a shaving cream consistency. If good rumen function can be achieved then FCE will entirely depend on the quality, quantity and variation of the cows ration. Acknowledging that the components of the cow ration have a symbiotic relationship with rumen function is the first step towards maximising FCE and hence profitability.

Silage

In Western Australia silage made from rye grass is the predominant summer feed for cows. It is most commonly mixed with cheap grain and to date this has proved to be an economical feed option. The primary advantage of this type of silage is that it improves pasture utilisation by conserving surplus pasture which is able to be fed out when there is a forage deficit.

However, the disadvantage of this type of silage can be inconsistencies in its quality. The inconsistencies arise when excess pasture is preserved at different times during the season, which is necessary to maximise pasture harvest. The resulting variations present issues in feed quality control. For large scale dairy enterprises it would be beneficial to produce consistent, high quality forages that are specifically targeted at the dietary requirements of cows.

In North America, dairy farmers base the majority of their cow feed rations around corn (maize) silage. Corn is a popular North American crop and underlies a large proportion of their Agricultural economy. The main advantage of corn silage is its high starch levels as starch improves the energy content of the diet. High starch forages are seen as a desirable characteristic in North American dairy feed systems. When corn is not available, forages are made with cereal crops such as wheat and barley. In order to maximise starch levels in wheat or barley crops, harvest must be delayed until the late “milk” stage or early “dough” stage of grain formation. This use of these types of forages was also witnessed in Canadian dairies and beef feedlots, particularly where protein and energy were deemed not as important as starch in forages.

In contrast, Western Australian dairy farmers have always placed far more importance on including energy and protein into the feed ration. As pasture silage contains no starch, the only source of starch has been in the form of cheap cereal grain included in the feed ration. As the cereal grains are slowly reduced from the ration, due to higher prices, it is necessary to look for alternative sources of starch such as maize, wheat and barley silage that contain high starch levels.

There are a number of high yielding varieties of wheat (Mace, Wedgetail, and Bonnie Rock) and barley (Urambie, Hindmarsh) currently being grown in Australia that are ideally suited to silage (Sellars, R.A. 2011 *pers.comm*). High grain yields can be directly related to starch content. As a cereal crop reaches full maturation the starch levels will rise. It is vital that

these crops be adequately preserved to obtain optimal starch levels. When making silage the chop length must be very fine at 8-12mm, which will vastly improve the compaction of the chopped crop and as a result limits the access of oxygen and allows for optimal fermentation. The chopping process provides the most ideal time for including additives such as inoculants into the silage.

Inoculants are essentially live bacteria, which will assist in dropping the pH of the chopped crop rapidly. The better quality inoculants will even offer some protection against spoilage, many hours after the silage has been fed out. Whilst additives such as inoculants can be useful in preserving silage, they will not counteract inept silage making practices.

The dry matter content of silage is vitally important to the silage-making process. The dry matter content of silage must be maintained between 33-40% (Ashbell, 1999). If the dry matter content falls below 30%, the silage will produce effluent, which will have a higher potential for pollution than domestic sewerage. 'Wet' silage with a low dry matter content will create an unsuitable environment for fermentation. Due to the fact that silage fermentation is an anaerobic process it is imperative that the silage bunker is adequately sealed. The exclusion of air and oxygen is paramount and can be achieved by covering the silage bunkers in a double layer of plastic. A new American product called SILOSTOP® is specifically designed for covering silage and is able to exclude up to twenty times more oxygen than traditional plastics. Ideally, one new sheet of plastic and one previously used sheet of plastic should be applied.

Silage production constitutes a large expense to the dairy farmer and therefore requires a certain amount of knowledge and skill to ensure that the best possible product is being created. A number of mixed grain and cattle feeding operations will offset low grain prices by ensiling their barley crops, which can then be used as an ongoing fodder source for many years for their cattle. An example of this was seen in a large Canadian cattle feedlot where an almost empty 18-20 year old silage bunker was being refilled with 40 000 tonnes of barley, rather than the crop being sold on the open market as feed grain. It is the fact that silage can be stored for long periods of time, with relatively low losses, that makes it such a valuable fodder option.

Alkalage™

High producing lactating dairy cows require excellent quality forage that will provide “effective” fibre in the diet. Effective fibre stimulates chewing and rumination, critical activities for thorough digestion and maintenance of stable rumen pH (Anderson & Schroeder 1999). The Alkalage process was developed in the UK and is a high energy forage made from a cereal crop such as wheat, barley, triticale, oats or maize. The crop is left to fully mature to a high level of dry matter (ideally in excess of 72%) as if ready for conventional harvesting. Whilst it does not need to be completely dry, there must be no green left in the plant. Any green in the plant will indicate the presence of sugar and hence the fermentation process will begin, which is not desired. Maturity of the cereal crop will also ensure the highest levels of starch and dry matter are achieved. The cereal crop is cut with a forage harvester fitted with a specialist small grain processing mill (roller mill) which cracks the mature grain to ensure the ease of digestion by ruminants. As soon as the crop is harvested and chopped, it is delivered to a bunker where an ammonia pellet is added.

The ‘Home ‘N’ Dry’ ammonia pellet is designed in the United Kingdom and is made locally. It is mixed into the chopped crop in the bunker and the reaction with the moisture in the crop causes the formation of ammonia gas (Picture 1). The ‘Home ‘N’ Dry’ pellet must be mixed with the crop and be adequately covered in the bunker so that the ammonia gas is not able to escape. Compaction is not required as the gas must be permitted to migrate throughout the entire crop. The entire ammoniation process takes approximately two weeks, after that the crop is stable and can be moved or utilised as fodder.



Picture 1: Mixing Home N Dry pellets into alkalage (Source: E. Cox, 2010)

Table 1: Analysis of Whole Crop Cereal Forages (Source: Sayle, A., Graham, M. (2010)

Analysis of Whole Crop Cereal Forages					
Dry matter	Total samples	DM	ME	Starch	NDF
<30%	144	26.09	9.43	11.69	53.25
30-40%	496	35.51	10.15	17.37	46.51
40-50%	385	44.16	10.51	21.76	44.49
50-60%	158	54.40	10.96	25.53	45.25
60-70%	65	63.69	11.25	26.19	47.19
>70%	24	74.36	11.68	27.42	48.72

Source: Frank Wright Laboratories, 2009

Table 1 illustrates a range of analytical results obtained in 2009 from whole crop cereal forages irrespective of their methods of preservation. These are based on the assumption that

a higher level of dry matter indicates a more mature crop. The results show that the maturity of the crop can be directly related to the proportion of grain, starch and energy levels.

Alkalage™ has a number of significant benefits. Firstly, the crop is fully matured, therefore maximising all of its nutrients. Secondly, the ability to preserve the crop without fermentation will reduce the amount of loss of the crop. Silage of the best quality will still experience fermentation losses of between 10-15%. Thirdly, the elevated pH of the crop at >8.5 provides a far more agreeable environment for fibre digesting bacteria in the rumen which prefer a pH of around 6 which will assist in alleviating the occurrence of acidosis. Overall, the ammoniated crop is more easily digested due to the process of delignification (lignin is an indigestible fibre that has no energy value to the cow). The chemical bonds holding the lignin, cellulose and hemicellulose together are broken down. (Church 1988) The lift in protein provides an improved protein energy balance in the forage.

Fourthly, the inclusion of the ammonia pellet will lift the level of protein in the crop by approximately 4-6%. The pellet contains full fat soy meal, urea and urease which all contribute to the ammoniation process. The 'Home N Dry' pellet costs approximately \$1500.00 (AUD) per tonne and with an inclusion rate of 3% it adds \$50.00 per tonne to the end product. If you take into account a 4-6% increase in protein, it is a beneficial and cost-effective process.

The final benefit of alkalage is the length of the harvest window. Mature crops can be harvested for alkalage on days when it would be too wet to combine grain without the need for expensive drying. The moisture levels in these crops can be higher than traditionally harvested crops and there will be very little effect on the yield and nutrients of the crop if harvest is delayed. Once preserved the material is very stable and much less attractive to vermin than whole-crop silage or maize silage.

Grain Tempering

The final process to be discussed is grain tempering. The tempering of grain is commonplace in large beef feedlots around the world. It involves a process where the moisture of the grain is lifted from 10% to 20% by adding water and a surfactant. The grain should be left to temper for 24 hours prior to rolling unless a wetting agent is used then 12 hours is sufficient

for tempering. The large number of small particles or ‘fines’ produced by aggressive dry rolling or grinding provide more surface area for starch digestion to occur, resulting in an increased rate of starch degradation (Picture 2). Rapid fermentation can lead to reduced pH and conditions more conducive to acidosis in the rumen.



Picture 2: A comparison between tempered rolled barley (left hand side) and dry rolled barley (right hand side) (Source: Cox, E.J. 2011)

There are a number of advantages of tempering grain. Due to the fact that the wet grain is swollen, it becomes easier to process resulting in less wear and tear on machinery. The increased size of the grain is beneficial because it enables the processing of a larger percentage of small grains in the sample. The tempering process creates a more superior product for the rumen with improved digestibility characteristics which results in a slower rate of movement through the rumen, utilising more nutrients. In feedlots a 6% improvement in efficiency is common and trials indicate that similar improvements can be achieved with dairy cows if tempered grain is included in their dairy feed ration. (Christen, Hill & Williams 1996) Significant progress will be made when it is possible to integrate the tempered grain with the pasture based systems. For example, if pasture (with its lower level of fibre) is combined with temper rolled barley it would remain in the rumen longer, therefore enabling an improved utilisation of an expensive product.

Recommendations

Long term trends indicate that grain prices will remain high as shortages are imminent due to increased human consumption. In response to this, the Australian dairy industry must continue to strive towards consolidating the use of our predominately pasture based grazing systems. While pasture forms a large proportion of the cows diet, it is also necessary to meet the total nutritional requirements of the cow.

Recommendations are as follows:

Grain Tempering

- Tempering grain has the potential to revolutionise efficiencies in concentrate feeding of lactating dairy cows in pasture based systems, whilst also reducing the risks to animal health.

Alkalage™

- Alkalage gives dairy farmers with run-off blocks the opportunity to produce home-grown forages with high amounts of dry matter that is more easily transported than grass and maize silage. The crop is able to be harvested in damp conditions and stored for long periods of time. Most significantly however, are the benefits to rumen health that this high dry matter feed offers.

Cereal Silage

- Cereal silage has the benefit of high starch which can reduce some concentrate usage and provides very high and consistent per hectare yields even where rainfall is limited.
- Silage making techniques have not evolved considerably in twenty years. It is a costly method of preserving grass and there is potential for improvement in every step of this process. It is imperative to minimise the cost of silage making whilst maximising the quantity and quality.

Rumen Function

- Rumen function is a critical consideration for the effective management of dairy cows. In-house or 'on-farm' systems to evaluate and monitor rumen function should be developed and implemented. Expert nutritional advice is paramount even for

totally pasture based systems. Optimal Feed Conversion Efficiency is reliant on the cow being in the best possible health.

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Plain English Compendium Summary

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Scholar:	Edward Cox
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Objectives	To examine different forages that has the ability to improve production and economic margin in our dairy systems and investigate better utilisation from grain inputs.
Background	Grass based dairy farming has an extremely low cost of production but to fully maximise returns from dairy cows some inputs are required. Forages and concentrates play an important part in milk production and balancing these with our pasture base will always be an ongoing challenge. Utilising whole crops and specifically targeting them into the cows' diet when needed may cut down on the use of expensive concentrates and also improve feed conversion efficiency by optimising rumen function.
Research	Research was undertaken in America, Canada, United Kingdom, and Ireland through visiting various dairy farmers and feedlotter, industry, and research and extension facilities.
Outcomes	Animal health and economic profitability can be achieved through improved forages and concentrates. Tempering grain, alkalage and high starch cereal silages are realistic options to improve total feed conversion efficiency at farm level.
Implications	This report provides nutritional options to improve our current pasture based systems. A higher level of nutritional management is required to deliver improved dairy cow performance.