# WATER USE EFFICIENCY

# PRESCRIPTION LIVESTOCK FEEDING

A REPORT FOR:

NUFFIELD AUSTRALIA FARMING SCHOLARS

By 2007 scholar Damien Smart

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# Executive Summary

## WATER USE EFFICIENCY

The term water use efficiency can be defined in many ways and can relate to numerous and diverse aspects regarding the use of water for agriculture, particularly irrigation.

This study concentrates on the use of that water once it has been accessed by the irrigator. For this purpose, my simple definition of the term is "***Driving the maximum production and profit per unit of water"*** or, put more simply***;*** **more crop per drop.**

The topics of climate change and the recent stress on many of Australia's water resources for both agricultural and urban use are well documented and as a result, increasingly scrutinised. As the overwhelming majority user of the nation's available water, agriculture falls under the greatest scrutiny, but also has the greatest scope to become more efficient and increase the production of food per unit of water. This is an important factor in the world's future protein needs, especially considering the declining area available to produce it.

To achieve this, the irrigator must have access to the most efficient system for their specific situation to more specifically match crop water needs with crop water availability. Furthermore, it is necessary to identify suitable crops for individual situations to maximise production and profitability per hectare and hence per megalitre per year.

If these steps are taken, Australia's irrigated agricultural sector has the opportunity to significantly increase production and more importantly, do so using less water.

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“Most of the world doesn’t eat red meat and those that do show a general decline against increases in the consumption of chicken, pork and seafood”

*(Professor David Hughes, Emeritus Professor of Food Marketing).*

Furthermore, Australian consumer trends predict that domestic consumption of beef and sheep meat will decline, while consumption of chicken will increase.

These are two statements that greatly affect the Australian red meat industry and its future in direct competition with protein sources that can be produced more efficiently and economically with a greater level of consistency in an increasingly competitive market.

Consumer trends show that the most important factor in marketing red meat is consistency and the only way for the producer to achieve this is by means of a prescribed and strict feeding regime.

These prescription feeding systems can then deliver the economics to compete against other protein sources.

This also enables the prescribed feed to be manipulated giving the product a point of difference in the market place through use of jargon such as Omega -3, free range, Natural etc that may attract a premium.

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# Table of Contents

# WATER USE EFFICIENCY

## Foreword

Irrigation is fundamental to vast areas of Australian Agriculture and rural communities, contributing significantly (25%) to the total Ag produce.
Sustainability, health and management of the water resource is under constant scrutiny as it affects all sectors of the population. This scrutiny has been significantly heightened due to the current threat of the city populations having limited water supply for their domestic use. This fact, above all, has caused dramatic decisions that will affect agriculture most significantly.
As a result, I believe it is imperative that irrigators have access to the most efficient and technologically advanced systems in order to provide every possibility of maintaining and sustaining what is arguably our most valuable resource.

I will investigate new technologies and trends in applying water, compare current systems and how they would perform in Australia, investigate any related issues in water resource pressure and how they have or could be overcome and finally, try to gain insight into how water will be more efficiently used for irrigation in the future.

# Introduction

Australian agriculture in general operates under severe moisture limitations, not surprising considering we are the driest inhabited continent in the world. The irrigation sector in Australia now faces major challenges as well as opportunities with the growth of the world population and the consequential increase in demand for food and water.

At only 0.4% of Australian agricultural land, irrigation accounts for $7.3b or 25% of our gross agricultural production, providing jobs and income for rural communities.

Current trends suggest that extraction is exceeding recharge and that poor practices are decreasing water quality. By necessity, we must adopt the most efficient irrigation systems for each individual purpose so that in the future, extraction can be matched with recharge as closely as possible whilst maintaining yields. This will ensure a sustainable resource and help secure the future for many rural communities.

A perpetual challenge is balancing the requirements of Rural versus Urban water use, Whilst this is far less in volume it is politically far more important, as evident in recent proposals and actions by state and federal governments to ensure the supply of domestic water.

Some of these decisions are greatly affecting those with permanent crops such as citrus that are more dependent on water for the plants' survival.

The open market for water trading in some systems has also seen an increase in the cost of permanent and temporary water as a result of the domestic customer requiring only small parcels of water that they are willing to pay for.

Climate change predictions indicate that rainfall patterns are set to greatly change (if they haven't already) the distribution of precipitation, most likely to the detriment of Australia.
This will further reinforce the need for the most efficient use of our water resource now and into the future.

These facts have placed even more scrutiny on the irrigator regarding their treatment of the resource.

Therefore, to maintain and sustain a quality water resource for both agriculture and urban use every effort must be made by government, households and irrigators to be more efficient in their regulation, storage and use of our most valuable resource.
In this report, I will try to provide some solutions, confirmations and opportunities for agricultural water users.

As large irrigators in an area that is under increasing pressure resulting from water quality and quantity decline, I believe it is important to provide an educated and positive example of improving water use efficiency through irrigation to the wider irrigating community.

## Sources of irrigated water

There are numerous sources of water available for irrigation such as:

- Rivers, creeks and streams
- Underground sources, including both unconfined and confined aquifers
- On farm storage such as dams and reservoirs
- Regionally, state and federally controlled distribution from dams and reservoirs
- Snow pack and rain fed reservoirs

The availability and delivery of these systems varies greatly between irrigation regions worldwide. With some areas such as California having a combination of many of the above and others such as the Salinas valley (California) and the south east of South Australia having only the one source.

Irrigation water usage doesn't always occur where the water enters the system and in many cases is used far from the source, creating political as well as delivery challenges.

This is evident in California, where the majority of water is collected as snow melt in the mountains and precipitation in the North of the state. It is then delivered via a vast network of open channels (see image 1 below) and pumping stations throughout the state but mostly to the desert region of the San Joaquin Valley.

This system carries its own inherent efficiency problems obviously with evaporation, pumping costs, filtration etc that do not occur to the same extent when pumping directly from a groundwater source.

Australia has similar systems where water is harvested from catchments and delivered by river or canal to other parts of the country for agriculture and domestic use. Often, these systems travel interstate, adding politics to the mix.

These factors along with soil, land and climatic conditions help highlight the fact that not all areas can be treated equally. However, once the water arrives at its application point, there are certain measures that can be taken to ensure that no matter where you irrigate, the water is delivered to the crop in the most efficient way.

Figure 1: Californian aqueduct

## Irrigation application systems

a. Unpressurised systems

- Border check flood irrigation

This system requires large quantities of water to be flooded across areas (often large) that are either laser levelled or contoured to ensure uniform application. Used extensively for rice production but it is still a popular option around the world for a range of crops. Its popularity is mainly due to a lower cost of installation.

- Furrow irrigation

Water is flooded between formed growing beds, generally irrigates root zone avoiding contact with the plant. More efficient than border check but highly labour intensive with a level of evaporation.

Once again a popular option due to low capital cost, lower water use and more control over water application.

Can be delivered via open channel and siphon pipes, or solid set main lines.

b. Pressurised systems

- Solid set sprinklers

This system can be permanent or movable depending on crop and labour. Is often used to germinate crops before being replaced by another system.

Movable systems are highly labour intensive; they require good water as the canopy is wet, high amount of drift and evaporation on hot windy days.

- Wheel lines

Laterally moving solid set sprinklers using galvanised wheels and swivelling sprinkler heads to traverse the ground. Same problems with drift and evaporation as with all high pressure sprinkler systems. Limited with the distance and width of run, prone to mechanical problems.

- Centre pivot /Laterals/ Corner systems

Permanent or moveable, centre pivots, corner systems and laterals deliver (see image 2 below) water generally from sprinkler nozzles. Drift and evaporation greatly reduce efficiency and in some cases the water quality doesn't warrant overhead application.

All these systems require obstacle free runs and the centre pivot can be an inefficient use of land. Corner systems and laterals can overcome this but at an increased cost.

These systems are very widely used and advances in the hardware and software are making them a more efficient, durable and cost effective way of applying water as well as other soluble inputs such as fertiliser.

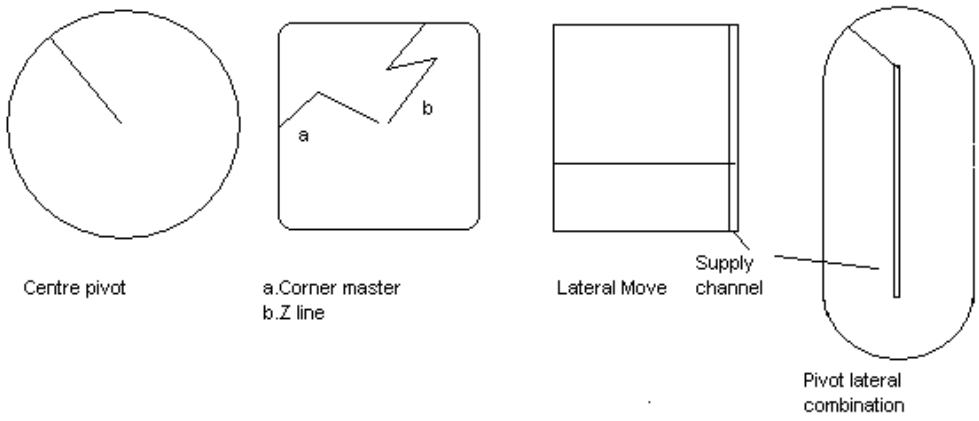


Figure 2 – Various pressurised systems

- Drop tubes

Drop tubes can be retrofitted or installed from factory to the above three systems, resulting in under canopy application. This results in zero drift, minimal evaporation and allows the use of water that could damage the plant if in contact with foliage and flower. All of this with a decrease in water use and evidence of increased yields makes it a great option for increasing efficiency where possible and will be discussed further in this report.

- Drip tapes/lines

Mainly used for permanent or long standing crops such as vines, almonds etc, this system allows for exact water application as well as other soluble products with minimal evaporation. A very efficient system for applicable situations. Advances in software are giving farmers easier and increased control of their water application, whilst improvements in the strength and durability of the tapes/tubes is increasing the life of the hardware. These two factors will continue to improve into the future.

- Sub Surface Drip

Intended for a long or indefinite life span, these drip tapes are buried underground to a certain depth to ensure their safety, as such installation and maintenance must be carried out so that once buried they will not need to be retrieved.
This system requires high pumping pressures and is extremely expensive to install and run. However with total control of the application of water and soluble inputs to the root zone alone, farmers can almost exactly match application to plant needs. This is the most water use efficient system but unfortunately is not suitable for all situations especially some soil types. This system will be discussed further in this report.

- Retrievable tapes

Advances in tape durability and removal techniques have seen a rapid rise in the use of removable tapes both above and below the surface. Ideal for paddock and crop rotations, this system gives all the benefits of the permanent drip systems with the flexibility to remove and reuse. Again this will be discussed further in the report.

## Under canopy emission via drop tubes

Centre pivot, lateral movers, corner master and combinations are all a widely used and acceptable means of delivering water. The ability to pressurise and control the amount of water applied has long given an edge in water use efficiency, while the variations allowing a pivot to irrigate in squares and parallelograms (see figure 2) have also improved the efficiency of land use and management.

Advances in software and hardware will continue to provide more control of water application and also the ability to apply fertiliser, chemical and biological agents through the system.

Cost, the need for obstacle free areas (particularly trees that in some areas such as South Australia are difficult to remove and relocate due to legislation) and poor water quality have limited the use of this system on some areas, ensuring the use of less efficient systems such as flood.

However, these systems still using overhead sprinklers are not as efficient as they could be, due to their inability to irrigate on hot windy days, spray drift, wetting of canopy and flower and evaporation.

To overcome these problems the system can be fitted with under canopy emitters (see figure 3 below), at various heights from the ground or dragging through crops as deemed most suitable.

This will ensure that basically all the water applied will enter the root zone, with zero being lost through drift and only a minimal amount through surface or canopy evaporation.

This will also allow some areas to use this system where it is was previously not possible through sprinklers due to water quality causing damage when in contact to flower or foliage.

The following table highlights the difference in figures when a sprinkler pivot is converted to under canopy to irrigate a Lucerne seed crop:

| | SPRINKLER | UNDER CANOPY |
|---|---|---|
| Water pumped ML | 4.6 | 4.5 |
| Yield kg/Ha | 600 | 800 |
| Return/Ha | $3,000 | $4000 |
| Yield kg/Ha | 130 | 177 |

Table 1: Sprinkler vs Under Canopy

As illustrated in table 1 (see page 13), the under canopy conversion has delivered a higher yield and a significantly higher return/ ML. This is due simply to ensuring most of the water pumped is being used by the crop and the negative effects of wetting the canopy and flowers has been eliminated.

Figure 3: Under canopy emitters in Lucerne (green crop shows flower drop under sprinklers)

### Sub Surface drip

Sub surface drip irrigation utilises the advantages of a pressurised, controlled drip system, allowing accurate and frequent application of water and nutrients, whilst avoiding evaporation losses through surface water.

This is due to the tape being buried under the surface, usually to a depth of 20 to 30cm allowing the targeting of the root zone only and eliminating surface wetting.

This, with the aid of moisture monitoring devices, gives the operator the ability to irrigate every day to match the plants' needs, avoiding plant stress as a result of both under and over watering, pumping only the required volume of water and ensuring an even and constant water supply in which plants can thrive.

An example of this benefit can be explained by comparing it with a pivot or flood system. Using both of these systems requires large amounts of water to be applied at longer intervals so that there is enough water in the profile to last until the application can be repeated. Generally the amount of water applied is in excess of what the plant can handle so it therefore 'slows down in order to cope'. There is then a period when the plant can utilise moisture to its maximum potential and the plant starts to grow and use a considerable amount of water per day. Depending on the infrastructure and when the next irrigation event can occur there is often a period where the plants moisture needs are exceeding that which is available in the soil profile and as a result the plant once again slows down before being inundated with water. This is referred to as the roller coaster effect and will seriously limit the amount of time the plant is at optimum performance in an irrigation season. A yield deficit is the resulting outcome.

In a sub surface drip system water is applied to the root zone at a rate (daily, hourly etc. as required) that is extremely closely matched with the plants required use to ensure optimum and continuous moisture supply and plant growth through the irrigation period. Results have shown that the same crops under similar conditions will mature up to four weeks earlier under sub surface drip compared to flood and pivot.

If installed and maintained correctly this system should last in excess of ten years, with some systems such as that at the Kansas State University predicting an indefinite life (their system is over thirty years in operation).
If undisturbed by man, pest and machine as well as good internal maintenance (cleaning of lines) this life span is easily attainable as the two main culprits in the deterioration of drip systems, sunlight and physical disturbance are obviously eliminated once the drip line are safely installed bellow the surface.

In my studies and experience this is the most water use efficient system available to irrigators, allowing controlled application to the root zone, even plant growth and in most cases yield increases: up to 45% in Lucerne seed while pumping one third the water.

| | Flood | Under Canopy | Sub Surface |
|---|---|---|---|
| Water Pumped ML/Ha | 10 | 4.5 | 3.5 |
| Yield kg/Ha | 800 | 800 | 1000 |
| Return/Ha | $4000 | $4000 | $5000 |
| Yield kg/ML | 80 | 177 | 285 |
| Return/ML | $400 | $885 | $1425 |

Table 2:Comparisons between Flood, Under Canopy and SDI

These figures clearly show the increase in yield and return per megalitre of water and a significant reduction in total water pumped moving away from the flood systems without a yield decrease.

Capital costs

The following are indicative prices per Ha to install the systems:

| | |
|---|---|
| FLOOD | $1900/ha |
| UNDER CANOPY PIVOT | $2500 |
| SUB SURFACE DRIP | $5000 - $7000 |

Capital costs have not come into the figures in table 2 (above) and as can be seen by the costing above, would have a considerable affect on the return on investment as a percentage of increased production on any given crop, particularly when water has no cost.

**However it is plain to see that for this particular crop there is only one viable option when buying temporary water out of the Murray-Darling system at $1000/ML.**

Unfortunately SDI is not suitable for all conditions, such as in areas of shallow soils, shallow clay layers, rocks or stumps and sandy soils depending on crop selection.

Water quality can also affect the performance and longevity of the system.

Another major problem mainly occurring in America is the damage to tapes caused by burrowing vermin, in many cases these vermin cannot be controlled and the damage is significant enough to warrant removal or abandonment of the sub surface drip system at huge cost to the producer.

This problem doesn't seem to be occurring in Australia although insect damage has been experienced in some situations.

This system is by far the most expensive so it is fair to say that before investing one must ensure that the soil type, water quality, crop selection and overall economics are suitable. If so this system will:

- Give a controlled, uniform watering
- Reduce water stress by providing higher irrigation frequency at low rates
- Increase crop transpiration
- Reduce herbicide use as summer surface weeds won't germinate if not irrigated
- Negate significant affect wind and temperature has on sprinkler systems and pooling/runoff from flood systems
- Give the opportunity to apply fertiliser and chemicals directly into the root zone resulting in high levels of uniformity over the crop
- Reduce volume of water pumped
- Provide near perfect moisture conditions for the plant
- Allow irrigating during normal paddock operation (harvest, hay etc)
- Promote earlier crop maturation

GPS technology has also enabled farmers to reconsider SDI after abandoning it as a result of issues with control traffic farming.

SDI isn't without challenges and it is important to point out the major ones:

- Fixed position makes crop rotation difficult
- Pest damage
- Root intrusion
- Soil back siphonage
- Shifting tape within beds
- Achieving uniform wetting patterns
- Crop germination
- Damage during installation

Under ideal conditions this system is by far the most water use efficient and will return the most 'crop per drop'. It is also evident that this system is the most expensive as a capital cost.

This makes it essential for the irrigator considering this option to investigate all strengths and weaknesses, suitable crops, water quality and availability and most of all soil type before investing in a Sub Surface Drip irrigation system.
All this to ensure not only 'more crop per drop' but also '***more return per drop'.***

## Retrievable tapes

Recent advancements in equipment and techniques have improved the suitability of retrievable drip tape systems. This gives the irrigator the typical advantages of drip irrigation without many of the disadvantages of SDI.
The system is generally referred to as surface tape and is either installed on the surface or approximately 5cm below.
Advantages:

- Can be installed before or after planting
- Can be buried if located in a bed, or placed on the surface if in the furrow
- Can be retrieved before harvest to be reused in other paddock/ crops
- Tapes have been improved to be tougher and less likely to stretch
- On short season crops (10 or less irrigations) growers have reused many times (6-15 times)
- Can use above or buried mains and sub mains or existing SDI mains
- Identifiable damage to tape
- Easy to repair and replace sections

Disadvantages

- Only suitable for crops that can handle wet surface
- Germination of surface weeds
- Limits machinery on paddock (manual labour)
- Often sprinkler irrigated until no more need for machinery
- Retrieval damage (main component on how many times it can be reused)
- Tapes need to be flushed with air before removal to decrease weight
- Careful storage to avoid damage or bacteria build up

This system obviously carries a higher cost but has allowed more lucrative crop options and rotations to be considered. So much so that in the last 10 years producers of high value crops such as cauliflower, lettuce, celery and broccoli in Californian have generally shifted from SDI to surface retrievable systems.

## Energy use in pressurised systems

"Agricultural applied water is directly proportional to energy use by agricultural water pumping. If the amount of applied water is reduced, in theory energy use will be reduced. However, in order to reduce the applied water, it may be necessary to actually use more energy."

*Itrc. Report no. R96-001*

This is the case when converting from a flood to a pressurised system such as pivot and especially drip.

In the endeavour to increase efficiency in water use, a valued resource no doubt, one must consider the impact on the energy resource and hence the environment by doing so.

To help outline and discuss the increased energy use as a result of converting to drip system I have included a three year case study addressing water and energy use efficiencies in a crop of Bell Peppers in California.

**Californian Polytech University, Irrigation Training and Research Centre. Report no. R96-001**

The 3 year average water and energy use efficiencies before and after buried drip:

Note: Acre Feet/Acre equates closely to Megalitres/Hectare

| | Furrow | Drip | %Change |
|---|---|---|---|
| Water Use (Acre Feet/Acre) | 2.7 | 2.6 | -2 |
| Energy Use (MBtu/acre) | 21.2 | 25.5 | 21 |
| Yield (tons/acre) | 18 | 24.7 | 37 |
| Water Use Efficiency (Tons/Acre Feet) | 6.7 | 9.5 | 38 |
| Energy Use Efficiency (Tons/MBtu) | .85 | .95 | 13 |

A summary of the water and energy use efficiencies consist of:

- The buried drip irrigation system resulted in a 2% reduction in total water use and a 38% increase in Water Use Efficiency when compared to the previous furrow irrigation system. It should also be noted that water use in year 3 increased 15% due to a doubling of the planting density and the use of a new hybrid pepper plant. However, the Water Use Efficiency in that year improved by 56% over the furrow system.
- Even though the average energy use went up significantly, the tons of peppers produced per unit of energy (Energy Use Efficiency) improved by 13%. A further improvement in energy efficiency will be realised in year 4 when the buried drip will be used initially on the pepper transplants, eliminating the need for any sprinkler irrigation.
- The drip irrigation system aided to bring an average yield increase of 37% in bell pepper production. The yield increase is principally due to the farmer's ability to irrigate and pick the crop simultaneously.

Report 96-001 Itrc CalPoly. www.itrc.org

This case study gives valuable insight to the increase in energy use when converting to drip or pressurised systems. But more importantly it demonstrates the ability to increase yields, considerably improve Water Use Efficiency and although the energy use increases there is a considerable increase in Energy Use Efficiency.

The increase in Energy Use Efficiency is in my opinion the most significant gain in this case study and in light of the projected global demand for food and the need to slow greenhouse gas emissions, converting to these systems gives the producer and agricultural sector the ability to do so.

# Recommendations

The farmer often has little or no control when it comes to receiving water for agricultural irrigation. We do, however, have control of how we deliver that water to the crop.

The ability to use any of the irrigation systems as well as crop selection and economics is obviously governed by the specific situation. This requires the individual to investigate the most efficient system to suit his or her needs and give the farmer and Australian agriculture the ability to gain the maximum return per unit of water, or more simply:

**"More Return Per Drop"**

# PRESCRIPTION LIVESTOCK FEEDING

## Foreword

Red meat consumption worldwide and in Australia is in decline and constantly competing with other sources of protein including chicken, fish and pork. These, as well as many other human food sources can produce a consistent product at a lower cost, which in turn gives the consumer a greater range of low cost protein options.

In order for red meat to maintain market share, studies show that consistency is as important as quality and price in influencing the consumer. For example, if a consumer has a bad experience with steak, research suggests it will take around three months before they purchase it again. Conversely, there are consumers who are willing to pay a premium for meat if they are assured of its quality and consistency.

I will investigate feeding options that will enhance red meat producers ability to deliver these outcomes and how prescriptive feeding can achieve desirable traits and marketing points of difference.

Functional food is a rapidly growing market around the world and already well advanced in the poultry and pork industry, who can now market products enriched with omega-3 among other things. To maintain market share the red meat industry must endeavour to enter this market, finding ways to seize the health conscious consumers attention by manipulating the prescribed feed to express these 'functional' traits.

Finally I will endeavour to gain insight into the state of the markets that I visit, what consumer trends are and what they are willing to pay for red meat.

# Introduction

The greatest challenge the red meat industry, specifically beef and sheep, faces is competing as a protein source in a marketplace that has cheaper options.

As a result, the industry must ensure a product that will be consumed nationally and internationally, endeavouring to arrest and reverse the current and predicted decline in beef and sheep meat consumption.

Protein sources such as chicken, pork and seafood enjoy a significant advantage concerning the cost of production. This is mainly due to increased conversion rates, a huge factor in today's feed grain markets. This is coupled with more advanced genetics, feed rations and nutrition with reduced constraints on land use.

These advantages are unlikely to erode so the industry must concentrate on ensuring beef and sheep meat are the meal of choice and that the consumer is willing to pay a small increase in cost per kilogram for their protein option.

Those consumers that will pay a higher cost for food are increasingly targeted for specialised or point of difference markets that generally attract a premium, or simply contribute to the sale. This is seen especially in the area of branded products that boast perceived desirable traits such as organic, free range, natural production as well as human health desirables including Omega-3, vitamins and cultures to name a few.

The pork, chicken, egg and milk industries in particular are well advanced in this area and it is important the red meat industry investigates the possibility and viability of joining this area of beneficial and functional food production and marketing.

Once again there is the option of contributing to the transfer of beneficial traits via a specific food additive in a prescribed feed ration.

The focus of this report has been to look at these issues firstly from a marketing point of view and secondly, from a processing point of view.

## Red meat on the global market

Both beef and sheep meat compete with all other forms of protein and in particular meat proteins such as pork, chicken and fish. In fact, beef comes in at number four in total world meat consumption behind pork, chicken and seafood.
A common misconception is that goat is the most consumed meat, it is in fact the most widely consumed meat around the world, but in terms of kilograms, falls behind the items listed above.

China basically ensures pork's place atop the consumption list and seafood's place is secured as a result of Asian consumption. Chicken, however, as a result of many factors is fast becoming the meat of choice around the world.

Growth in Global Meat Market 1985- 2025

| | 1985-1995 | 1995-2005 | 2005-2015 | 2015-2025 |
|---|---|---|---|---|
| Beef | 1.1% | 1.5% | 1.7% | 1.7% |
| Pork | 2.9% | 2.6% | 2.1% | 2.0% |
| Poultry | 5.7% | 3.8% | 2.9% | 2.5% |
| Sheep | 2.4% | 2.1% | 2.0% | 1.8% |

Table 3 Source: USDA, FAO, World Bank, MALF Brazil

Chicken has many advantages over other meats in the market place. Foremost is the price per kilogram to the consumer, a factor hard to compete with when considering such favourable feed conversion rates (2.4 in 1975 to 1.8 in 2005). Furthermore, the fact that the consumer can be guaranteed a similar, satisfying meal every time almost anywhere ensures chicken's popularity as a protein source.
This consistency factor can be attributed to the standard genetics (only a few companies supply the world industry) and similar feed regimes around the world, an advantage also exploited in the pork industry.

Many countries don't consume red meat and those that do show a general decline in consumption in favour of cheaper protein sources such as chicken.

The red meat industry faces considerable challenges in ensuring and increasing market share. While providing a product that is safe, satisfying, good value and consistent, to meet the worlds nutritional needs.

### Australia's beef production and consumer trends

**(***MLA Beef facts June 2006, Australian Bureau of statistics 2005***)**

- As at June 05, there were 27.7 million cattle in Australia
- Australia produces approximately 2 million tonnes of beef annually and is ranked 8$^{th}$ in the world producing 4% of world supply
- Australia is the second largest exporter at 973,878 tonnes behind Brazil
- Domestic expenditure on beef is $6.4 billion
- Australians consume 35.6kg beef per capita annually
- With 35% of market share, beef is the number one fresh selling meat at retail
- It is the second most popular fresh meat at foodservice after chicken
- Consumer preferences to cheaper forms of protein e.g. chicken has grown. Consumption of chicken increased from 24kg per capita in 1988 to 31kg in 1998. The current figure is 35kg and only marginally less than beef but this is likely to change within the next 2 years.
- Australian consumers have preferred leaner beef while markets in the US & Japan (31.1 and 41.4% of exports) prefer higher levels of marbling. To meet these markets higher numbers of cattle are finished on high protein grain diets (33% of total cattle slaughter)

## Australia's Lamb production and consumer trends

*(MLA Sheep Facts 2006)*

- As at June 2005, there were 101.1 million sheep in Australia
- Australia produces around 412,600t of lamb and 271,000t of mutton annually
- Australia is the third highest lamb and mutton producer in the world behind China and EU-27 and 7% of world supply
- Australia is the largest exporter of mutton and the second largest exporter of lamb behind New Zealand
- Domestic expenditure on lamb is approx. $1.8 billion
- Domestic expenditure on Mutton is approx. $305 million
- Australians eat 10.2kg of lamb and 2.8kg of mutton annually
- This lamb consumption is amongst the highest in the world
- Lamb accounts for 19% of the fresh meat market at domestic retail
- In 1988 Australians consumed 22kg of sheep meat per capita. By 1998 this had fallen to 16kg and it has now stabilized at approx. 13kg annually

As can be seen, both the domestic and export markets are an extremely important part of the Australian red meat industry.

## The consumers need for consistency

As highlighted, the domestic and international consumer is generally moving away from red meat in favour of other sources of protein, in particular chicken.

Many factors are contributing to this such as price, marketing, perceived health benefits and general ease in preparation to name a few. But the underlying factor in my view is the consistency of the product.

The most important thing when purchasing a meal is the knowledge that the eating experience will be pleasantly the same as the last time you ate it. Especially important when preparing a meal for the family and more so when entertaining guests.

Studies have shown that an unsatisfactory eating experience with steak can prevent the purchase of another steak for three months.

Most will agree that chicken and pork have been able to provide a consistent product for many years, leaving the consumer safe in the knowledge that they know what they will get. While continuing to be produced in intensive shedded environments with similar genetics and standard feeding regimes they will retain their consumer perceived level of consistency.

The same, however, cannot be said for beef and sheep meat to the same extent. The vast difference between breeds, production systems, environment, feed sources, feed regimes to name but a few have thus far made it very difficult for both the beef and sheep meat industries to provide the consumer with a consistent product.

Many of these factors cannot be standardised throughout the industry. Different breeds will always be produced, different environmental conditions experienced as well as disparity amongst feed source and availability.
However, the one thing that can be easily done is standardising to the best of our ability a prescribed feed regime to finish livestock before slaughter.

A feed system providing the same feed for the same period of time before slaughter is the best way to ensure the consistency of red meat.

This statement doesn't mean necessarily that animals must be fed on this system for their entire life, ensuring the flexibility of grazing systems. Consistency can be achieved by feeding the prescribed feed ration for at least 90 days before slaughter.
This system would allow cattle or sheep from different backgrounds, breeds, grazed or grain fed, region etc to be marketed under the same brand with the same level of consistency.

This cannot happen when marketing simply by breed or region or even as 'grass fed'. If the animal has been finished on different pastures, prescribed feeds and for varying lengths of time the product will lack consistency, regardless of whether it is the same breed or from the same region.

## Point of difference in the marketplace

Once the producer can ensure a consistent quality product, they can then explore the possibility of establishing a point of difference for that product in an attempt to attract a premium or to simply increase market share.
This is essentially a marketing exercise and it needs to be researched thoroughly to ensure the consumer will respond and ultimately pay a premium.
There are many examples of this currently in the red meat marketplace, where producers are using terms such as 'natural' (Hirsche Meats case study), 'Free Range', 'Grain Fed', 'Grass Fed' etc to differentiate their product.

Further differentiation can be made as a result of a prescribed feeding regime, whereby a specific trait can be expressed in the meat as a result of a particular ingredient or ingredients. Traits such as high marbling, guaranteed tenderness, increased shelf life, fat colour and the one that I concentrated on: Functional Food, or traits of benefit to human health such as Omega-3, selenium and Vitamin E.

## Functional Foods

Because foods naturally contain thousands of phytochemicals that are biologically active in the body, virtually all of them have some special value in supporting health. In other words, even simple, whole foods, in reality, are functional foods. But that hasn't stopped food manufacturers from trying to create functional foods as well. The creation of more functional foods has become the fastest-growing trend and the greatest influence transforming the American food supply.
"Many processed foods become functional foods when they are fortified with nutrients or enhanced with phytochemicals or herbs (calcium fortified orange juice for example). Less frequently, an entirely new food is created, as in the case of a meat substitute made of mycoprotien – a protein derived from a fungus. This functional food not only provides dietary fibre, polyunsaturated fats, and high quality protein, but it lowers LDL cholesterol, raises HDL cholesterol, improves glucose response, and prolongs satiety after a meal. Such a novel functional food raises the question – is it a food or a drug."

*Rolfes,Pinna,Whitney. Understanding Normal and Clinical Nutrition*

The red meat industry, in particular the beef industry, is endeavouring to enter the functional food market, foremost by enhancing the level of Omega-3, an area already well advanced in the pork, chicken, egg and milk industries. Some work is also being done on increasing levels of Selenium and Vitamin E.
This can be done by manipulating the prescribed diet, through inclusion of feeds and additives that will manifest as the desired functional trait in the meat.

### *Omega-3*

The human body needs fatty acids, and it can make all but two of them – linoleic acid (18 carbon omega-6 fatty acid) and linolenic acid (18 carbon omega-3 fatty acid) (differentiated by the position of the double bond on the carbon chain) . These two fatty acids must be supplied by the diet and are therefore called essential fatty acids.
The intake of omega-6 fatty acids is generally high, especially in a high meat (western) diet. This results in an imbalanced ratio of omega 6 to 3 at 10-25:1 instead of the desired ratio of 4:1. To balance this ratio an increase in omega-3 fatty acids is recommended usually via the consumption of fatty fish (salmon, sardines, mackerel), however, availability and pressure on fish stocks have led us to obtain omega-3 through other dietary sources.

Linolenic acid is the primary member of the omega-3 family known as ALA (alpha-linolenic acid) the 18 carbon fatty acid that must be supplied by diet. Once supplied, the body can make small amounts of the 20 and 22 carbon members of the omega-3 group, EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). These fatty acids are essential for normal growth and development and are said to aid the prevention and treatment of heart disease. Helping prevent blood clots, protect against irregular heart beats and lower blood pressure, especially in people with hypertension or atherosclerosis.
Sources of Omega-3 fatty acids include oils from flaxseed, canola, walnut, wheat germ and soybean, nuts and seeds (butternuts, flaxseed, walnuts and soybean kernels) as well as soybeans. These sources will provide linolenic acid.
EPA and DHA can be made from linolenic acid and can also be sourced from human milk, pacific oysters and fish (all fish contain varying amounts of EPA and DHA).

As well as these sources, functional foods are being developed to increase the consumer's intake of omega-3. For example hens eating 10% ground flaxseed produce omega-3 enriched eggs, one of these eggs per day can significantly increase omega-3 intake.
The market for omega-3 products is close to maturity in Europe and is a rapidly growing market in North America (now the strongest sector in the functional foods market) and the rest of the world.
Worldwide, launches of new foods and beverages containing omega-3s have more than doubled since 2002, having been given a boost in September 2004 when the Food and Drug Administration (FDA) extended the qualified health claim linking DHA and EPA to reduced risk of coronary heart disease from dietary supplements to foods.

Already the egg, chicken, milk and pork industries offer products marketed as containing high levels of omega-3 as a result of a prescribed feed additive. Fish oil, fishmeal, marine algae, canola oil, linseed oil, flaxseed and forages are concentrated sources of omega-3s. These products have been fed to livestock to enhance the omega-3 fatty acids in livestock products. Flaxseed is higher in omega-3 fatty acids and lower in saturated fatty acids than other feed supplements.
Flax (*Linum usitatissimum)* is an oil seed that contains 41% oil, 20% CP, and 20% NDF. The oil component of flax is approximately 50% ALA, an omega-3 fatty acid.

It is more difficult to create higher levels of omega-3 in ruminant tissues by feeding flax in the diet, because of bio-hydrogenation in the rumen (polyunsaturated omega-3 fatty acids become saturated), a factor that has promoted future research into bacterial species that don't bio-hydrogenate or slow the process as to let more polyunsaturated fats pass through the rumen. But as with poultry and pork, feeding a percentage of flaxseed in a prescribed diet will increase the level of omega-3 fatty acids in red meat.

Research and commercial trials have indicated that 8-10% flaxseed as part of a prescribed diet will increase levels of omega-3 in sheep and beef enough to be marketed as enriched.
But as only about 5% of what is in an animal's diet gets assimilated into the muscle tissue of the animal, there is a limit to how much flax can be fed before feed and cost efficiency decreases.

### *Selenium*

Selenium is one of the body's antioxidant nutrients and regulates the thyroid hormone.
Selenium deficiency can result in a predisposition to heart disease characterised by cardiac muscle tissue being replaced by fibrous tissue (Keshan disease).
Some research suggests that selenium may protect against some types of cancer. It is important to note that food derived selenium is far more effective that supplements.
The significant sources of selenium are seafood, meat, whole grains and vegetables (depending on soil content).
Average intakes in the United States and Canada are above the RDA (recommended daily intake) but the UK are deficient as a nation.
Countries that have selenium poor soils may need to eat grains and vegetables from other regions as well as consuming meat and other animal products that are high in selenium.
An upper RDA limit is recommended as high doses are toxic and causes loss and brittleness of hair and nails, garlic breath and nervous system abnormalities.
This fact has increased the awareness of selenium and contributed to some bad press, but in balanced proportions provided without supplements it is an essential and beneficial nutrient.

Levels of selenium can be increased by adding selenium yeast at 100g per tonne of feed. This is currently being experimented with in a prescribed feed but at this stage not advertised as a result of the consumer concerns about selenium toxicity.

China has low soil selenium levels and consequently is more predisposed to selenium deficiency diseases such as Keshan disease (named after a province in China), highlighting a possible market for selenium enriched red meat.

### *Vitamin E*

Vitamin E is a fat-soluble anti-oxidant and one of the body's primary defenders against the adverse effects of free radicals. Amongst other functions, vitamin E prevents the oxidation of the polyunsaturated fatty acids (PUFA).

Studies have shown that animals having been fed Vitamin E (Alpha tocopherol) at a rate of 1500 mg per day for 60 days as part of a feed ration produce meat of superior colour, increased shelf life and in cases improved taste.

In one trial, beef from animals fed Vitamin E had the longest shelf life of all treatments including the control.

## Case Studies

### Grant Hirsche - Hirsche Farms and Hirsche Frazer Meats, Alberta Canada

Grant Hirsche is a successful Hereford breeder, having won several local and state awards for stud animals as well as exporting genetics to Australia.
As a cattle producer the BSE outbreak in Canada greatly affected him, slowing both the sale of genetics and of his grain finished beef. It also provided him the opportunity to sell his own beef direct to the consumer.
Grant noticed that once the local population was convinced of the product's safety they were willing to support the Canadian farmer, purchasing their meat in preference to imported or meat from large processors.
As a result Grant, with a few local farmers started selling their home grown beef from a roadside van at the rate of around two animals per week.
These animals were marketed to highlight that they were grown by the people selling them, had total traceability, and were hormone and steroid free. Behind the scenes they were all fed the same prescribed ration for the same period, were hung for the same length of time (at least 21 days) and as a qualified meat grader Grant was able to sell only the animals that reached the premium grade.

At first a slow moving project but as more consumers gave positive feedback, commenting that his meat 'tasted like it used to' the confidence was there to expand the operation to its current position.

He now owns a butcher shop in Okotoks Alberta and in 4 years the business has grown to selling fifteen of his own animals per week plus fifty cases of extra cuts sourced from elsewhere.
Average monthly turnover in 2007 was $90,000, projected to $100,000 for 2008.
Grant believes he could sell up to 60 head per week, with his current slaughtering arrangements the limiting factor.
Prices for his primal cuts are very competitive, while his sausages attract a 15% premium and still 'walk off the shelf'. He aims for a 5-10% premium on all his meat and is confident the market will bear this.

All meat is marketed as 'natural' in this case meaning the animals are hormone and steroid free (he will administer antibiotics if necessary) and he has patented the phrase 'Field to Plate' emphasising the origin and traceability of the product.
These are his points of difference in the market place, and in his opinion the reason for their success and ability to compete with the larger plants that have a slaughtering capacity of 6000 head per day (Since the outbreak of BSE, 3 of 3 new small to medium plants in Alberta have gone out of business trying to compete with these large plants).

The following are some points and comments from Grant on this successful venture:

- Natural beef is important to the health conscious and discerning customer (his market demographic)
- Ability to own product through the supply chain
- 99% of beef sold in the shop reaches the highest Canadian grade (similar to MSA grading). The remainder sold to another market
- 1kg of mince from the supermarket could represent 6000 animals, his represents 1 animal
- Several customers report that they reacted or could not eat beef but can eat Hirsche natural beef
- Concentrates on the discerning customer that buys on quality not price
- Quantifies the use of antibiotics by saying "if you give penicillin to a sick child what's wrong with giving it to a sick animal"
- In 4 years would not have lost 4% of his customers

Grant found himself in the unique position where he started from the retail level first, established a customer base and then expanded production to ensure supply as needed as opposed to the common model of developing a product, then endeavouring to find a market for it.

Grant plans to build a plant to process up to 150 head per week of his own and selected cattle and formulate a prescribed ration and feeding regime for these cattle to better control quality and consistency.
He also intends to investigate the inclusion of flaxseed in that ration in an attempt to increase omega-3 levels in his meat.

**Celtic pride, Welsh Meat Company- Wales**

"The Celtic Pride name is owned by the Welsh Meat Company, the largest red meat co-operative in Wales with 750 stakeholders who are predominantly beef and sheep producers. The co-operative is farmer owned and was launched in 2002.
The Celtic Pride brand was developed to offer the producer-members an identity in the market place, as well as offering a 'point of difference' to our product range. It is an undisclosed assumption that our brand image represented on our red meat product range creates value and quality via consistency and this in turn, gains loyalty and trust from consumers who embrace the 'eating experience'.
This project relied on our quality brand image to first perceive, then guarantee a consistent, traceable product to the consumers and was pivotal to the development of the marketing strategy."

*Nicola Raymond –Past CEO Welsh Meat Company*

For its Cetlic Pride beef brand the Welsh meat company will source only animals produced in Wales and by those adhering to the strict producer protocols for Celtic Pride Premium Beef (CPPB).

To outline the producer protocols the following are some relevant excerpts from the document:

- Farms producing CPPB must be registered holdings in Wales and registered under a recognised farm assurance scheme.
- All cattle must be born, reared and finished on Welsh registered farms
- Producers maintain animal liveweight records at agreed intervals
- Farm premises, land, livestock and livestock identification movement records available for inspection at reasonable request by CPPB representative.
- Animals will be reared and finished in semi intensive or extensive systems of production in which grass and other home grown feeds form the major part of the animal's lifetime diet.
- Animals should have at least one summer grazing at pasture in its lifetime.
- Progeny of beef type damn and beef type sire.

- Growth rates of .6-.9 kg/day throughout main growth period.
- Growth rates of 1-1.2 kg/day for 60 days prior to slaughter
- Celtic Pride Feed Compound or Celtic Pride Mineralised Protein Supplement will be fed as a forage supplement during a minimum period of 60 days prior to slaughter.
- Maximum travel distance to slaughter 150miles to avoid stress

The Welsh meat company works in partnership with Wynnstay Feeds, who produce with assistance from the Institute of Grassland and Environmental Research (IGER), the feed and supplement compounds and formulate the required ration each animal must be finished on for at least 60 days before slaughter. As the sole supplier to the CPPB the prescribed feed can be formulated to deliver the quality and consistency Celtic Pride have built their market on, while continuing to investigate areas and opportunities to further enhance the final product such as enriching with Omega-3, Selenium and Vitamin E.

They also work in partnership with Castel Howell Foods Limited, who are the sole distributors of the branded product to many of their 4000 foodservice and independent customers across the UK. Working closely to ensure the production base is adequate and to advise on the supply and demand of the product.

Animals are slaughtered under contract before being distributed to the company's own processing facility, controlling what Nicola believes is the most critical stage of the supply chain process, maturation and packaging. All animals hung and matured on the bone for at least 21 days before processing, packaging and distributing.

Producers delivering to the Celtic Pride brand currently receive a premium of 15pence /kg, 7.5% above the average market price.
The prime cuts attract a 'healthy' premium, whilst the secondary (65% of carcass) cuts are utilised in ready meals and processed foods such as sausages and burgers under the brand, also retaining a premium.

In Jan 2005 the Welsh Assembly Government made it mandatory that all service outlets (hospitals and schools) would only use 100% Welsh traceable meat. As the only project offering this traceability Celtic Pride is in high demand.

The company list the following as their main reasons for their success:

- Controlling the maturation, processing and packaging by owning the processing facility
- Audit and manage producer members who supply the program
- Accept new producers only when market demand warrants
- Wynnstay and IGER invest heavily into R&D, ensuring production methods are modern and effective
- One distributor
- The three businesses (Wynnstay, Castwell Howell Foods and The Welsh Meat Company) are in financial partnership, none carrying more weight than the other.
- 60 day strict feed regime before slaughter, ensuring quality and consistency

Before the brand was launched the company completed extensive market research throughout the supply chain, assessing consumer trends, existing branded programs, distribution packaging and processing.

It was recognised that product availability, consistency and quality were fundamental from producer to the consumer in order to be viable. They also recognised an opportunity in the Welsh foodservice industry. They were looking at a very patriotic Welsh population of over 3 million that had no current branded beef program at the time.

# Recommendations

When marketing red meat you are not only competing against other brands but also against other meats. It is therefore imperative to engage the customer to gain a market share and then ensure that you maintain or improve that market share.

Today's consumer demands a product that is safe, satisfying, convenient and healthy and are increasingly prepared to pay for it. But above all they demand consistency. They must be assured of having the same satisfactory eating experience every time they select a given product, safe in the knowledge that it will be as good as last time.

Australian sheep and cattle are generally marketed by way of region, breed, grass fed, free range etc, aiming for a point of difference in the market place but often not delivering any form of consistency in the final product. For example sheep sourced and marketed under a regional brand that has no strict feeding policy allowing a variety of pasture and grain feeding options will never provide a consistent product regardless of any other constraints or guidelines imposed on the producer.

In my opinion this will result in a loss of market share for that brand. A chef would be reluctant to source meat from a brand if they have no idea how this week's supply will present itself. The same can be said for any consumer.

The easiest way to ensure a more consistent meat product is to finish all stock on the same prescribed feed for the same period of time thus reaching the desired result regardless of differences in breed and environment.

It is also possible to manipulate this prescribed feed, to add ingredients that will translate into desirable traits that will achieve a point of difference in the market.

Once a desired level of consistency has been achieved the producer has a solid marketing base and can then investigate other systems that may give a point of difference. Things like natural, hormone free and free range.

To produce a specific meat product it is imperative to establish a market for it. The appropriate resources must be used to ensure that the consumer will indeed buy the product before you even consider producing it, to use an old Chinese proverb 'if you want to cut the tree down fast, spend twice the time sharpening the axe'.