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MAIZE GRAIN
FOR DAIRY COWS

CONTENTS

INTRODUCTION

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During the past decades New Zealand dairy farms have intensified, with farmers milking more cows per hectare and producing more milk per cow. Feed demand per hectare has increased at a greater rate than pasture supply and as a consequence, there has been a move towards farm systems that strategically use supplementary feeds.

While many farmers have recognized the benefits of feeding home-grown or purchased forages such as maize silage, there has been a large increase in the use of concentrates fed mainly through in-shed feeding systems. In-shed feeding systems are convenient, allowing farmers to easily feed concentrates during milking by simply pushing a button or pulling a cord. While feeding forages normally requires some forward planning, concentrates can usually be purchased as required.

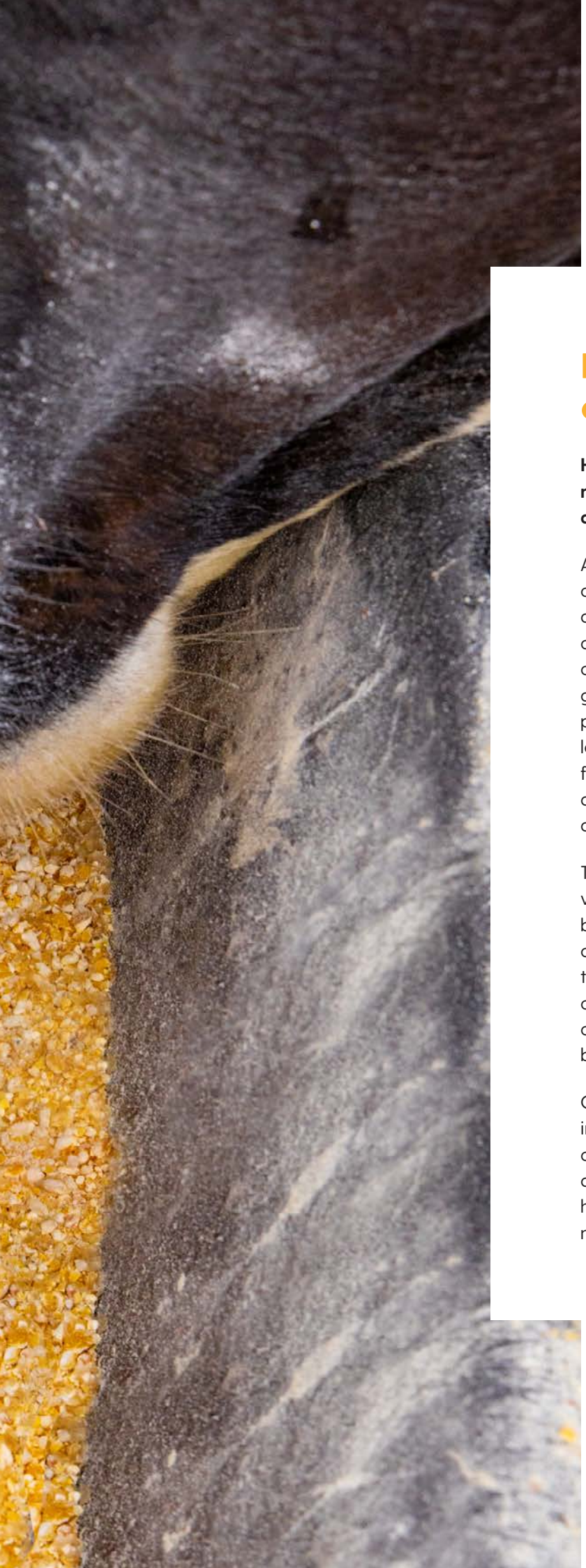
There are a range of concentrates available on the New Zealand market including grains, dairy meal, molasses and palm kernel extract. Maize grain is increasing in popularity with dairy farmers. It has a number of key advantages over other grains and concentrates.

Pioneer® brand maize seed is grown right here on Gisborne farms – it's processed and distributed by a Kiwi family business.

Every Pioneer maize grain crop utilises local merchants to supply its inputs including seed, fertiliser and herbicides. Every hectare is cultivated, planted, sprayed, and harvested by local contractors. Every tonne is dried by local grain companies. Buying locally grown grain supports local growers and the grain industry that purchases their product. Price and supply are not subject to the exchange rate or overseas demand and there is no risk of imported weeds or diseases.

Maize grain is the highest quality commonly used concentrate with higher energy levels than other grains, molasses, palm kernel extract and most dairy meals. It is more slowly digested in the rumen than other grains, decreasing the risk of acidosis. The low nitrogen content of maize grain means it can be used to reduce urinary nitrogen levels, decreasing nitrogen leaching.

1. NUTRITIONAL BENEFITS FOR DAIRY COWS



Feed value relative to other concentrates

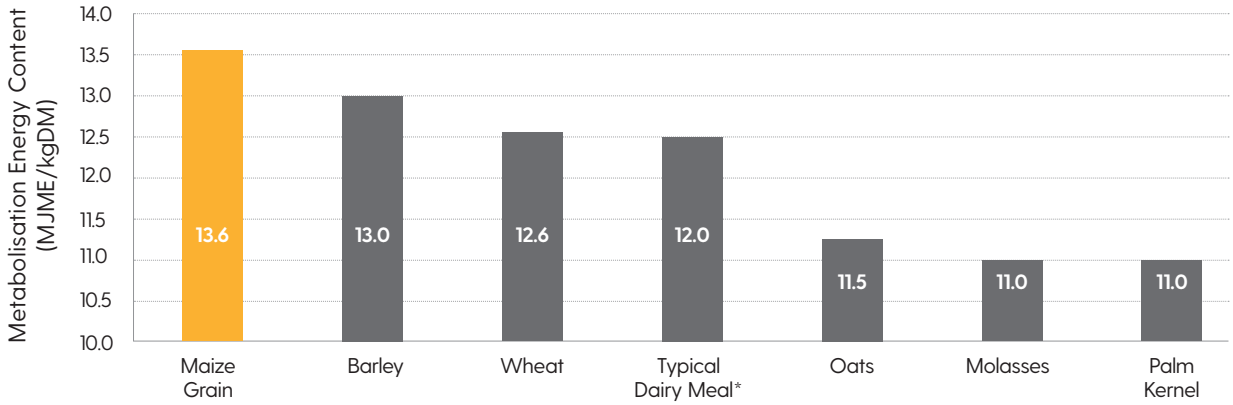
High producing cows have high energy requirements and they must be fed high amounts of high energy density feeds.

A concentrate is a feed with a high concentration of energy. It contains highly digestible components like starches, sugars, other readily available carbohydrates, and fats or oils. Concentrates are mostly processed, i.e. ground, kibbled or pelleted and have very little physically effective fibre. Concentrates create less pasture substitution than forages (such as fresh crops, silages or hay) and they can add additional energy and other nutrients to fill deficits in the diet.

The quantity of pasture available to the cows varies greatly throughout the season. Pasture-based diets can also be deficient in energy and/or protein at times of the year depending on the pasture quality and the type and amount of other supplements in the diet. The composition of the rest of the diet will help determine the best concentrate option to feed.

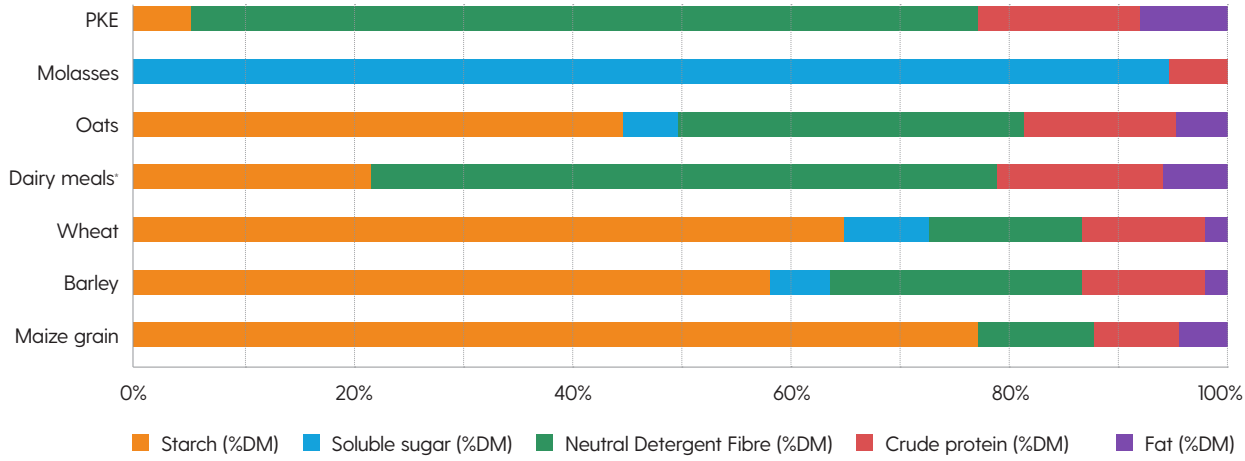
Concentrates which are commonly available in New Zealand include dairy meals, maize or cereal grains (wheat and barley), molasses and palm kernel expeller (PKE). Maize grain has higher energy content than other grains and many other commonly available concentrates.

Figure 1: Typical energy values of New Zealand concentrates [1,2]



Concentrates have differing sources of energy. Some feeds deliver energy via sugar (e.g. molasses) or fibre and fat (e.g. PKE). Maize grain energy comes mainly from starch. The nutrient composition of feeds influences how they are digested, and the end products of digestion affect milk volume and component levels.

Figure 2: Typical nutrient composition of concentrates[3]

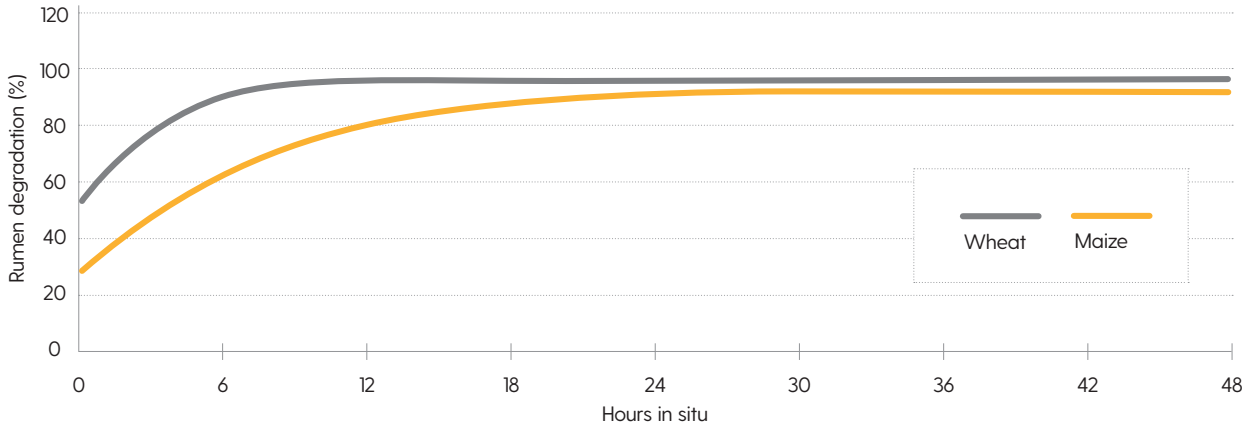


*Dairy meals have different nutrient compositions depending on the components used in the blend

Rate of starch digestion and other nutritional benefits

Although starch and sugar deliver high density energy, over feeding can cause a negative animal health effect known as acidosis. Acidosis occurs when high levels of sugar or starch are converted to large quantities of acid by the rumen microbes. This results in a fast reduction in rumen pH with negative effects on rumen digestion. While the amount of starch or sugar fed is critical, the speed and extent of starch digestion also influence the risk of acidosis. Maize starch is less risky than many other starch types because it is digested more slowly and to a lesser extent in the rumen.

Figure 3: Rumen degradability of maize grain compared with wheat grain[4]

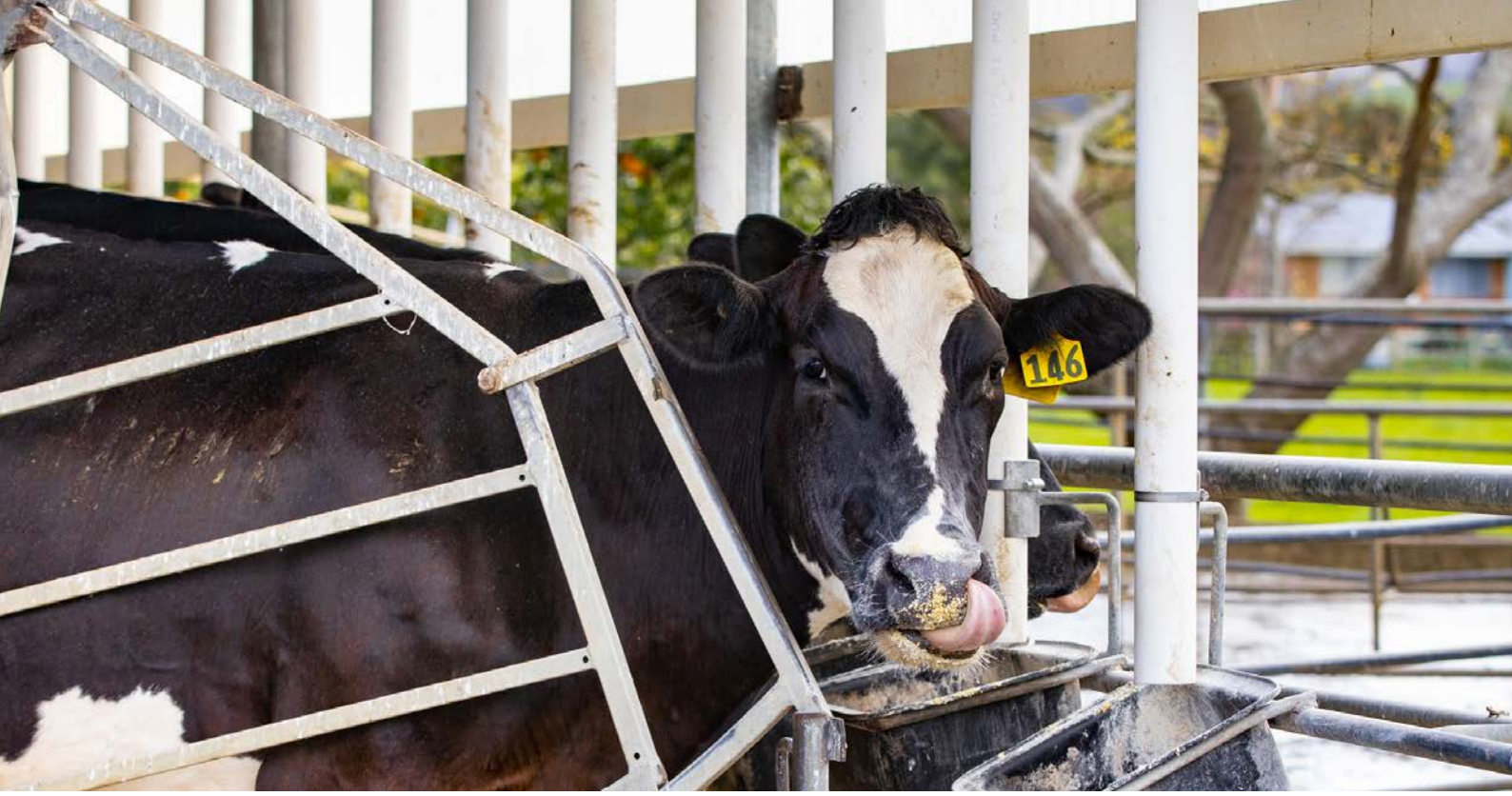


While total digestibility of maize and wheat starch is similar, an extended research project in Germany demonstrated that less maize starch is digested in the rumen and more in the intestine when compared to wheat starch. This resulted in a healthier rumen pH reflected also by a higher rumen digestion of fibre which is a typical indicator of rumen health.

Table 1: Effects of different concentrates (containing 87% maize grain or 87% wheat) on rumen digestion[5]

	Maize	Wheat
Starch digested in rumen (%)	76[a]	95[b]
Rumen pH	5.8[a]	5.5[b]
Crude fibre digestion of diet in rumen	76[a]	69[b]

[a,b] Values with different superscripts are significantly different from each other (P<0.05)



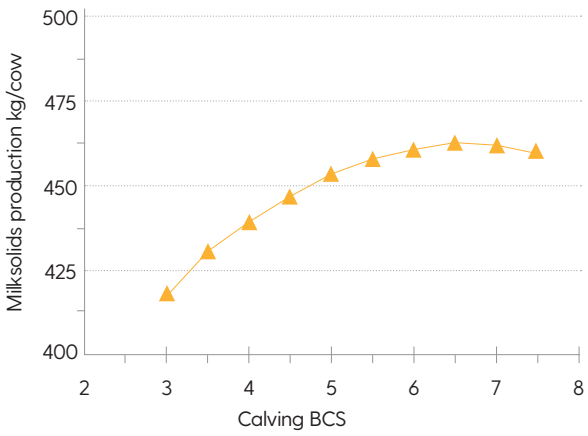
Impact of feeding maize grain on cow condition score and reproductive performance

Following the post-calving period of body condition score (BCS) loss, cows begin to gain BCS. The rate of gain is affected by both genetics and nutrition. In general, high milk production cows gain less BCS than low yielding cows, while milking cows fed supplement that contains non-structural carbohydrates (i.e. starch and sugar) gain more BCS than cows fed pasture alone. With the decline in mid-season pasture quality (and possibly insufficient quantity), BCS gain slows down or cows lose BCS once more. This loss of BCS is different to the loss in BCS post-calving and can be minimised by ensuring pasture quality is high or by providing the cow with high quality supplementary feeds when there is insufficient pasture[6].

Cows selected for high milk production preferentially partition nutrients to milk production and not to BCS gain. BCS increases much more quickly when cows are offered supplements to pasture after they have been dried off.

The benefits of having cows in better condition (the target is condition score 5.0 for mature cows and 5.5 for two and three-year-old cows) are substantial. A cow calving at condition score 5.0 will produce on average 12 kg more milksolids than a cow that calves at condition score 4.0. Cows that meet condition score targets at calving cycle earlier, have higher in-calf rates and are more likely to give birth to a heifer calf the following year.

Figure 5: Relationship between BCS at calving and annual milksolids production[6]



Substitution rates (concentrate vs. forage)

When grazing cows are fed supplements, pasture drymatter intake usually decreases. The rate at which pasture is replaced by supplements is known as the substitution rate.

Forage supplementation decreases pasture drymatter intake more than concentrate. Trials have shown that the substitution rate ranged from 0.84 kg to 1.02 kg for grass silage supplementation and from 0.11 kg to 0.50 kg for concentrate supplementation[7].

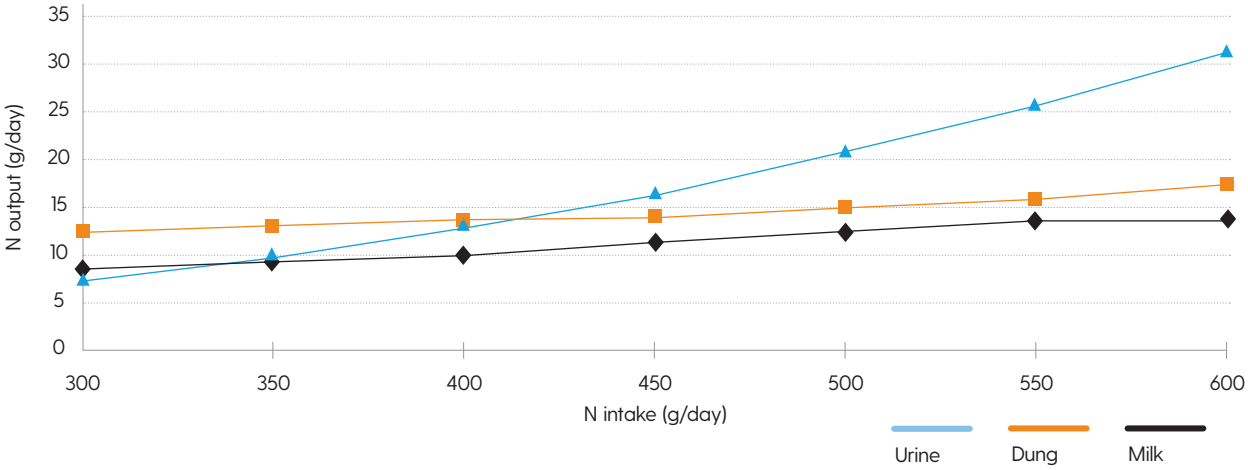
In practical terms this means that feeding concentrates to grazing cows will reduce pasture intake, on average 0.3 kgDM pasture/day for each kgDM concentrate eaten. It will lift total energy intake and enable cows to produce more because metabolisable energy intake is the first limiting factor for milk production for most New Zealand cows.

02.
ENVIRONMENTAL BENEFITS

Reduced dietary nitrogen

Throughout most of the year New Zealand's ryegrass-clover pasture contains more than 20% crude protein. At times, especially in the spring and during the autumn flush, pasture protein level can exceed 30% crude protein. Lactating cows require 14–18% crude protein to support milk production. While nitrogen excretion in milk and dung increases linearly with dietary nitrogen intake, nitrogen concentration in the urine increases exponentially as nitrogen intake increases[8,9]. Put simply, the more nitrogen cows eat above requirements, the more they excrete in the urine and urinary nitrogen levels may be as high as 1000 kg N per ha.

Figure 6: The relationship between daily total N intake and N output in dung, milk and urine[8].



Livestock urine is the dominant source of nitrate-nitrogen leached from soil. Leached nitrate-nitrogen can enter groundwater and waterways, potentially causing ecological harm. Feeding a low protein feedstuff such as maize silage (7.5% crude protein) or maize grain (8% crude protein) in conjunction with high protein pasture dilutes dietary protein content and reduces nitrogen excretion by the cow (Table 3).

Table 3: Effect of feed source on N output in milk, dung and urine in absolute and relative terms (in parenthesis)[10].

Type of silage	N intakte[a]	N output (kgN/cow) *(% intake)*		
	(kgN/cow)	Milk	Dung	Urine
Lucerne	37	6 (16)	8 (22)	23 (62)
Pasture	24	6 (25)	7 (29)	11 (46)
Cereal	16	6 (38)	5 (31)	5 (31)
Maize	12	6 (50)	3 (25)	3 (25)

[a] Based on an intake of 1 tDM/cow.

Maize grain can be grown in lower risk areas and fed in sensitive catchments to decrease dietary nitrogen and therefore the magnitude of nitrate leaching.

03.
ECONOMIC BENEFITS

Milk response rates (DM or energy basis)

The response rate to supplements varies depending on a number of factors including the type of supplement, the time of the year when it is fed, pasture cover levels and the total drymatter intake.

Strategic feeding (e.g. using feeds to extend lactation or to fill feed deficits during the lactation) will normally generate a higher milksolids response rate than feeding continuously throughout the lactation.

DairyNZ's Facts and Figures for New Zealand Dairy Farmers[11] gives a range of possible response rates to good quality supplements (> 10.5ME) fed with low (< 15%) wastage (Table 4).

Table 4: Seasonal milksolids response to supplements (on a drymatter and energy (MJME) basis)[11].

Time of season	Milk response rate*	
	(gMS/MJME)	(gMS/kgDM) @11 MJME
Spring	8.0 - 12.0	90 - 130
Summer	7.5 - 11.0	90 - 120
Autumn	7.0 - 8.0	80 - 90

*Residuals <6 clicks (1,350 kg DM/ha) if no supplement fed

Milksolids response of cows fed grain

A number of New Zealand trials have measured the milksolids response of cows fed grain:

- In the 1.75 t MS/ha trial, Herd 6 was fed a total of 1,247 kg maize grain per cow during the lactation. The milksolids response rate was 99 g MS/kgDM fed or 7.6 g MS/MJME[12].
- Penno et al. (1996) offered rolled maize to grazing dairy cows in a two-year farmlet experiment. At a stocking rate of 3.24 Friesian cows per hectare annual milk yields were increased by 76 g MS/kgDM of grain fed. When stocking rates were increased to 4.48 cows per hectare annual response rate was increased to 88 g MS/kgDM grain fed[13].
- In a further farmlet trial Friesian cows stocked at 4.41 cows per ha conducted over three complete seasons the milksolids response was 96 g MS/kgDM grain. Penno concluded that full lactation responses of 7.5 g MS/MJME can be expected when grain is offered to dairy cows grazing restricted amounts of pasture[13].

Data collected from 60 seasonal supply farms situated in the lower North Island and South Island was used to determine the response to grain being achieved under commercial conditions[14]. On average the farms fed 179 kg grain per cow per year with the range between 0-952 kg/cow/lactation. Average milksolids production was 435 kgMS/cow with a range from 310-595 kgMS/cow. The average response to grain was 88 g MS/kgDM fed in the 2009-10 season and 146 g MS/kg fed in the 2010-11 season. The average response over the two years was 117 g MS/kgDM grain. The short-term response to grain varied between seasons with the response rates being:

- Spring (50-54 g/kgDM grain fed)
- Summer (141 – 193 gMS/kgDM grain fed)
- Autumn (116 – 138 g MS/kgDM grain)[14]

It is worthwhile noting that these responses were calculated using a range of grain types. Milksolids response is generally driven by energy intake. Arguably higher response rates could be expected with maize grain since it has a higher energy content than other grains.

04. OTHER BENEFITS

Labour

There is minimal labour required to feed maize grain through an in-shed feeding system compared to feeding silage or hay or grazing a green-feed crop. Usually the person milking the herd can “push a button” or “pull a cord” to feed each row of cows.

Convenience

Maize grain is convenient to feed in that it can be ordered when required and delivered within a few days. In many cases payment for the grain is due at the end of the month by which time the grain has been fed and a milk return generated. This is very good for cashflow.

Reliability of supply

There is an established maize grain industry in New Zealand ensuring year-round supply of maize grain as and when required.

Price stability

There are a large number of factors that impact the NZ landed price of imported feeds such as palm kernel. These include:

- Production costs at origin
- World demand for the product
- Shipping costs
- Exchange rate

Locally grown maize grain prices are subjected to less variation with the pricing being determined only by growing costs and local demand relative to supply. While the price of imported feeds tends to change on a daily basis, maize grain price is more stable over time.

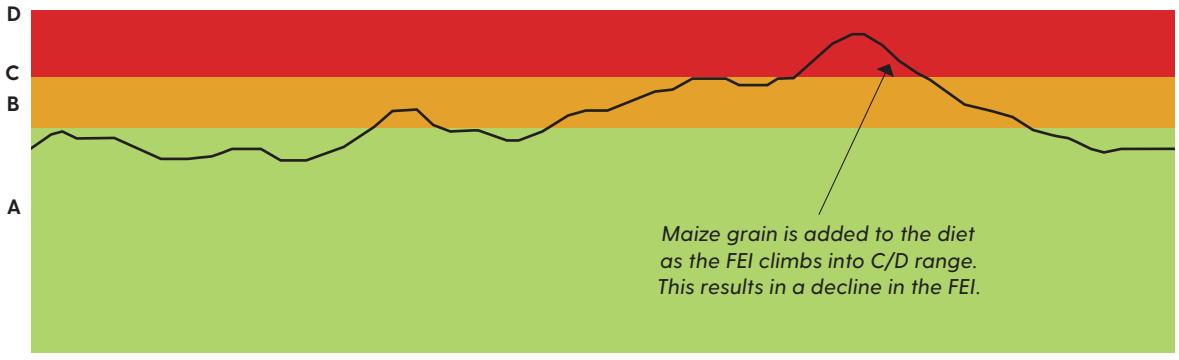
Milk quality

Fonterra customers will be penalised if the fat evaluation index (FEI) of their milk sits in either the C or D range. The penalties for a C grade are

two demerits and 10% deduction per collection day while a D grade penalty is four demerits and 20% deduction per collection day.

As PKE has been considered the key culprit, farmers have been advised to feed no more than 3 kgPKE/cow/day. For those farmers needing to feed more than 3 kgDM/cow/day, maize grain provides a high quality alternative which will not negatively impact FEI.

Figure 7: Typical summer FEI graph showing penalties associated with high PKE feeding rates



A grade milk meets processing requirements

B grade milk meets processing requirement but is approaching the threshold

C and **D** grade milk exceeds threshold limits

05. MAIZE GRAIN OPTIONS FOR DAIRY COWS

Maize grain can be fed as earlage, high moisture corn or dry grain. Product form has implications for pricing, logistics, losses and feed value

Table 6: Composition, harvest, processing and storage method of maize production options[15]

Maize product	Composition	Harvest and processing method	Storage method	ME MJ/kgDM
Earlage	100% kernels +100% spindle + 80-100% husks + <20% stover	Precision chopper with ear picker	Silage (bunker, bag or bale)	12.5
HMC	100% kernels	Combine and mill	Silage (bunker, bag or bale)	13.6
Dry grain	100% kernels	Combine, drying and cracking or grinding	as dry grain in bins	13.6

Table 7: Nutritional value of maize product options[16]

Maize product	Drymatter %	Starch %DM	NDF %DM	Crude Protein %
Earlage	55-65	50-60	20-25	8-10
HMC	68-72	69-72	8-10	10
Dry grain	89	75	9	8

Dry grain

Maize grain is normally harvested at 23-26% moisture (74-76% DM), transported to a drier and air dried to 14% moisture (86% DM). Dry grain has advantages for transport because very little water has to be shipped. It is also very stable and will hold its quality for long periods as long as it is kept dry. Dry grain needs to be processed to allow cows to efficiently utilise the nutrients it contains (see pages 19-20 for more details).

The feed value of dry grain is characterised by high energy density and a lower rumen degradation rate when compared to high moisture corn (HMC) or maize earlage.

Alkagrain maize

Alkagrain maize is a mix of maize grain and patented pellets which contain a unique mix of urea, soya and a specialist enzyme that breaks down urea to give off ammonia which is a powerful preservative. Maize grain is harvested at 65-85% drymatter, mixed with the pellets, processed and stored in a bag, under cover in a shed or in a silo. Alkagrain is preserved in an alkaline state. It has a higher protein content and is claimed to have higher ME and higher digestibility than dry grain maize.

High moisture corn

High moisture corn is typically harvested when the maize grain is between 68-72% drymatter using a combine. The grain is rolled prior to fermentation. The key advantages of high moisture corn are that it can be harvested prior to normal grain harvest maturity, there is no drying cost and it is very high in feed value. Dr. Mike Hutjens (University of Illinois, USA) likens this product to “rocket fuel”.

High moisture corn is not as easy to transport as dry grain. It must be ensiled and there is a loss in drymatter during the ensiling to feed-out process. High moisture corn has a potential for aerobic instability (heating at feed-out time) and because it has a relatively high moisture content for a concentrate, it will not flow through most in-shed feeding systems.

Earlage

Maize earlage is an ensiled product that has a feed value and yield that falls between that of maize grain and maize silage. It is normally harvested at 55-65% drymatter using a snapper head on a forage harvester.

Earlage is normally harvested several weeks prior to grain harvest and because it is an ensiled product there is no requirement for drying. Earlage delivers some physically effective fibre which makes it safer to feed than other concentrate options.

Earlage must be ensiled and there is a loss in drymatter during the ensiling to feed-out process. It contains more water and is less energy dense than dry grain so the transport cost per unit of energy is higher. Earlage has a potential for aerobic instability (heating at feed-out time) and it will not flow through in-shed feeding systems.

06. FEEDING GUIDELINES FOR MAIZE GRAIN

Feeding rates

Maize grain feeding rates will vary depending on the age and production level of livestock and the amount and type of other feeds in the diet. General recommendations are as follows:

- Feed a maximum of 30% of the total drymatter intake as maize grain*
- Start at lower rates (e.g. 1 kg maize grain per cow per day) and increase the feeding rates gradually over 7-10 days
- Feed a maximum of 2.5 kgDM maize grain in a single feed

Feeding a proven buffer such as sodium bicarbonate or Acid Buf (see *www.feedworks.co.nz*) can help reduce the risk of acidosis. Talk to your local dairy nutritionist or veterinarian for farm specific advice and ration balancing.

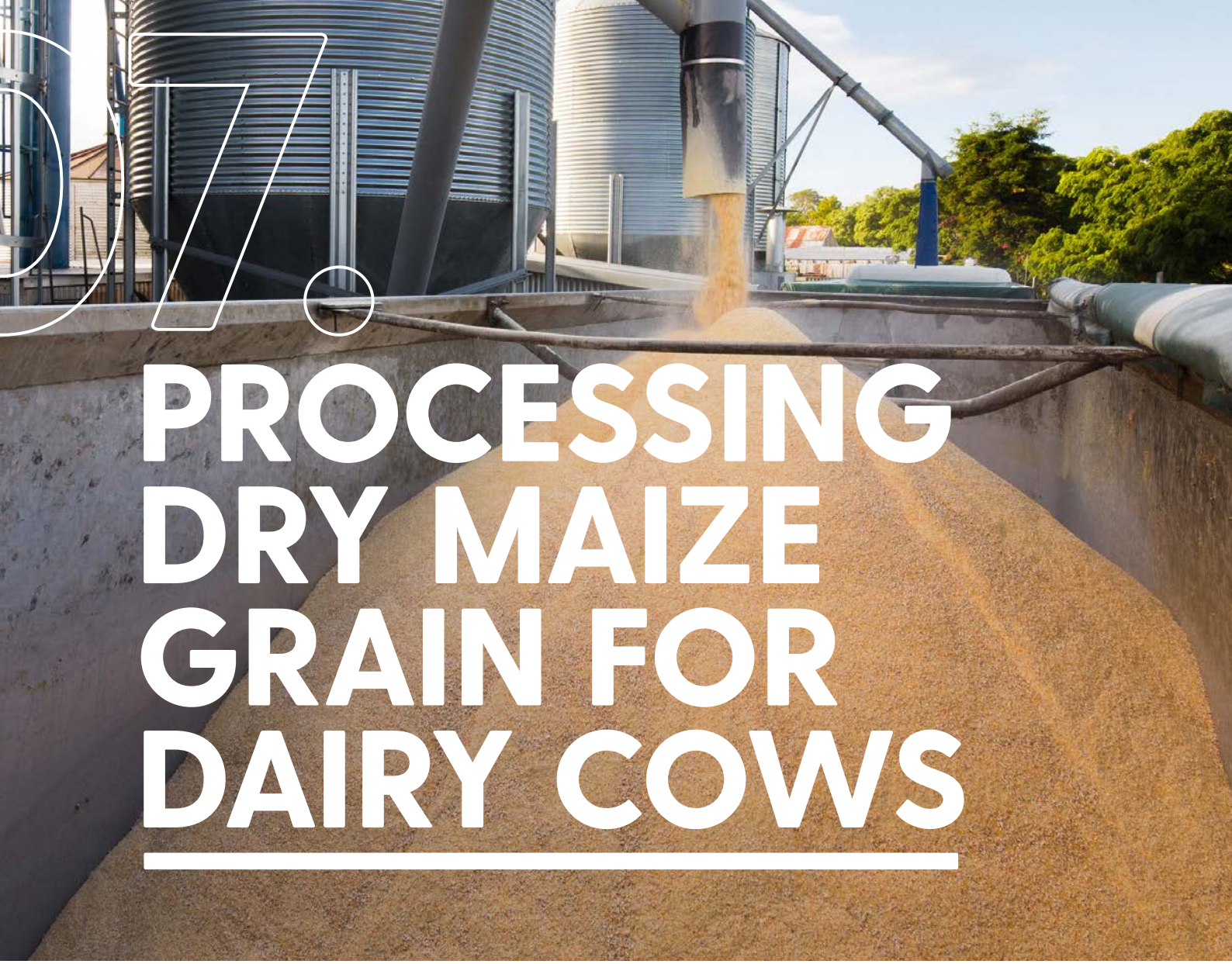
* Feeding rates will be lower in diets that contain other sources of carbohydrates (e.g. other grains, dairy meal, molasses or high sugar or starch by products).

Acidosis

Acidosis can occur when cows are fed either too much starch or sugar, or where the starchy/sugary feed has been introduced too rapidly into the cow's diet. Starch and sugars are digested quickly by microorganisms in the rumen of the cow. The end products of this digestion are acids, which the cow then uses for energy. However, when a cow eats a lot of starchy or sugary feeds and/or she is not accustomed to these feeds, she produces dangerous levels of lactic acid, becomes ill, and in severe cases can die.

To reduce the risk of rumen acidosis always:

- Introduce high starch or sugar feeds into the diet slowly
- Watch total dietary levels of starchy or sugar feeds.
- Ensure that the diet contains adequate levels of long (functional) fibre
- Ensure that individual animals cannot gorge high risk feeds



07. PROCESSING DRY MAIZE GRAIN FOR DAIRY COWS

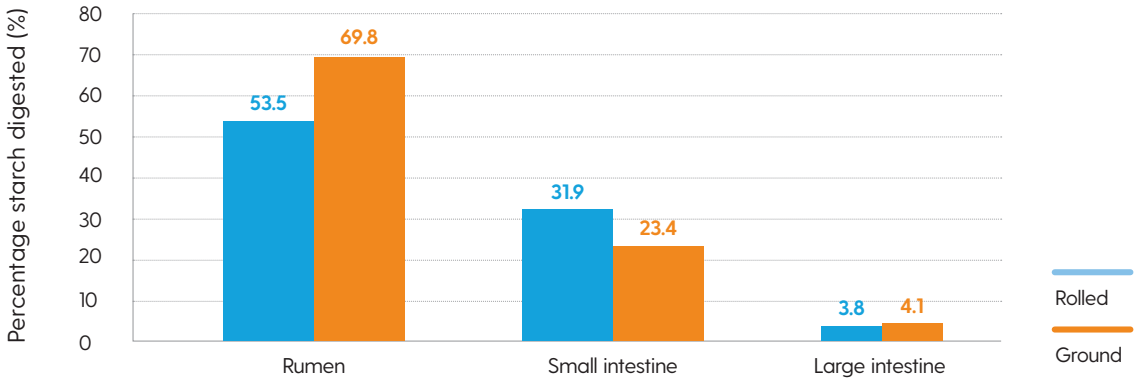
When unprocessed maize grain is fed to dairy cows 15-30% will pass through the digestive tract as undigested whole grain. To minimise this loss, grain must be processed to maximise its feed value. Processing grain disrupts the kernel and exposes the nutrients to rumen fermentation and lower gut digestion. Reducing the particle size or increasing starch solubility (such as in gelatinised or high moisture grain) increases the rate and level of rumen fermentation and digestion.

Impact of particle size on starch digestion and milk production

Maize that is finer ground has a higher digestibility than coarse ground maize. Fine grinding will increase total tract and rumen starch digestion and reduce small intestine starch digestion.

In a USA feeding trial, ground maize (568-micron particle size) or rolled maize (3458-micron particle size) was fed to lactating cows at 5.6 kg maize grain per day[20]. When compared to the rolled maize, the ground maize had 8% higher total tract digestibility, 16% more starch was digested in the rumen and 8.5% less starch was digested in small intestine (i.e. smaller particles shifted the site of digestion from the intestines to the rumen[17]) (Figure 10).

Figure 10: Effects of grinding on the site and extend of maize starch digestion[17]



Grain processing targets

A fine line exists between maximum rumen performance and an unhealthy rumen environment particularly where a high amount of starch or sugar is being fed. The ideal amount of grain processing will depend on a number of factors including the amount of grain being fed, the frequency, the grain feeding system and the type and amount of forage in the diet.

Dr Mike Hutjens (University of Illinois) makes the recommendation that maize grain in USA dairy cow rations is ground to 1100 microns. He says, "To determine if your dry maize averages 1100 micron, take a cup of it and sift through a baker or kitchen flour sifter. If 2/3 of the grain passes through the screen, it is about 1100 microns"[18].

Time between processing and feeding

Processed maize grain will hold its quality for long periods when stored in a clean, dry place.

08.

SOURCING MAIZE GRAIN

There are a significant number of grain companies who can supply whole or processed maize grain. Talk to your local maize planting or harvesting contractor or call 0800 PIONEER (0800 746 633) to speak to a pioneer representative & find the supplier closest to you. Some farmers are choosing to grow their own supply of maize grain on farm or a run-off. Alternatively, the crop can be harvested as earlage or high moisture corn. The latter two products are not suitable for feeding in most meal feeding systems.

CONCLUSIONS

Maize grain is an excellent supplementary feed option for New Zealand dairy farmers. For more information on any aspect of feeding, processing or storing maize grain, or if you are considering growing a crop yourself talk to your local Pioneer representative on **0800 PIONEER (0800 746 633).**

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