The Future
Of
Fodder Beet

Kellogg Course

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1.Executive Summary

This report aims to identify the advantages and disadvantages of fodder beet (FB) as a feed option for lactating cows in the dairy industry. In this report I analyze the cost to grow, harvest and transport fodder beet. In addition, I compare similar stock feed that includes: palm kernel expeller (PKE), and grain. I pay particular attention to the nutritional and environmental factors involved with each type of feed.

To begin, I give a brief overview of PKE, grain and FB. Next, I examine the key physical attributes and history of the different supplements. The next section outlines the different dairy farm systems in relation to the level of supplements used on farms.

In this report, I review the factors that influence the cost of supplements. From these factors, I then assess the actual cost of the different supplements. Once I convert these dollar figures and apply the amounts to an energy unit, I then pair this information against the average dairy payout figures from past years. From here, I then calculate the profit margin of each feed. This figure is then extended beyond an individual farm by applying industry statistics to the calculation. I use the calculation to then highlight the potential benefits a change in feed could provide for the entire dairy industry.

Another major issue associated with supplements is the environmental concerns. In my report I provide the opposing viewpoints with regard to the usage of PKE. This section is designed to highlight the difficulty associated with achieving collaboration when the opposing views are so strong.

I conclude by addressing the difficulties with feeding FB, one example is acidosis. However, I also provide the potential nutritional benefits associated with lower levels of excreted nitrogen, and therefore more protein is utilized and absorbed by the cow.

This report strives to be both informative and provocative. I want to inform the reader on the current issues surrounding supplements, but also, and perhaps more importantly, challenge the reader to think outside the box and reach for solutions. We live in a world of constant change as this report continually highlights. For us to move forward as a collective, we must embrace this constant change in order to prosper.

2. Introduction

Traditionally in the temperate climate of New Zealand, dairying consists of grazing animals outdoors for the entire year (Beukes et al., 2008). Farmers supplement pasture with conserved feed. The factors that determine the conserved feed amount include: seasonal pasture growth, genetics of the herd and stocking rate (Beukes et al., 2008).

In recent years farmers feed supplements that are imported from often far outside the farm gate. This causes New Zealand to lose its competitive advantage as a low cost producer on the global stage. Examples of these supplements are grain and PKE. In 2014 grain usage in New Zealand exceeded one million tons, and PKE imports exceeded two million tons (NZFMA, 2015).

The New Zealand dairy industry received criticism from environmental organizations, in which these organizations suggested the import of PKE contributed to deforestation. The media then created a flow on effect of misinformation, which could result in a negative public perception of the industry. This report outlines some of these issues, and provides possible solutions.

3. PKE

PKE is a by-product made from the extraction of oil from the palm kernel seeds and fruits of the oil palm*.* The oil palm originated in Africa, and was later exported to grow around the world for its oil properties (Ministry for Primary Industries, 2013a).

The palm kernel is the edible seed of the oil palm tree (Figure 1). The fruit yields two distinct oils: palm oil derived from the outer parts of the fruit (crude palm oil, and palm kernel oil) and palm oil derived from the kernel. The pulp left after this extraction forms into the palm kernel expeller. The palm kernel expeller is the mashed solid part of the seed kernels that remains after the oil extraction process. The industry refers to this product as palm kernel expeller or extract PKE (Ministry for Primary Industries, 2013a).

As a final product, PKE (Figure 2) is a pure homogenous processed material produced under extremely high temperatures (Ministry for Primary Industries, 2013a)

Figure1: Palm Kernel Seed

FIGURE 2: PALM KERNEL EXPELLER (PKE)

(Ministry for Primary Industries, 2013a)

4. Grain

Grains are small, hard, dry seeds, with or without attached husk or fruit layers, harvested for human or animal consumption (Babcock, 1976). Grain usage in New Zealand's dairy industry is predominantly barley, wheat and maize grain. Grains involvement in human food production dates back a millennium. For example, the Inca grew corn as staple food in Central America (National Research Council, 1989).

The small size and hard dry shell, allows grain to be stored, measured, and transported more readily than other kinds of food crops, such as fresh fruits and roots. The use of grain agriculture allowed people to produce excess and easily stored food for the first time. This ability to store excess food may have contributed to both the creation of the first permanent settlements and the division of society into classes. Kings, priests and soldiers could easily measure and "tax" a portion of a farmers grain crop, allowing the non-farming classes to pursue activities other than farming, hunting or gathering full-time (Wessel, 1984).

Farmers kept the best performing grains every year for re-planting the following year. This resulted in overall genetics positively evolving from the original strains of grains farmed thousands of years ago, and created the high performing crops of today (National Research Council, 1989).

In New Zealand dairy systems, the different grains are either crushed or palletized either on farm or at processing sites to aid animal digestion. This can add an extra cost to grain use, and contrasts the relatively inexpensive option of FB as a feed.

5. Fodder Beet

FB is a high-energy feed 12.5 – 13 Mega Joule Metabolisable Energy (MJME) with a similar nutritional profile to maize. Like maize, FB is high in carbohydrates and low in protein (DairyNZ, 2012).

People domesticated FB pre-historically somewhere in the Middle East. Because the wild species normally flowers two-three months after emergence, the first farmers would likely have selected beets with delayed bolting and flowering. Through this method of selective breeding, FB developed into a biennial plant and entered a reproduction phase after winter. It is speculated that FB was grown in the Mediterranean 1000 BC, and it later spread through the Roman Empire (Bradshaw, 2010).

Unlike ancient FB, sugar beet is a relatively new plant. It was not cultivated until the early 1800s and was bred from FB. This breeding established different traits in sugar beet from the original FB. These properties include, lower moisture content (less volume for carting) and higher energy levels. In addition, the main use for sugar beet is to serve as an alternative to sugar cane in areas that are not suitable for sugar cane cultivation, such as in parts of Europe (Bradshaw, 2010).

For the area FB needs to grow in, it produces a high yield and can grow up to 100% more volume than grass. As a result of this high yield, it requires more nutrients relative to grass to grow. In recent years FB gained popularity in New Zealand's farming systems as a main feed source for stock in winter (Gibbs, 2011). FB currently also plays a role during the shoulders of seasonal lactation to fill feed deficits (Gibbs, 2011).

6. Systems

Farm systems that feed grain and PKE are usually systems 3-5, with the exception of silage imported from outside the dairy platform (Figure 3). Profitability of feeding supplements in pastoral systems are affected by the substitution rate. "The substitution rate is defined as the decrease in pasture intake per KG of supplement fed" (Kellaway & Harrington, 2004).

Table 1: Farm Systems In New Zealand

System 1 – All grass, self- contained, all stock on the dairy platform No feed is imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows are not grazed off the effective milking area. System 2 – Feed imported, either supplement or grazing-off, for dry cows Approx 4-14% of total feed is imported. Large variation in % as in high rainfall areas and cold climates such as Southland, most of the cows are wintered off. System 3 – Feed imported to extend lactation (typically autumn feed) and for dry cows. Approx 10-20% of total feed is imported. Feed to extend lactation may be imported in spring rather than autumn. System 4 – Feed imported and used at both ends of lactation and for dry cows. Approx 20-30% of total feed is imported onto the farm. System 5 – Imported feed used all year, throughout lactation and for dry cows. Approx 25-40% (but can be up to 55%) of total feed is imported.

(DairyNZ, 2012)

7. Cost of supplements

Both national and global factors directly dictate the prices of supplements. One of the major contributors to this price is the supply and demand for a product. Factors that dictate the rate of supply and demand include: crop growth, energy price movements, the influx or decrease in milk or beef price (which can influence the demand for supplements) and government regulations and subsidies (Westcott & Hoffman, 1999).

In my opinion, valuing supplements from solely a supply and demand standpoint does not offer enough information to make a well-informed decision on the real "cost of feed." Instead, to understand the complexities associated with the "cost of feed" one must consider how expanding globalization can make prices and industries more volatile.

Globalization is one of the core factors that induce reallocation. In principle, the opening of markets and the reduction of trade barriers permits productivity and enhances restructuring and reallocation. Globalization also involves globalized financial markets. The increased sophistication and globalization of financial markets is again in principle favorable for productivity-enhancing reallocation. This propels the ongoing need for reallocation of outputs and inputs from less productive to more-productive businesses or markets. This need involves firm entry, firm exit, firm expansion and firm contraction and thus creates volatility (Haltiwanger, 2011).

In theory, these richer financial markets should allocate risk more effectively through diversification and the wider financial instruments available. The traditional view that this increased specialization into the production of products for which a country has comparative advantage. However, it is also clear, especially from the past few years, that global financial markets are fragile and subject to sudden collapses in some segments which can become contagious in other segments of the market. Such fragility in financial markets can act as a source of undesirable volatility and a distortion to productivity-enhancing reallocation (misallocation of capital) (Haltiwanger, 2011).

Table 2: Price Comparison Per Tonne

PKE $190-$370 T 2012-2015 (DBC, 2015) **Barley & Wheat** $350-$480 T 2012-2015 (NZX Agrifax, 2015) **Fodder Beet** To grow fodder beet on farm: Growing/ha $2250 Lifting/ha $875 Cartage/ha $330 Storage/ha $100 Total/$3555 Tonnage per Ha 15-25 T = $142-$237 T (DFL SEEDS, 2015)

8. Profitability of Supplements

Dairy NZ states that as long as the post pasture grazing residuals do not exceed 1550 kilograms (KG) of dry matter (DM) per hectare (Ha) then the milk solid (MS) response rate will be in the range 5.5 - 7.5 grams (g) per MJME (DairyNZ, 2015).

I used this relation between feed weight, energy and milk solid to calculate the profitability of the supplements. New Zealand's price paid to farmers for milk is paid per KG/MS. The average paid price after inflation during the last ten years was $6.65 KG/MS (LIC, 2014). If this is converted to cents (c) per g/MS, then the average payout for the last ten years was 0.67c g/MS. In fact, since 1995 just four years of inflation adjusted prices fell under $5.00 KG/MS (LIC, 2014). The lowest price adjusted for inflation paid by Fonterra of $4.40 in the 2014/15 season once converted to cents per g/MS equals 0.44c g/MS. The average payment in the last ten years has therefore equated to 3.69c – 5.03c MJME. Fonterra's low payout of $4.40 equated 2.42c – 3.30c MJME.

Converting different feed types using the price paid per tonne in **Table 2** from **Cost of Supplements** section, into c/MJME effectively compares the profitability of different supplements.

Table 3: Energy Values Of Feed

PKE 11 MJME KG/DM	Wheat 13 MJME KG/DM
Barley 12.5 MJME KG/DM	Fodder Beet 12.5 MJME KG/DM

(DairyNZ, 2012)

PKE 19c-37c/ 11 MJME = 1.72c-3.36c MJME
Wheat 35c-48c/ 13 MJME = 2.69c-3.69c MJME
Barley 35c-48c/ 12.5 MJME = 2.8c-3.84c MJME
Fodder Beet 14.2c-23.7c/ 12.5 MJME = 1.14c-1.90c MJME

Compared to the average ten year payout of 3.69c - 5.03c MJME, almost all of the supplements are profitable except barley at $461 T if the lowest response rate is realised.

During the Fonterra 2014/15 season record low payout of $4.40 KG/MS or 2.42c – 3.30c MJME, the farmer could only gain a return using grain if he purchased grain at a cheap rate and received an above average milk response. Conversly, if the same farmer fed PKE at a cheaper cost than $266 T using the low milk response, he could have been also profitable.
If the farmer fed FB that he purchased at $237 T (15 T Yield) if we calculate using the lowest milk response rate, then the gross income would equal $302 per T fed, with a margin of $65 T. This is a 27% return, which is very profitable.

To highlight the potential of FB to profit in a New Zealand dairy system, I used the equation as mentioned above. I used an average milk payout of $6.65 KG/MS(LIC, 2014), and converted this with a DairyNZ low response rate of 5.5g. After I did this the total income per T of FB fed was $461 T. From this number and using improved average yields of FB from 20T/Ha (DFL SEEDS, 2015)to 25T/Ha. FB would cost just $142 T, it shows an increase margin to $319 T fed a 225% return.

The approximate total amount of PKE and grain fed to dairy cows in the 2014/15 dairy season was 3 million T (NZFMA, 2015). Using FB with a margin of $65 T and $319 T, the total benefits to the economy equal $195,000,000 and $957,000,000 respectivly. If we divide these amounts by the estimated 12 000 New Zealand dairy herds, this equals $16,250 and $79,750 per farm (LIC, 2014).

9. Environment

PKE is the most controversial feed product out of PKE, grain and FB. As a nation, New Zealand increased imports of PKE from 200,000 T (Ministry for Primary Industries, 2013a) in 2006 to 2,000,000 T by 2014 (NZFMA, 2015). This rate of import is a 900% increase in just eight years.

Fonterra, New Zealand's largest manufacturer of milk, originally started importing PKE as an easy option to secure milk production during major feed deficits (such as droughts). Fonterra recognized that customers will pay a premium for grass produced milk. Today, Fonterra recommends that its suppliers limit their feeding to 3 KG/DM cow per day of PKE. In addition, Fonterra indicates that the company will start to regulate the amount of PKE fed to maintain the grass fed premium received from world markets (Fonterra Co-opritive Group Limited, 2015).

In 2013 the palm oil industry was Indonesia's third biggest export earner. In this year, 87% of New Zealand's imports came from both Indonesia (44%) and Malaysia (43%). Because of the demand for palm oil in this region, the total palm oil plantation area worldwide sits around 8 million ha with a predicted rise to 13 million ha by 2020. (Ministry for Primary Industries, 2013a).

There are several groups in New Zealand that are concerned about the amount of PKE imported into New Zealand. The main concern by environmental groups such as Greenpeace is deforestation, animal and habitat extinction and the increase in greenhouse gas emissions due to land usage change and palm oil industry activities (Carlton, 2011).

PKE represents only 1.2% in value chain of the palm oil industry received by palm growers, derived from Malaysian statistics by Federated Farmers. They debate that "PKE does not drive destruction of Borneo's rainforests or habitat loss, just as plastic recycling does not drive the oil industry." They reply to the question; "Does New Zealand Need PKE? PKE is imported so long as it remains economically viable for importers to do so." (Federated Farmers of New Zealand, 2011).

When PKE is converted into milk production using 20% wastage figures, 11 MJME per KG/DM (DairyNZ 2012) and a conservative 5.5g response rate, (DairyNZ, 2012) 2 million T of PKE converts into 121 million KGMS milk, and significantly contributes to the LIC reported 1,825 million KGMS collected (LIC, 2014) in the 2013/14 season, or 6.7% of New Zealand production.

Another concern with importing PKE is the biosecurity risk that it poses to New Zealand. In 2013 MPI conducted audit reports on exportation from Indonesia and Malaysia. Based on these reports the MPI found minor biosecurity breaches in storage facilities regarding bird protection. New Zealand security worked with overseas authorities to ensure they amended these breaches. The certification and fumigation procedures now fully meet New Zealand's requirements (Ministry for Primary Industries, 2013b). A potential method to avoid PKE's biosecurity risk may be found with a decrease in import of PKE and a simultaneous increase in grain or FB consumption.

Grain and FB have similar environmental risks at the initial planting stage. When the farmer preps the ground for plants to germinate, and also during root establishment, the soil is vulnerable to any adverse weather events (wind and heavy rain) and this can lead to soil erosion. Soil erosion reduces fertility of land and degrades river quality (Ministry for the Environment, 2001).

FB could offer potential solutions to effluent disposal on dairy farms in New Zealand. Effluent disposal is a constant environmental concern and the effects of effluent on the environment vary depending on the level of treatment and the state of the disposal area. The organic processes that break down dairy effluent require a lot of oxygen. The Environment Bay of Plenty Regional Council (2003) states that when effluent is discharged to a watercourse it can significantly reduce the ability of the water to support aquatic life. The addition of nutrients to water commonly results in rapid growth of weeds and algae, which can then lead to further loss of oxygen as the plants die and decompose. When effluent is continually discharged to a waterway, the water quality can deteriorate to a degree that most dissolved oxygen is removed. Resulting in loss of aquatic life and a collapse of the freshwater ecosystem.

If the farm relies on FB as a major crop, the farm could apply effluent at a higher rate when cultivating ready for crop establishment. Because FB has a deep tap root and it requires more nutrients then grass per Ha/year, uptake of effluent would be higher then grass. These nutrients would later then be redistributed around the farm when FB was lifted and fed to cows. Leading to less nutrient runoff.

10. Nutrition

Fodder beet is high in energy and moisture, but low in protein and fibre. The high-energy content comes from the very high sugar levels (60–70% of dry matter)(DBC, 2015).

As there is a large proportion of rapidly degradable sugar in beet, it acts as a concentrate for the cows. When cows eat large amounts, the rumen microbes rapidly produce Volatile Fatty Acids (VFAs) and lactic acid. The lactic acid is the main driver that drops rumen pH, resulting in acidosis. So transition is key to feeding beet to allow the rumen microbial population to adjust to the different

source of energy (compared with fibre from pasture)(DBC, 2015).
To assist with the drop in rumen pH, fibre is essential to maintain a rumen mat (for the microbes), which helps with buffering (justifying the need for silage, hay). In addition to fibre, the time in which the farmer feeds fodder beet is essential; cows should not transition onto FB while hungry.
Lactating cows require a balanced diet of fibre, protein and energy. When cows are on lush pasture (spring and autumn) they have access to an excess of protein and energy, but lack sufficient amounts fibre (DBC, 2015).

FB can increase the rapidly fermentable energy to the microbes to convert excess protein (N) in the rumen (utilized by cow creating more protein in milk) so that less excess protein (N) is excreted in the cow's urine. However fibre supplements are still required to create and maintain the rumen mat. The rumen mat allows for the microbes to slow the passage rate and reduce waste of feed that passes through the rumen before all easily degradable proportion of the feed is degraded (DBC, 2015).

There is a major difference in the type of rapidly fermentable carbohydrates that FB supply when compared with grain. Grains supply starch, which is more readily converted to propionate (the rocket fuel of the VFAs), and provide more energy than the sugar from beet (relatively more sucrose), which increases the butyrate VFA produced. Grains are preferable to beet to improve rumen fermentation characteristics, but with the price of beet, it can be a viable option in increase the energy density of a ration while helping to convert more protein in the rumen to utilizable microbial protein (DBC, 2015).

11. Critical Findings

- Public opposition to the palm oil industry places increased pressure on dairy farmers to reduce palm kernel imports to New Zealand.
- PKE usage produced roughly 6.7% of New Zealand milk supply in 2014/15 season.
- If New Zealand fed three million tones of FB instead of grain and barley, in the 2014/2015 record low season, ($65 margin/T) the industry could have profited $195,000,000, rather than breakeven or loss for grain and PKE.
- Replacing grain and PKE with FB and increasing FB yields on average to 25T/Ha gives New Zealand potential average year financial benefit of $957,000,000. Or $79,750 per farm.
- The environmental benefits of FB use in New Zealand dairy systems could include reduced nutrient leaching levels.

12. Conclusion

This analysis on fodder beet raises a number of questions for the dairy industry moving forward. Does New Zealand want to increase profitability and remain unique on the world stage with its current production levels of dairy? Or, should New Zealand reduce the reliance on consumption of expensive supplements (some of which exploit the environment) and risk a significant decrease in dairy production? Forgoing environmental costs in the name of productivity is a major problem globally, and it will only continue to intensify. I think there is a solution that can mitigate the environmental costs without a decrease in production, and I think the alternative solution lies within the farm gate.

Implementing fodder beet as a main supplement source could resolve this predicament for New Zealand's dairy industry. If industry leaders support a collaborative approach and funnel resources into research, experimentation, education and communication. The success and longevity of New Zealand's 140+ year dairy industry centralizes on constant evolution. For New Zealand to keep dairy as a major export product, and as the backbone of the country's economy, the country will need to adapt and make changes some of which start within the farm gate.

13. Abbreviations

c Cents
DM Dry Matter
FB Fodder Beet
g Grams
Ha Hectare
KG Kilogram
ME Metabolisable Energy
MJ Mega Joule
MS Milk Solid
PKE Palm Kernel Expeller
T Ton
VFA Volatile Fatty Acids

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