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RURAL BANK
Milk payment and quality
ANIMAL INDUSTRIES WORKSHOP
MAY 1989

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INTRODUCTION

This booklet has been produced in conjunction with a workshop which was convened to help South Island dairy farmers to understand the new milk payment system and to consider means for coping with it. The text is set out in three major sections which deal separately with the effects of the new payment scheme, factors affecting milk quality and managerial influences on the composition and yield of milk. Hopefully this information will equip dairy farmers with knowledge of the scope for manipulating milk protein levels and of the means by which they can avoid penalty payments. Much of this comes back to on-farm practices such as milking plant hygiene, pasture management and herd health. It is without apology that these topics are re-examined here. Nevertheless there are changes afoot in terms of technological advances in processing and on the farm. The latter include improved methods of milk harvesting, breeding of cows for increased yield and of forage species suited to different seasonal and climatic constraints. This information thus goes beyond the South Island dairy farmer concerned with the new payment system as it has messages for a wider readership.

All authors are thanked for their co-operation in providing material and for participating in the workshop. Staff of Lincoln College who contributed to the organisation and running of the workshop and who helped with the production of this booklet are thanked for their special efforts.

G.K. Barrell,
Animal & Veterinary Sciences Group,
Lincoln College.
May, 1989.
THE NEW PRICING SYSTEM: ITS INFLUENCE ON HUSBANDRY PRACTICES ON THE FARM

J.D. STEWART
New Zealand Dairy Board Consulting Officer,
Papakura.

INTRODUCTION

For several seasons now, some dairy companies have paid their suppliers for the protein component in their milk as well as for the milkfat. They also have applied a deduction related to milk volume collected and processed, in the pursuit of greater equity relative to the solids concentration of the milk. Mr Kerry Paul (N.Z. Co-operative Dairy Co Ltd, Hamilton) has said "The ideal payment system should recognise variations in milkfat, protein and lactose supplied in the milk as well as the pattern of supply during the season." We have not got quite that far in New Zealand yet, but are well on the way to extending the original A + B - C payment system of those early payout pioneers throughout the industry.

For the new season (1989-90) the South Auckland Dairy Association, which includes N.Z. Co-operative Dairy Co Ltd, will be changing over from the traditional milkfat based payments. I have used them as my example for this discussion.

During the present season (1988-89) suppliers are going through a 'learning' exercise by being presented each month with their A + B - C information from the company to simulate what the 'real' thing will be like next season. Table 1 shows the information provided on a Milk Price Advice statement as received by all the suppliers this year. The milk price for the month, together with the season’s average litre price is circled as well as the tests. It is planned to have a fixed litre charge for the whole season and this will be deducted each month in full.

Table 1: Proposed calculation of the milk price.

<table>
<thead>
<tr>
<th>TOTAL MILK LITRES</th>
<th>WT. AV. FAT TEST %</th>
<th>WT. AV. PRO. TEST %</th>
<th>MILKFAT kg</th>
<th>PROTEIN kg</th>
<th>PENALTIES $</th>
<th>SEASON TO DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>80351</td>
<td>4.56</td>
<td>3.57</td>
<td>3664.0</td>
<td>2868.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1. Advance Rate of</td>
<td>195 cents/kg Milkfat</td>
<td></td>
<td></td>
<td></td>
<td>$7181.44</td>
<td>Your Share</td>
</tr>
<tr>
<td>2. Advance Rate of</td>
<td>243 cents/kg Protein</td>
<td></td>
<td></td>
<td></td>
<td>$6970.46</td>
<td></td>
</tr>
<tr>
<td>3. Less litre charge</td>
<td>4 cents/litre</td>
<td></td>
<td></td>
<td></td>
<td>$3214.04</td>
<td></td>
</tr>
<tr>
<td>MONTH'S MILK PRICE PER LITRE</td>
<td>12.61 TOTAL $</td>
<td>10937.96</td>
<td>10937.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Typical farm: (October production)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEASON TO DATE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk Total Value $</td>
<td>Your Share $</td>
<td>Gross Credit $</td>
<td>10937.96</td>
<td>10937.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23928.35</td>
<td>23928.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* GST Value of $ = GST Inclusive Total $</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 1987/88 NZDB Basic Price $3.35/kg Milkfat: milkfat 219 c/kg protein 266 c/kg volume 4 c/kg litre
At each of the Advance Price stages of the season, farmers will be issued Milk Price charts from which they can easily work out their respective litre price at given test levels, as shown below (Table 2).

**Table 2: Milk price chart.**

<table>
<thead>
<tr>
<th>Milkfat Test</th>
<th>3.50</th>
<th>3.55</th>
<th>3.60</th>
<th>3.65</th>
<th>3.70</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.70</td>
<td>13.72</td>
<td>13.84</td>
<td>13.96</td>
<td>14.08</td>
<td>14.20</td>
</tr>
<tr>
<td>4.75</td>
<td>13.82</td>
<td>13.94</td>
<td>14.06</td>
<td>14.18</td>
<td>14.30</td>
</tr>
<tr>
<td><strong>4.80</strong></td>
<td><strong>13.91</strong></td>
<td><strong>14.03</strong></td>
<td><strong>14.16</strong></td>
<td><strong>14.28</strong></td>
<td><strong>14.40</strong></td>
</tr>
</tbody>
</table>

Throughout the season a company's ability to maximise revenue and minimise costs will be limited by the amount of solids in the milk and the changes in the total milk supply. These both will vary for each supplier throughout the season, so their individual milk price will vary considerably, influenced by stage of lactation, feed supply and feed quality. Table 3 gives the N.Z. Co-operative Dairy Co Ltd calculations of the monthly variations of the Milk Price for their average supplier, using the Advance Price levels ruling at the time the campaign was launched. This table also shows the wide range of extreme highs and lows they estimate could have been paid out.

**Table 3: Monthly variations in the milk prices (cents per litre).**

<table>
<thead>
<tr>
<th>Month</th>
<th>Milk Price</th>
<th>Minimum (average)</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>19.34</td>
<td>11.04</td>
<td>32.34</td>
</tr>
<tr>
<td>July</td>
<td>15.85</td>
<td>7.81</td>
<td>24.26</td>
</tr>
<tr>
<td>August</td>
<td>14.84</td>
<td>11.21</td>
<td>18.92</td>
</tr>
<tr>
<td>September</td>
<td>14.18</td>
<td>10.22</td>
<td>18.19</td>
</tr>
<tr>
<td>October</td>
<td>14.39</td>
<td>10.73</td>
<td>18.66</td>
</tr>
<tr>
<td>November</td>
<td>14.51</td>
<td>11.09</td>
<td>18.52</td>
</tr>
<tr>
<td>December</td>
<td>14.38</td>
<td>10.96</td>
<td>18.37</td>
</tr>
<tr>
<td>January</td>
<td>14.42</td>
<td>11.21</td>
<td>18.78</td>
</tr>
<tr>
<td>February</td>
<td>15.28</td>
<td>11.29</td>
<td>20.63</td>
</tr>
<tr>
<td>March</td>
<td>17.14</td>
<td>11.90</td>
<td>24.18</td>
</tr>
<tr>
<td>April</td>
<td>18.21</td>
<td>12.80</td>
<td>27.26</td>
</tr>
<tr>
<td>May</td>
<td>19.71</td>
<td>14.70</td>
<td>31.74</td>
</tr>
</tbody>
</table>

From these examples alone it is possible to see some of the difficulties we may have 'on farm' when comparing between seasons, between farms as at discussion groups, writing up farm stories and interpreting research and experimental farm results!
Grades and their effects on bulk milk are directly related to the volume of poor quality milk sent in and to the type of grading offence. It has therefore been decided that grades will be deducted on a per litre penalty basis, depending on the severity of the quality problem.

Table 4 simply illustrates a supplier who has incurred both a Second grade at 3 c/litre and later in the month an Inhibitory Substance grade at 6 c/litre, using figures based on what would have happened in 1987/88 with the penalty levels of that company. At that same time the relative levels for other grades would have been 1st Grade, a deduction of 1.1 c/litre; cress grade 3 c/litre and excess water also 3 c/litre.

Table 4: Proposed calculation showing penalty adjustments.

<table>
<thead>
<tr>
<th>TOTAL MILK LITRES</th>
<th>WT. AV. FAT TEST %</th>
<th>WT. AV. PRO. TEST %</th>
<th>MILKFAT kg</th>
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<td>3664.0</td>
<td>2868.5</td>
<td>106.0</td>
<td></td>
</tr>
<tr>
<td>1. Advance Rate of</td>
<td>196 cents/kg Milkfat</td>
<td>$7181.44</td>
<td>Your Share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Advance Rate of</td>
<td>243 cents/kg Protein</td>
<td>$6970.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Less litre charge</td>
<td>4 cents/litre</td>
<td>$3214.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONTH'S MILK PRICE PER LITRE</td>
<td>13.61</td>
<td>TOTAL $</td>
<td>10937.86</td>
<td>10937.86</td>
<td>174783</td>
<td></td>
</tr>
<tr>
<td>Second Grade 3500 litres @ 3.0c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitory Substance 1800 litres @ 6.0c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The Milk Price is based on the gross value of the milk before the deduction of penalties and grades.

During the season increases in the N.Z. Dairy Board basic price and hence changes in Advance Rates will be calculated as Retrospective Payments for the total production to date for both the milkfat and protein portions of each supply.

WHAT EFFECT WILL ALL THESE CHANGES HAVE ON GROSS INCOME FROM MILK SALES?

I believe the first point of importance to accept is that the company will have no more or less money in total to disperse than it was going to have under the old cents/kg milkfat system. What is hoped is that under the new system the monies are paid out in a more fair and equitable way to the people sending in the most saleable milk solids.
Table 5: Changes in farmers' gross incomes under the Milk Price.

<table>
<thead>
<tr>
<th>% Change in Gross Incomes</th>
<th>% of Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2% or greater</td>
<td>8.7</td>
</tr>
<tr>
<td>-1%</td>
<td>22.9</td>
</tr>
<tr>
<td>0%</td>
<td>34.2</td>
</tr>
<tr>
<td>+1%</td>
<td>23.3</td>
</tr>
<tr>
<td>+2</td>
<td>8.1</td>
</tr>
<tr>
<td>+3% or greater</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 5 summarises the percentage change in gross income alongside the percentage of suppliers in each range. It can be seen that 80% of suppliers will receive within 1% of the income they would have received under the old system. At the extreme end of the distribution however 9% of suppliers will receive 2% or greater reduced payments while at the high end 11% will receive 2% or more gross income. At today’s prices this would represent $3500-4000 difference in gross income on a production of 25000 kg milkfat. It is for these sorts of inequities that the new system is being brought in, to reward more justly the producer supplying the most important milk products.

WHAT MIGHT THE NEW SYSTEM AFFECT IN FARM MANAGEMENT PRACTICES?

I would like to give an over-view of how much or how little the new payments may influence you and your management decisions. Obviously the herds that will benefit the most will be those with high total yields of both milkfat and protein combining per cow and per hectare.

Each farmer’s average Milk Price multiplied by litres/cow and litres/ha will be the measures to study profitability. Increasing the milkfat and/or protein content of a supplier’s milk will lift that farmer’s Milk Price. Increases from the breeding and selection efforts will be slower to achieve but will be long lasting, whereas increases from feeding changes, while quicker to appear, will be of shorter and of less predictable duration.

On the breeding side we in New Zealand have concentrated, within each breed, on milkfat yield in bull selection based on performance of daughters. Studies of data from very large numbers of animals show that whilst concentrating on the milkfat goal we have achieved 90% of the potential progress in protein yield increases that we could have achieved, concentrating solely on protein yield selection criteria. That means there is a strong correlation between selecting for milkfat and progress with protein.

Perhaps, over the years, only a few town supply farmers selecting solely on milk yields, have in the process increased protein yield indirectly while concentrating on volume, as have overseas dairy industries.
Bull selection concentrating more on total milk solids as in the new milk payment system, is already with us. The Payment Breeding Indexes introduced in sire proofs two years ago take account of the new milk values under A + B - C systems. Although the N.Z. Dairy Board brought these assessments in quite early for A.B. sires in particular, we must remember that the heifer calves from the 1987 matings will not calve until spring, 1990. At least we have moved in the direction of the new milk payment systems.

Cow selection for rearing heifer replacements and for culling will depend more on herd recording data than ever before. When we look at the present N.Z. Co-operative Dairy Co Ltd ratio of payment for fat: protein of 1:1.5 kg of component, the ‘earning’ value taking volume as well into account of a cow, perhaps expressed as an ‘earning or payment’ index, assumes more importance than simple kg of milkfat produced. Unfortunately each dairy company will pay out at slightly different levels for each component and will have distinct volume deductions per litre so a mid line has to be used for new indexes to establish some stability and long term worth for the assessments. Because protein yield is most easily increased by lifting milk volume rather than increasing protein content, and because selection for increasing milk volume tends towards increasing cow size within a breed, it follows that cow size will increase with more emphasis on total protein yield.

Many farmers will have heard about or been involved in discussions about protein to fat ratios. Some people, when it suits, talk of both cow and breed selection based on such ratios. Getting wrapped up in such selection talk can be dangerous and quite misleading and may be completely unrelated to total yields and payments. Table 6 illustrates some of the potential confusion generated by the protein:fat ratio figures, using data from the High BI-Low BI trials that were conducted at Ruakura.

Table 6: Income from High and Low BI Jersey cows producing at the same stocking rate (Ruakura Trial) using April advance payments from N.Z. Co-operative Dairy Co. Ltd of 246 c/kg for milkfat and 376 c/kg for protein.

<table>
<thead>
<tr>
<th>Per cow</th>
<th>High BI</th>
<th>Low BI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (kg)</td>
<td>120</td>
<td>102</td>
</tr>
<tr>
<td>Milkfat (kg)</td>
<td>172</td>
<td>140</td>
</tr>
<tr>
<td>Protein:fat ratio</td>
<td>0.70</td>
<td>0.73</td>
</tr>
<tr>
<td>Income -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>$451</td>
<td>$384</td>
</tr>
<tr>
<td>Milkfat</td>
<td>$423</td>
<td>$344</td>
</tr>
<tr>
<td>Total</td>
<td>$874</td>
<td>$728</td>
</tr>
</tbody>
</table>
In the example the low BI cows have the higher protein:fat ratio, so it follows from this that milk from low BI Jerseys was worth more money per kg of milkfat than milk from the high BI cows. Unfortunately, such logic completely ignores the total production of the animals of each group. As can be seen cows with the lower protein to fat ratio have, at the same stocking rate, produced milk components worth about $150 per cow per season more (some 20%) than their low BI, but higher ratio, counterparts.

Other authors here deal with feeding aspects and their influence on the total yields of fat and protein and it suffices for me to say that the goal must be to maximise the total yield of both fat and protein components in milk to the profitable or economic limit. Within any given herd, well known management techniques already exist as the simple proven systems to achieve maximum economic milkfat production per cow and per ha. In any commercial herd, calving cows in good condition, feeding adequately after calving both for quantity and quality and drying-off in reasonable condition, followed by good wintering, is the known, proven path or recipe to maximise that herd’s economic production of milkfat.

To maximise protein production the same management practices apply; nothing has changed.

Since both milk constituents tend to follow a similar pattern during the lactation, any attempts to influence on by feeding will generally influence the other as well. Figure 1 attempts to illustrate the general trends in fat and protein content through the lactation. The curves are not parallel but certainly change similarly as the lactation develops.

**Figure 1**: Changes in milk composition during lactation.

![Solids %](https://via.placeholder.com/150)

<table>
<thead>
<tr>
<th>Solids %</th>
<th>Milk</th>
<th>Lactose</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The only real difference appears during periods of under-feeding when milk volume is restricted. Reasonably conditioned cows can mobilise body fat and prop up fat test during stress periods as in early spring. Thin cows do not have such reserves and so their fat test may drop under the same conditions. Unfortunately cows do not mobilise body protein
with the same facility and so the protein levels in the diet have a more direct reflection in the milk levels.

Most producers, certainly the town supply farmers, will have experienced the effects of feeding large portions of the ration as silage in late winter or during prolonged droughts, where milk volume can be sustained reasonably well but the solids-not-fat levels fall, often to the penalty level. The same happens in herds fed large amounts of brewer's grains. In summer when there may be adequate high energy feed but little protein through lack of green grass and clover, we find that the milk level falls, protein percentage slips yet the fat percentage often increases. These are all relatively short-term effects when the feeding system is under stress and total yield of milk components is reduced.

Breeding and selection effects may be slower to show but will be of much longer-term influence. The following values illustrate between breed effects on production and income. These are based on results of a survey in 1985/86 by the Bay of Plenty Livestock Improvement Association and have been updated to present-day returns of 246 c/kg for milkfat, 376 c/kg for protein and a volume deduction of 4 c/litre.

1. Production based on Herd Testing figures.

<table>
<thead>
<tr>
<th></th>
<th>Friesian</th>
<th>Jersey</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cows</td>
<td>4447</td>
<td>4503</td>
</tr>
<tr>
<td>Milk volume (l/cow)</td>
<td>4020</td>
<td>3017</td>
</tr>
<tr>
<td>Milkfat (kg/cow)</td>
<td>175</td>
<td>173</td>
</tr>
<tr>
<td>Protein (kg/cow)</td>
<td>139</td>
<td>121</td>
</tr>
<tr>
<td>Value (per cow)</td>
<td>$776</td>
<td>$760</td>
</tr>
</tbody>
</table>

2. Transposed to a farm situation using comparative stocking rates of 1.1 Jerseys per 1.0 Friesians (i.e. 165 Jerseys versus 150 Friesians).

<table>
<thead>
<tr>
<th></th>
<th>150 Friesians</th>
<th>165 Jerseys</th>
</tr>
</thead>
<tbody>
<tr>
<td>milk volume (l/farm)</td>
<td>603,000</td>
<td>497,805</td>
</tr>
<tr>
<td>total milkfat (kg/farm)</td>
<td>26,250</td>
<td>28,545</td>
</tr>
<tr>
<td>total protein (kg/farm)</td>
<td>20,850</td>
<td>19,965</td>
</tr>
</tbody>
</table>

Payment:

<table>
<thead>
<tr>
<th></th>
<th>150 Friesians</th>
<th>165 Jerseys</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$64,575</td>
<td>$70,221</td>
</tr>
<tr>
<td>B</td>
<td>$78,396</td>
<td>$75,068</td>
</tr>
<tr>
<td>C</td>
<td>-$24,120</td>
<td>-$19,912</td>
</tr>
<tr>
<td>Total (A+B-C)</td>
<td>$118,851</td>
<td>$125,377</td>
</tr>
</tbody>
</table>

It is clear from this that on a per cow basis the Friesians produced more saleable product than the Jerseys. However when the per ha result is worked out the difference is not so clear-cut, even at the stocking-rate of 1 Friesian to 1.1 Jerseys.
CONCLUSION

In summary, I suggest that dairy farmers should continue doing what they are already experts at: maximising milk and fat production at lowest possible cost, which will also maximise protein production and, thus, gross incomes in the future.

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K.R. MARSHALL
New Zealand Dairy Board,
Wellington.

SUMMARY

Milk payment systems have had a long history of debate in New Zealand and elsewhere. Equity of payment to farmers, the increasing revenue from protein and solids-not-fat relative to that from milkfat, increasing consumer demand for decreased milkfat in products and diets and the need to encourage farmers to take effective steps to increase their real income have lead to the strong urging to adopt a milk payment system which pays for protein as well as milkfat and places a charge on excessive volume to reflect costs of processing - the A + B - C system.

BACKGROUND

At the National Conference in June 1987, the dairy industry agreed to a proposal that each company be urged to adopt a payment system for milk at the farm gate which incorporated a payment for milkfat and protein and a volume component which was a charge to account for the extra costs associated with processing relatively lower-testing milk with a lower total solids concentration.

This move to adopt a payment system which was more comprehensive than the fat-only one has a long history.

HISTORY OF FAT AND PROTEIN PAYMENT

In 1934 a Commission of Enquiry into the Dairy Industry pointed out that butterfat content was not an accurate measure of the cheesemaking capacity of milk. The Commission concluded that an equitable method of paying for milk for cheesemaking should take into account both the casein protein content and the fat content of the milk. No action was taken probably because of the lack of reliable and rapid methods of analysis for protein.

In 1968 a Dairy Board Committee on Payment for Milk showed that there was a disparity between the actual net realizations for milks of different compositions and the payout received for those milks. The disparity varied depending on the composition of the milk, particularly the ratio of fat to protein, and individual company circumstances, particularly the product mix manufactured by the company. The Committee recommended a change from the milkfat only payment system to a system based on milkfat, protein and volume, a system which has become to be known as A + B - C. No action was taken because the catastrophic fall in skim milk powder prices in the mid-60’s gave little incentive to change.

Further intensive efforts to bring about such a change were made in the mid-1970’s.
In 1986 the New Zealand Dairy Board formed a committee to detail how an alternative payment system for milk could be implemented by the industry. The reports from the committee lead to the resolution at the June 1987 Conference and the changes which are now taking place in payment for milk at the farm gate.

The debate has not been confined to New Zealand. Many countries in Europe have now moved to adopt payment systems which include milkfat, protein and, in a few cases, lactose. In U.S.A. and Canada there is debate on changes to fat-only, solids-only or volume-only systems. Australia is also going through the debates with at least some states now changing to A + B - C type systems.

WHY CHANGE?

The basic reasons for changing the milk pricing system are to:
(a) provide farmers with a more equitable method of payment;
(b) encourage farmers to make farm management decisions which will work to their advantage;
(c) provide market signals to farmers which reflect the market trends in milk component values;
(d) encourage farmers to modify the composition of milk, making it more suitable for modern dairy products.

(a) Equity

The compositions of milks and yields of milk components produced on individual farms vary significantly as a result of breeding, farm management practices, type of feed, animal health, etc. The yield of different products made from the milks from individual farms varies as a result of these differences in composition and amounts of components. Thus the net revenue for the products manufactured from the milks of these farms also varies. In the past, milkfat content was taken as a measure of the variability of milk composition and this was a satisfactory arrangement when butter and cheese were our main revenue earners. Today's dairy industry is more complex than that of 35 years ago and milkfat is no longer a good indicator.

Each farmer has an expectation of receiving revenue which reflects, as far as is possible, the true value of his/her milk to the company. This is the equity issue.

A milkfat-only payment system results in a significant number of farmers being paid more or less than the actual revenue for the products manufactured from their milk. An audit of one company showed that a milkfat-only system would over or underpay two thirds of the suppliers by more than 0.6% of the net revenue received for the products manufactured from their milk with 4% being over or underpaid by more than 2.5% of that value.

No single system completely eliminates these inequities but they can be substantially reduced by a system which incorporates milkfat, protein and volume. An audit of the same company showed that none of the suppliers is over or underpaid by more than 0.6% of the net value of the products from their milk.
(b) Farm decisions to improve income

This subject is covered by other authors.

(c) Market signals

Currently our industry obtains approximately 45% of its income from milkfat and 55% from protein and other solids-not-fat (SNF). About 30% of our gross revenue is generated by products containing predominantly milkfat (butter and anhydrous milkfat), 33% from products containing predominantly protein or SNF (skim milk powder, casein, whey) and 37% from products containing significant quantities of both components (cheese, whole milk powder, butter milk powder).

These facts are not clear from a milkfat only payment system. Adjustment to these market signals by increasing the yield of protein over a lactation relative to the increase in yield of milkfat should improve the revenue gained for products and hence improve the farmer’s income.

(d) Milk composition

A major current consumer trend is towards a ‘more healthy’ diet and, in many countries, dietary guidelines advocate a lower intake of fat (particularly saturated fat) and cholesterol. While we can debate the wisdom of these guidelines the reality is consumers are seeking to reduce their milkfat intake. At the same time there is an increased demand for balanced proteins and milk is a major source of such proteins. This, together with the promotion of milk as a major source of essential nutrients such as calcium, has increased the demand for milk solids-not-fat. This has seen the development of such consumer products as low fat milks, cheese and yoghurts, dairy spreads with half the fat of butter, imitation cheese and coffee whiteners, etc. Thus a shift in the composition of milk is desirable to meet market trends.

Data obtained in New Zealand and overseas indicate that placing increasing emphasis on protein yield over a lactation would lead to the production of increasing quantities of milk with a low total solids concentration. This would lead to an increase in processing costs (transport of milk, removal of water by evaporation, etc.) per unit of solids which would outweigh the extra revenue obtained from the extra protein. For this reason the payment system has incorporated a charge on the volume of the milk to reflect the costs of handling that volume. This is the C factor in the milk payment system.
DAIRY COMPANY PAYOUTS CALCULATED USING THE A + B - C SYSTEM

P.A. LARKING
Alpine Dairy Products Ltd,
Temuka.

BACKGROUND
Payment for product by the New Zealand Dairy Board is governed by legislation which in its simplest form provides that the New Zealand Dairy Board will pay a base price for milk, plus average milk collection and engineering unit measured manufacturing costs plus an allowance for interest and depreciation. The latter is a hybrid calculation and allows a write off at current replacement costs of plant and buildings. The milk price announced by New Zealand Dairy Board is determined from the basket of product realisations less selling and administration costs, etc. incurred by the Dairy Board and may include an amount for transfer to its own reserves. The milk price is then converted by measured yield to arrive at the cost of milk solids per product. These figures assume a standard composition for milk. In practice this varies between geographic areas and breeds of cows.

It is important to realise that a company may pay for its milk supply as it chooses but there is an increasing tendency to follow a standardised system. Under A + B - C system the amount available for distribution by the company is not changed from the amount available under a milkfat payment basis but the allocation of that amount amongst suppliers does alter. In this current year, an industry accountants' working party has completed a paper on a standardised A + B - C system, which is recommended for use in the industry. A copy of this paper is appended (Appendix A).

At the commencement of each year, the New Zealand Dairy Board announces an advance price in cents per kg of milkfat, which may increase once or twice during the season, and at the end of the year the Board announces the final season price which, if it increases, includes the end of season bonus. The price currently is $5.00 per kg of milkfat and the New Zealand Dairy Board has said that companies will be paid 49.7% of this as milkfat and 50.3% as solids-not-fat (SNF). (Please note that SNF is not equal to protein.)

The recommendation of the accountants' working party (Appendix A) details how costs are accumulated and payout arrived at. The end of year final calculation would always be done in this manner.
EXAMPLES OF CALCULATIONS

The following is a simplified calculation which may be easier to follow and is useful for calculating the interim advance for milkfat and protein during the season.

<table>
<thead>
<tr>
<th>Dairy Board advance to the company</th>
<th>MILKFAT</th>
<th>SNF</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>49.7%</td>
<td>50.3%</td>
<td>$5.00</td>
</tr>
</tbody>
</table>

| Company advance                    | $2.137  | $2.163| $4.30  |

*Volume factor .1937c/litre
+ 4.47% (Av. fat test)

|                                   | .2189   | .2189| .4378  |

| Conversion of SNF to protein      |         |      |        |
| Budgeted total fat 7,500,000 kg   |         |      |        |
| Budgeted total protein 5,970,786 kg x 2.3819 = 2.9919 |

<table>
<thead>
<tr>
<th>Payout rounded off</th>
<th>MILKFAT</th>
<th>PROTEIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2.35</td>
<td>$2.99</td>
</tr>
</tbody>
</table>

* Calculation of volume factor

Milk collection expenses, are determined as follows:

- Milk collection wages
- Vehicle direct costs
- Road user charges
- Depreciation
- Farm vat repairs
- Collection overheads

Total Costs divided by Budgeted litres = cents/litre

Under the scheme being advocated by the Dairy Industry Accountants' Committee the volume factor increases to include volume costs within the factory. This increases a company's volume charge from around 2c/litre to approximately 4c/litre and the payout for fat and protein also increases.

The payout figures calculated above alter as follows:

<table>
<thead>
<tr>
<th>Dairy Board advance to company</th>
<th>MILKFAT</th>
<th>SNF</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.7%</td>
<td>$5.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Company advance                | $2.137  | $2.163| $4.30  |

| Volume factor 4c/litre + 4.47% | .4475   | .4475| .895   |

|                                   | 2.5845  | 2.6105| 5.195  |

14
Conversion of SNF to protein

Budgeted total fat 7,500,000 kg
Budgeted total protein 5,970,756 kg x 2.6105 = 3.2791

Payout rounded off

<table>
<thead>
<tr>
<th>MILKFAT</th>
<th>PROTEIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2.58</td>
<td>$3.28</td>
</tr>
</tbody>
</table>

CHANGES IN MILK COMPOSITION

Under conditions of drought protein falls more than milkfat and this is the experience on the east coast of the South Island this year. Figure 1 is a graph illustrating the ratio of milkfat to protein during the last two seasons.

Figure 1: Ratio of milkfat : protein during two seasons as recorded by Alpine Dairy Products Ltd.

Note the changes that occur over a season. Farmers can plot their own performance against this standard experienced by Alpine Dairy Products Ltd.

CONCLUSION

Hopefully, what has been provided here will help in understanding why a component payment system has been adopted and how it will influence returns.

Note, the herds which will benefit most in gross return will be those with higher milkfat and protein tests and a higher protein to fat ratio.

Section 6.1 Milk payment on basis of milkfat, protein and volume

The following are non-mandatory guidelines which may be applied by companies in setting the price payable for milk acquired.

Payment formula

The milk payment system for each farmer can be described in mathematical terms as:

\[ R = (A \times F) + (B \times P) - (C \times V) \]

where

- \( R \) the payment to the farmer, ($),
- \( F \) the quantity of milkfat supplied by the farmer, (kg),
- \( P \) the quantity of protein supplied by the farmer, (kg),
- \( V \) the volume of milk supplied by the farmer (litres),
- \( A \) the milkfat component price, (c/kg milkfat),
- \( B \) the protein component price, (c/kg protein),
- \( C \) the volume component price (c/litre)

The component prices \( A \), \( B \) and \( C \) are determined by firstly establishing a Volume Account to calculate \( C \), and then adding back the volume costs to the Company’s surplus to obtain the amount payable for the \( A \) and \( B \) components.

Volume Account

The Volume Account includes those costs associated with the following cost centres based on the Cost Centre reporting system as set out in the Dairy Industry Accounting and Standards Manual:

A) Cash costs (volume related)
   100% of on farm cost centre \( \$ \ldots \ldots \)
   100% of milk collection cost centre \( \$ \ldots \ldots \)
   100% of milk grading & testing cost centre \( \$ \ldots \ldots \)
   100% of reception & storage cost centre \( \$ \ldots \ldots \)
   100% of separation & pasteurisation cost centre \( \$ \ldots \ldots \)
   100% of powder evaporation cost centre \( \$ \ldots \ldots \)
   51% of casein making cost centre \( \$ \ldots \ldots \)
   59% of cheese making cost centre \( \$ \ldots \ldots \)

Total volume-related cash costs e.g. \( \$7,000,000 \)
B) Capital servicing costs (volume related)  
Necessary to calculate:
(a) Total Company CCP Allowance received  
(b) Volume-related CCP Allowance received on basis of company-specific volume-related percentages, 
e.g. 100% of collection capital cost payment allowance 
48% of skim powder capital cost payment allowance 
12% of butter capital cost payment allowance 
42% of lactic casein capital cost payment allowance 
47% of cheddar cheese capital cost payment allowance 

Total volume-related CCP Allowance received can then be expressed as a percentage of Total CCP Allowance received.

Company to take total depreciation written off plus interest cost in manufacturing accounts plus reserve difference, if applicable, between AUP requirement & depreciation written off.

x volume % of total CCP received = volume-related capital servicing costs

$8,000,000 x 40% = $3,200,000
C) Total volume costs
   Volume-related cash costs (A) $7,000,000
   Volume-related capital costs (B) $3,200,000
   Total volume cost $10,200,000

Divided by no. litres whole milk collected, e.g. 320m litres Volume Charge (cents per litre) 3.18

Milkfat and protein component prices

The amount payable in respect of the A and B components is calculated in proportion to the prices paid by the New Zealand Dairy Board for the season as follows:

Company surplus per appropriation account e.g. $60,000,000
Company volume deductions, e.g. $10,200,000
Total distributable $70,200,000

NZDB Milk component prices:
  fat $2.49 per kg
  protein $3.36 per kg

Company production statistics:
  milk 320m litres (V)
  fat 16m kg (F)
  protein 12m kg (P)

Therefore component values are apportioned:

<table>
<thead>
<tr>
<th>Component</th>
<th>Revenue</th>
<th>%</th>
<th>Distributable</th>
</tr>
</thead>
<tbody>
<tr>
<td>fat</td>
<td>2.49 x 16m</td>
<td>$39,840,000</td>
<td>49.7</td>
</tr>
<tr>
<td>protein</td>
<td>3.36 x 12m</td>
<td>$40,320,000</td>
<td>50.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$80,160,000</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Expressed as cents per kg:
  fat $34,890,000/16m = 218.062 c/kg
  protein $35,310,000/12m = 294.250 c/kg

Company payout
On the basis of the above example company payout would be:

<table>
<thead>
<tr>
<th>Component</th>
<th>Payout</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>16m kg fat</td>
<td>@ 218.062 c</td>
<td>(A)</td>
</tr>
<tr>
<td>12m kg protein</td>
<td>@ 294.250 c</td>
<td>(B)</td>
</tr>
<tr>
<td>Less volume deduction:</td>
<td>320m litres milk @ 1.88 c</td>
<td>(C)</td>
</tr>
<tr>
<td>Company payout</td>
<td>(R)</td>
<td>= 60,000,000</td>
</tr>
</tbody>
</table>
HOW DOES THE NEW ZEALAND DAIRY BOARD DETERMINE THE VALUE FOR MILKFAT AND PROTEIN?

K.R. MARSHALL
New Zealand Dairy Board,
Wellington.

SUMMARY

The N.Z. Dairy Board calculates the ratio of milkfat and protein values from market data, averaged over three seasons. These values of milkfat and protein are designed to give farmers and dairy companies direct market signals. The changes as a result of the introduction of milkfat and protein values will be slow but are expected to increase the revenue of the industry and individual farmers.

INTRODUCTION

The title raises the question of how the payment by the N.Z. Dairy Board for products manufactured by a dairy company and purchased by the Board for export is worked out.

PRODUCT PRICE

The standard price paid for a product purchased by the N.Z. Dairy Board is made up of a number of parts:
- milk value at the farm gate
- whole milk collection costs
- manufacturing costs.

The whole milk collection and manufacturing costs, in turn are each made up of:
- cash costs
- administration costs
- interest on working capital
- capital cost payment.

Here I will elaborate only on the milk value part of the product price.

VALUED COMPONENTS

As part of the determination of the stand and price for each product a calculation is made of the quantities of the valued components, at present milkfat and protein, required to manufacture each tonne of a product. This calculation takes account of the amount of each of the valued components in a tonne of product of typical composition, and the losses of each of the components from the time the milk is collected at the farm gate until the product is in the store. Thus, it is calculated that the manufacture of one tonne of creamery butter requires 825.85 kg milkfat and 5.73 kg protein in the milk at the farm gate. By using the values for a kilogram of milkfat and protein determined by the Board, we can thus calculate the milk value, at the farm gate, for each tonne of butter - $1944.69 (milkfat $2.33/kg; protein $3.57/kg; Advance Price $5.00/kg milkfat). Some values for further products are given in Table 1.
Table 1: Valued component use and milk value at farm gate for some products (using $2.33/kg for milkfat and $3.57/kg for protein)

<table>
<thead>
<tr>
<th>Product</th>
<th>Milkfat used kg/t product</th>
<th>Protein used kg/t product</th>
<th>Milk value $/t product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>825.85</td>
<td>5.73</td>
<td>1944.69</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>8.48</td>
<td>386.70</td>
<td>1400.28</td>
</tr>
<tr>
<td>Whole milk powder</td>
<td>273.67</td>
<td>284.88</td>
<td>1654.67</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>383.95</td>
<td>319.89</td>
<td>2036.61</td>
</tr>
<tr>
<td>Casein</td>
<td>26.21</td>
<td>1195.47</td>
<td>4328.90</td>
</tr>
</tbody>
</table>

The amount of valued component used and the values assigned to those components are a major portion (66%) of the total amount paid by the Board to the dairy companies.

RELATIVE MILKFAT AND PROTEIN VALUES

The N.Z. Dairy Board has resolved to pay the milk value portion of the product price on the basis of milkfat and protein values. It has also resolved to reflect, as far as is possible, the current values which the market ascribes to each of the components. An alternative would have been to determine milkfat and protein values which reflect the Board’s best estimate of the future marketing needs - bearing in mind the time it takes to change the typical milk composition this method could be used to bring about more rapid changes, but is dependent on a judgement of the market trends over a significant time period, say 5 to 10 years from now, which is a difficult task.

The calculations of the relative values of milkfat and protein use data on the gross sales revenue, sales quantities, the amounts of milkfat and protein required to manufacture each tonne of product, the standard cost paid and the costs of marketing for each product group (cream products, skim milk powder, whole milk powder, cheese, casein and whey). From these data, using a straightforward mathematical technique, the best values for milkfat and protein to describe the relationship between these components and the net revenue are calculated. (For the mathematically minded the technique is a constrained multiple regression between total component values and net revenue.) This technique gives unique values for milkfat and protein which best describes the average values for these components for all products.

This product is more comprehensive than the simple procedures of determining the relative milkfat value from the net revenues for butter and anhydrous milk fat, the relative protein value for the net revenues for skim milk powder and casein and ignoring the revenues from cheese and whole milk powder. The procedure adopted also does not require a subjective proportioning of the values of milkfat and protein in products which contain significant quantities of both components.
The procedure adopted for determining the relative values of milkfat and protein is an objective one, takes account of the net revenue from all products sold by the Board and is easier to use than to describe!

**ACTUAL MILKFAT AND PROTEIN VALUES**

The procedure described above calculates relative values of milkfat and protein, i.e. a ratio between the two values. This ratio is set at the beginning of the season and is held constant for the whole of the season so as to avoid changing relative prices to be paid to companies for the products they manufacture. Once the Board determines the Advance Price (in c/kg milkfat or c/litre standard milk) the actual values of milkfat and protein to give that Advance Price and to maintain the ratio of values are calculated.

**THE MESSAGE**

The purpose behind determining the milkfat and protein values from the Board’s trading account using the techniques described above is to reflect the market returns for milkfat and protein from all products to companies in the product purchases prices. Companies are given market signals that will influence their product mix decisions and manufacturing processes to enable the companies to reflect these market returns in payouts to farmers. In the long term these price signals will affect farm management practices. As these changes are medium-term changes rather than short-term ones, major fluctuations in the ratio between the milkfat and protein component values should be avoided.

The last few seasons have seen significant changes in the relative values of milkfat and protein (or solids-not-fat) in the N.Z. Dairy Board advance prices reflecting changes in market returns. Two years ago, milkfat values, above a certain production, were essentially zero while protein could still be sold at significant revenues. As the world dairy market has changed the prices of protein-containing products have recovered more rapidly than prices for the major fat-containing products. For the next two or three years it is expected that prices for cream products and hence returns for milkfat are likely to increase relative to protein prices.

At times of such rapid change, in order to avoid instability, it is prudent to average returns over a period, rather than have the ratio of component values fluctuate widely. For this reason, the Board adopted the average ratio from the actual returns for 1987/88 and the estimated returns for 1988/89 in setting the ratio for 1988/89. This has been extended to three seasons (actual for 1987/88, estimates for 1988/89 based on eight months trading and the estimate for 1989/90) in setting the ratio for the 1989/90 season. The ratio has to be set in March for the following season in order for standard prices to be set so that companies can make their product mix decisions. The trends in the ratios set by the Board and the fat and protein values adjusted to an Advance Price of $5.00/kg are set out in Table 2.
Table 2: Milkfat and protein value ratios and values at an Advance Price adjusted to $5.00/kg milkfat

<table>
<thead>
<tr>
<th>Season</th>
<th>Ratio</th>
<th>Milkfat Value</th>
<th>Protein Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986/87</td>
<td>1.49</td>
<td>3.33</td>
<td>2.23</td>
</tr>
<tr>
<td>1987/88</td>
<td>1.03</td>
<td>2.90</td>
<td>2.81</td>
</tr>
<tr>
<td>1988/89</td>
<td>0.74</td>
<td>2.49</td>
<td>3.36</td>
</tr>
<tr>
<td>1989/90</td>
<td>0.65</td>
<td>2.33</td>
<td>3.57</td>
</tr>
</tbody>
</table>

For a typical New Zealand milk composition a farmer will receive 47% of income from milkfat and 53% from protein in 1989/90 compared with 67% from milkfat and 33% from protein in 1986/87.

MONITORING

The most important monitor on whether the message to dairy companies and farmers is getting through is the net returns to the farmers. This monitor is a function of many things and at the present time is being swamped by the rapidly changing relative market returns for product groups.

Another monitor will be the changing composition of milk and yields of milkfat and protein. The Cost Engineering Unit commissions a survey each year which determines the composition of the milk in all regions at various times of the year. This will also give some indication of change, although the movement will be slow and swamped in the short term by variations from season to season.

The Livestock Improvement Corporation will also be monitoring changes in farming practices and breeding decisions taken by farmers.
MILKING PLANT HYGIENE

S.R. LODGE
Dairy Advisory Officer (Farms), MAFQual, Christchurch.

BACKGROUND

Penalties for downgraded milk can and do represent a large monetary loss for dairy farmers, with penalties for first grade milk ranging from 3% - 15% and second grade milk from 10% - 30% depending on the company. Companies are required by legislation to penalise at not less than 3% for first grade milk and 10% for second grade milk.

For every 5000 litres of milk with a 4.1 test and an average payout of $5/kg this represents penalties of $30.75 to $153.75 for first grade and $102.50 to $307.50 for second grade.

Dairy factories need good quality milk to produce product of acceptable standards for local and international markets and the penalties for poor quality reflect this.

CLEANING OF MILKING PLANT

Poor cleaning of milking plant accounts for 70% - 80% of all downgrades experienced by dairy farmers in New Zealand, so this 70% - 80% of milk penalties is within direct control of the farmers as the production and preservation of acceptable milk quality is primarily dependent on a clean milking plant. Poor milk grades often arise because of a failure to monitor the effectiveness of cleaning systems until it is too late and the grade has been issued. An effective cleaning system will result in:

- no milk soil accumulation in the plant
- no grade penalties due to plant insanitation.

There are other related factors which also have an influence on milk grading and are part of the milking machine cleaning system:

- compatibility of detergents and water
- condition of rubber ware (perished rubber ware cannot be cleaned, no matter how good the cleaning practices are)
- hot water cylinder capacity, thermostat and element.

Downgrades can be caused by factors other than milking plant cleaning for example: inhibitory substances, colostrum, added water, mastitis, and occasionally refrigeration failure.

The pre-requisites for an effective cleaning system are:

- correct amounts of detergent
- mix with water at the correct temperature
- use of sufficient volumes to give adequate contact time
- operator familiarity with cleaning system
- regular checks to ensure the system is operating.
DETERGENTS

It is essential that the detergents used are approved by the Ministry of Agriculture & Fisheries (MAF) for use in farm dairies on milk-contact surfaces. This will ensure that there are no problems with taints, inhibitory substances, etc. in the final product, if used as directed. There are many approved detergents available and although some are sold only in selected areas, most are available nationwide. It should be noted that MAF approval does not guarantee satisfactory results. All detergents on the market, if used as per manufacturer’s instructions and with compatible water, give satisfactory results.

The major causes for failure of detergents have been found to be: farmer misuse, i.e. incorrect concentrations, incorrect temperature and contact time.

Most detergent systems available are a two-step system. An acidic-detergent sanitiser and an alkaline-detergent which are designed to be used together. Most systems involve the use of the acidic-detergent sanitiser six days a week with the alkaline-detergent being used on the 7th day. There are farmers who use one type of detergent continuously for good results but the two types of detergents used together give better removal of milk deposits:
- Acid detergents work best on milk and mineral stone deposits.
- Alkaline detergents work well on milk protein and fat deposits.

Some companies also market sanitising rinses to be used to sanitise the plant before milking. Also available are milkstone removers used for the removal of heavy deposits. Most general acidic-detergent sanitisers and alkaline detergents can be used at higher than the recommended strengths to carry out a periodic descale. It is possible but not always safe or desirable to fine-tune detergent concentrations and hot water temperatures.

CLEANING SYSTEMS

There are three major cleaning systems in use on dairy farms in New Zealand at the present time:
- Bucket cleaning system
- Reverse flow cleaning
- Jetter cleaning.

(See Table 1 for relevant merits of the three common systems.)
Table 1: Relative merits of three common cleaning systems.
(From Aglink FPP611)

<table>
<thead>
<tr>
<th></th>
<th>Bucket system</th>
<th>Reverse flow system</th>
<th>Jetter system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital outlay</td>
<td>The only equipment required is a set of buckets, or mobile container, so capital outlay is very low.</td>
<td>Equipment required includes a centrifugal pump which must be coupled to hot and cold water, and piping to the milk system with satisfactory connections. Water cylinders may need to be raised to allow sufficient “head” to centrifugal pump inlet.</td>
<td>Many installations cost about 1/3 of the equivalent reverse flow installations. A booster pump may be required for large installations. Pipework and jetters constitute the bulk of the cost.</td>
</tr>
<tr>
<td>Ease of installation</td>
<td>No installation required.</td>
<td>Installation involves wiring and plumbing. Installation must be in an approved (safe) manner.</td>
<td>Installation easily carried out by most farmers. Jetter systems are often sold in kitset form.</td>
</tr>
<tr>
<td>System design</td>
<td>No system design.</td>
<td>System must be designed to give adequate flow to all clusters, and to avoid problems associated with pumping hot water.</td>
<td>System design must be designed to give adequate flow through all clusters, and to prevent flooding of the vacuum pump.</td>
</tr>
<tr>
<td>Suitability to large plants</td>
<td>More suitable to small plants.</td>
<td>Suitable to plants of any size providing the system design is satisfactory.</td>
<td>System design is more complicated for larger plants. Best suited to mid-sized plants.</td>
</tr>
<tr>
<td>Operating costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Water requirements</td>
<td>Same as bucket system.</td>
<td>A greater quantity of hot and cold water is required as the contact time is less.</td>
<td>Same as bucket system.</td>
</tr>
<tr>
<td>— Detergents and sanitisers</td>
<td>Moderate.</td>
<td>High, as the contact time is less.</td>
<td>Low, as the cleaning solutions can be recycled. If approved detergents are reused this also reduces costs.</td>
</tr>
<tr>
<td>— Labour</td>
<td>High; time consuming and comparatively hard work.</td>
<td>Very low time requirement.</td>
<td>Moderate time requirement. Jetters must be connected to teatcup.</td>
</tr>
<tr>
<td>Safety</td>
<td>Dangerous. Usually buckets of very hot water are carried around.</td>
<td>Safe provided the installation is carried out using approved methods and materials.</td>
<td>Safe.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Very basic system with little to go wrong.</td>
<td>Providing system design and installation are sound then problems are minimal. Detergent metering should be checked regularly.</td>
<td>Once teething problems have been eliminated there are usually few problems. Jetters may become blocked.</td>
</tr>
<tr>
<td>Detergent types</td>
<td>Powdered and liquid detergents can be used.</td>
<td>Only liquid detergents can be used.</td>
<td>Powdered and liquid detergents can be used.</td>
</tr>
<tr>
<td>Ability to recycle solutions (for milkstone removal)</td>
<td>If a hose is connected from the milk delivery line to the buckets, solutions can be recycled.</td>
<td>Cleaning solutions can be recycled by the bucket method.</td>
<td>Cleaning solutions can be recycled.</td>
</tr>
<tr>
<td>Ability to reuse solutions</td>
<td>Cleaning solutions can be caught for reuse.</td>
<td>Cleaning solutions run to waste.</td>
<td>Cleaning solutions can be caught for reuse.</td>
</tr>
<tr>
<td>Heat loss</td>
<td>There is some heat loss from hot water in buckets.</td>
<td>Minimal heat loss.</td>
<td>Excessive heat loss will occur if solutions are recycled for an extended time.</td>
</tr>
<tr>
<td>Effect on liners</td>
<td>Minimal.</td>
<td>Minimal.</td>
<td>Liners may become distorted when using some types of jetter.</td>
</tr>
<tr>
<td>Vacuum pump flooding</td>
<td>The release milk pump may need to be accelerated for cleaning, to prevent flooding of the vacuum pump. Flooding can also be prevented by cleaning only 4 clusters at a time.</td>
<td>Flooding of vacuum pump not possible providing isolating valves are fitted.</td>
<td>The release milk pump may need to be accelerated for cleaning, to prevent flooding of the vacuum pump. This is often accomplished by the use of a variable speed pulley on the releaser milk pump drive.</td>
</tr>
<tr>
<td>Other factors</td>
<td>The outside of the clusters must be clean prior to cleaning plant, to prevent contaminating the plant with dirt on the teatcups.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For the three systems variations and adaptations can be made for differing milking plants installation.

The best system for your dairy is determined by:
- dairy type and size
- milking plant lay-out
- water heating facilities
- type of detergent to be used
- labour limitations
- capital limitations
- personal preference.

In general bucket cleaning is only suitable for the small plants, jetter cleaning is suitable for medium to large plants and reverse flow is usually only found on very large plants. It has been found that on large plants the best system is a combination of reverse flow and jetter cleaning as this enables the cleaning solutions to be re-circulated when required or just reverse flowed normally to save time. Large bore milk lines require a special cleaning system such as can be best described as a backwards jetter system.

Some people would say that with modern detergents and cleaning systems farmers can throw away brushes. This is not so, even the best cleaning systems benefit from the use of a brush at times.

AREAS TO CHECK FOR EFFICIENT CLEANING

Even with a cleaning system up and running, it is very short-sighted to expect the system to keep operating efficiently without some sort of regular check. Routine checks are offered by a number of groups, e.g. MAFQual Farm Dairy Instructors. But milkers can check a number of problem areas themselves to ensure that the system is operating correctly. These are:
- teat cup liner
- sight glass
- top of receiving can
- filter drain
- delivery line
- agitator
- vat sight glass
- silo door seal
- claw
- end of milk & air lines
- milk pump diaphragms
- cooler
- underside of vat lids & walls
- spinner valve
- outlet.

CONCLUSION

Approved detergents should be used at the recommended concentrations and strengths as per manufacturer’s label. The cleaning system used should be set up to suit both the dairy and the milker, taking into account time and hot water requirements. Automated cleaning systems for vats can be used especially if on night collection. Regular checks of the system are essential if penalties are to be avoided. An effective cleaning system that results in no grade penalties should not be changed without a very good reason because
grade penalties can quickly erode the 'on paper' advantage of a change in water temperature, detergents, etc.

Finest grade milk is an achievable goal for all dairy farmers as a large proportion of dairy farmers already demonstrate.

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MILK QUALITY FROM THE FACTORY PERSPECTIVE

C.A. BLEAKEN
Canterbury Dairy Farmers Limited,
Christchurch.

INTRODUCTION

I am sure some dairy farmers have an image of dairy company executives, especially those responsible for milk grading, as some kind of ogres who lie awake at night dreaming up new ways to persecute their poor victims, the farmers.

I wish to demonstrate that this is far from the truth and that current milk quality requirements are no more than a true reflection of the demands of the commercial marketplace.

I will take each milk quality parameter in turn and examine the reason for that test and why the standard for the test is set at the level it is. I will not dwell on the applied monetary penalties or disincentives as these are really a commercial matter for each individual company; suffice to say that the penalty should normally be set at a level sufficient to either achieve the target milk quality or to recover the costs of processing sub-standard milk.

The milk quality parameters typically examined are:

- Standard Plate Count
- Thermoduric Plate Count
- Coliform Count
- Sensory evaluation
- Sediment or Foreign Matter
- Inhibitory substances
- Freezing point
- Bulk Milk Somatic Cell Count
- Colostrum
- Milk Constituents e.g. Total Solids, Fat
- Temperature
- other contaminants e.g. DDT, etc.

1. **Standard Plate Count (SPC)** - measures the total bacterial load in milk.

   Typical standards -
   - **Premium**: < 25,000/ml
   - **Finest**: < 100,000/ml
   - **First**: 100,000 - 200,000/ml
   - **Second**: > 200,000/ml

This test reflects the customer specification requirements for modern dairy products. Many dairy powders now have requirements for SPC less than 5000/g. At Canterbury Dairy Farmers Ltd we aim to produce market milk with SPC less than 1000/ml to achieve the required shelf life.
2. Thermoduric Plate Count - a count of those bacteria that are able to survive pasteurisation.

Typical standards -

- Finest: < 5000/ml
- First: 5000 - 25,000/ml
- Second: > 25,000/ml

Pasteurisation is our main tool in dairy processing to control bacterial numbers. If high levels of thermoduric bacteria are present they will continue to grow and contaminate product after pasteurisation. As for SPC the thermoduric standards are set at levels that reflect product requirements.

3. Coliform Bacteria - a count of bacteria sourced from insanitary hygiene and faecal matter.

Typical standard - Finest: < 100/ml

Presence of Coliform bacteria is widely accepted as an indicator of poor sanitary conditions. This is certainly the general case for milk. The standard is determined from typical easily achieved levels in milk produced under sanitary conditions.

4. Sensory Evaluation

Typical standard - Finest: no defect

The purpose of this test is self evident. All dairy products are required to free of sensory defects. Farmers often debate a senses grade, but forget they lack the benefit of routine sensory grading experience and an ample supply of defect-free comparison samples. This evaluation involves smell, sight and, if necessary, taste.

5. Foreign Matter or Sediment

Typical standard - Finest: A disc, or better

Again a self evident requirement, as all dairy products are required to be free of foreign matter. This standard is easily met by farmers if an approved milk filter of adequate size is used correctly.

6. Inhibitory Substances - a test primarily for contamination with animal treatment antibiotic residues.

Typical standard - Finest: < 0.003 IU Penicillin equivalent/ml

The test detects any residues, not solely antibiotics, that inhibit growth of a standard test bacteria, and is expressed as the equivalent amount of penicillin.

Many people are allergic to penicillin and can be sensitized by minute traces in foods. For this reason many customers demand dairy products devoid of inhibitory substance residue. The other major reason is that antibiotic residues in milk inhibit the growth of starter bacteria cultures used in cheese making, casein making, and other cultured products.
The 0.003 IU/ml level is the detection limit of the current routine test method.

7. Freezing Point - a test for added water contamination of milk.

Typical standard - Finest < -0.530 °C

In all milk supplies added water increases transport costs. In manufacturing companies added water increases processing costs, and in market milk added water causes milk to fail to meet legal compositional standards. The -0.530 °C standard is based on the worst case natural variation in normal unadulterated milk.

8. Bulk Milk Somatic Cell Count (BMSCC) - a count of white blood cells (leucocytes) contamination of the milk.

Typical standard - Finest < 600,000/ml

There is a direct correlation between BMSCC and levels of mastitis infection in a herd. Mastitic milk from herds with high BMSCC is markedly different in composition to normal milk and can adversely affect processing of the milk as well as keeping quality of the resulting dairy product.

The standard is based on industry experience of readily achievable levels.

9. Colostrum

The test measures levels of Bovine Gamma Globulin (BGG) in the milk.

Typical standard - Finest < 0.3% BGG

Colostrum bears little resemblance to normal milk in taste, colour, odour or composition. It is simply not possible to manufacture high quality dairy product from milk containing significant quantities of colostrum. Colostrum produces defects in flavour and functional properties of dairy products. The standard is based on industry experience of readily achievable levels.

10. Milk Constituents

Grading requirements may be set for various milk constituents such as fat, total solids and solids-not-fat (SNF).

The standards applied vary and are usually set to achieve required composition of the manufactured product. This is routinely applied for minimum fat and total solids levels in market milk which reflects legal minima for these constituents in liquid milk products.

11. Temperature

Usually the temperature of milk at the time of collection.

Typical standard - Finest 7 °C maximum
It is generally accepted that bacterial growth is sufficiently restricted at temperatures below 7°C that milk quality will remain stable for the normal duration of on-farm storage. Bacterial growth becomes rapid at temperatures above 10°C.

12. Other contaminants e.g. DDT residues, Free Fatty Acids
   From time to time various other contaminants or milk component degradation products may become significant problems in milk for the manufacture of dairy products.

Currently DDT residues (DDE - a DDT metabolite) is a problem in cheese manufacture. Certain specific bacterial groups may be significant in certain products, such as Clostridia in some European-type cheeses, or thermophilic spore-forming bacteria in milk powders. Free fatty acids which are the rancidity breakdown products of milk fat may receive more attention in relation to their effect on flavour and keeping quality of dairy products.

In these cases standards and grades are typically set in response to each individual situation.

CONCLUSION

I have attempted to demonstrate that what initially may seem to be a raft of punitive tests is in fact a realistic set of milk quality parameters that simply reflect market-place demands for product quality.

In may cases dairy companies rely on dilution of an individual farmer’s errors in the bulk of good milk from other farmers, and the standards are sometimes set tighter than absolutely necessary to enable this to be achieved.
NEW TECHNOLOGY IN NEW ZEALAND MILK HARVESTING

M.W. WOOLFORD
MAFTech, Ruakura Agricultural Centre,
Hamilton.

INTRODUCTION

The fundamental operating principles of New Zealand pipeline milking machines have changed very little over the past 25 years. While individual components such as liners, claws, pulsators and regulators have improved in design and function, the basic milk handling mechanism within the machine has remained the same. Milk is conveyed from cow to pump by blowing air through it, that is, air from the claw air admission hole. This generates considerable air entrainment and frothing and often causes problems with pumping.

The Ruakura Integrated Milk Harvester (IMH) is a new generation milking system which uses micro-computer technology to control the milking machine operation in individual bails. One of the original objectives of the development was to improve on the milk transport system used in conventional machines. The system capitalises on the flexibility offered by software control to provide unique features not previously available.

The overall IMH design concept is quite unique, particularly in relation to the traditional New Zealand milking machine design. The programme has been a very major undertaking since it has involved the ground-up development of a complete system, and one which differs in a major way from traditional thinking and design concepts. This machine, and developments from it, has the capability to become a major component of milking management methods through the 1990's.

The IMH machine has been developed as a joint venture with CHH Plastic Moulding Co. A more detailed description and some experimental results are to be found in the 1987 RFC Proceedings where it was referred to as the 'SMT' system.

This paper gives a brief update on the research and development which has taken place over the last two years and that which is planned for the future.

FEATURES

The flexibility of the system made possible by the micro-computer control is evident in the extensive list of operational features and options. The standard specification of the machine offers the following features.

- Air-milk separation at the claw under micro-computer control
  High efficiency of separation, less than 5% air in the milk.
- Yield display in each bail during milking.
- Several pulsation models (training, fast-milk and standard)
  In fast-milk the ratio changes with milk flow rate.
o Discard milk mode for excluding milk from colostrum or antibiotic cows (i.e. no test buckets required).
o Optional no-letdown detection which automatically invokes phases of stimulatory pulsation.
o Automatic cup removal (can be switched out for swing-overs).
o Keypad input of cow number (if required).
o A milk conductivity facility to assist with identification of mastitis.
o New rotary lobe milk pump with micro-computer flow control.
o Computer controlled wash mode.
o Plugs directly into PC-type farm computer for optional link to on-line farm database and recording system.
o Extensive self-testing for faults and facilities for checking function in each bail.

OPTIONAL FEATURES

The principal optional feature is the connection of a PC-type farm computer to the milk system. It should be clearly understood that the IMH machine can be operated as a stand-alone milking machine with all the above functions without such a computer. The additional features made possible by connecting a PC are still in the process of development. They require the use of a link to a PC computer, either an IBM compatible AT or a Macintosh, preferably having a 20 Mb hard-disk and 1 Mb of memory. The enhanced features of the system then depend on the frequency with which cow ID’s are entered in the milk shed. There are a number of possible scenarios and a few which we are working towards are outlined below. Some of these features are implemented already.

(a) Keypad entry of cow ID (4 digits) for targeted cows before cluster attachment.

Accesses PC database and checks stored data such as rolling mean yield, mastitis or antibiotic treatment status, last heat, and generates a coded readback to the operator in the shed.

Provided the mastitis data in the PC database is kept up to date will automatically switch the machine to discard mode in that bail if milk is still to be excluded at that milking.

Turn on an alert light if attention is required to that cow on the basis of database details accessed automatically.

(b) Keypad entry of cow ID and event code at any stage during, before or after milking.

Will enable shed observations such as heats, clinical mastitis, antibiotic treatment, milk fever, etc. to be entered directly into the PC database for individual cows.

(c) Keypad entry of cow ID at any stage during milking but on a regular basis. Carried out either daily, weekly, fortnightly or monthly, depending on farmer needs. (N.B. at Ruakura we do it at every milking without a major compromise on throughput.) It may be carried out for either targeted cows, groups or the whole herd.
The regular measurements of milk yield may be used for performance of individual cows relative to the herd average. Fluctuations in relative performance may indicate health, reproductive or milking abnormalities. Results may be either plotted as a graph, or listed on a statistical basis. The value of this option depends on the frequency of cow ID entry. Used at every milking only during the mating period it may improve the efficiency of heat detection, for example. Used at weekly or fortnightly intervals it will allow cows who have have a downward trend in relative performance to be targeted for either attention or perhaps drying-off.

(d) Automatic cow ID.

The system cannot realise its full potential until automatic cow identification becomes a reality in New Zealand. It is, however, well established technology in U.S.A. and Europe although under quite different management conditions to those prevailing in New Zealand. Development of appropriate implementations for New Zealand conditions is currently proceeding at Ruakura.

The IMH machine has been designed to be completely compatible with an automatic ID system, virtually at the ‘just plug it in’ level.

HERD TESTING

The IMH system is completely compatible with the present Livestock Improvement Corporation herd recording system. The standard herd test meters may be connected into the milk tube just as is done with conventional machines. The meters function completely normally without additional air admission. This is because of the airspace in the sample chamber of the meter and the high milk flow velocity when the milk valve in the claw opens.

Work is proceeding on how best to integrate the metering and data-handling capabilities of the IMH system with the Livestock Improvement Corporation system.

MANAGEMENT SOFTWARE

It is anticipated that a basic database system incorporating some of the concepts described above will be available for use with the IMH machine in the short term.

A fully comprehensive package which fully interfaces with the Livestock Improvement Corporation herd recording system and wider issues in farm management is currently still in the discussion and planning stage.
MILKING PERFORMANCE

The IMH machine is specifically designed to milk high yielding high flow cows as quickly as possible. Using a ‘claw vacuum’ of 50 kPa this is certainly achieved and the 1986 RFC paper reported a 23.8% gain in milking rate over a conventional system. This gain is due to two factors:

- The claw vacuum is stable at 50 kPa during peak milk flow. In conventional machines the mean claw vacuum may fall to 30 kPa or less during this phase.
- The pulsation changes with flow rate during peak flow.

While the IMH system milks considerably faster at a claw vacuum of 50 kPa, there is also the option to use a lower claw vacuum but still milk at about the same rate as a conventional machine at 50 kPa. Experiments with small groups of twins have shown the same milking rates with IMH using a claw vacuum of 40 kPa as were obtained using a conventional system at 50 kPa. Therefore the option exists with IMH to either milk faster or to milk at the same rate using a lower vacuum level.

CONCLUSION

- The IMH machine offers a wide range of operational features in its standard configuration and specification.
- The system offers faster milking and semi-intelligent control and monitoring of the milking progress.
- Numerous management options are made possible by use of a PC or Macintosh computer connected to the machine.
- These options are dependant on the entry of cow ID and the system will only fully realise its potential when automatic cow ID becomes a reality.
- Development is proceeding on software packages which use the data recording capabilities of the system.

ACKNOWLEDGEMENT

Staff of #1 Dairy, Ruakura are thanked for their wide-ranging inputs to the developmental programme.
INTRODUCTION

Milk produced by New Zealand dairy cows can be valued using the A + B - C payment system. This system, currently being adopted by most dairy companies involves payment according to the amount of fat and protein supplied coupled with a charge for the volume of milk supplied. The significance of the payment system is the message it gives about the product which is desired by the market. This message goes to cattle breeders who have a large influence over both the future composition of milk and the profitability of dairy farming.

Dairy farmers are faced with the task of making a living by producing pasture and converting it to milk. The genetic merit of the cows used in this process has a large influence on the profitability of dairy farming. Genetic merit influences milk volume and composition as well as the costs of production associated with feeding and milk harvesting.

The purpose of this chapter is to consider recent developments in dairy cattle breeding as they relate to dairy farm profitability, with special emphasis on milk composition.

PAYMENT BREEDING INDEX

In 1987 a new breeding index, the Payment Breeding Index, was introduced in New Zealand by the Livestock Improvement Council. The index was developed in recognition of the positive value associated with protein, and the negative value associated with water, in milk. Although, at that time few companies were paying farmers on the new payment system, it was widely expected that many dairy companies would change in the near future. Prior to this change in 1987, breeding for production was based almost entirely on fat yield alone.

The Payment Breeding Index is calculated from fat, protein, and milk breeding indexes by combining them according to the relative values of these milk components in the new payment system.

The relative values used in 1987 and 1988 were:

1 (fat/kg) : 1 (protein/kg) : -.01 (milk/litre)

These values were obtained from an examination of expected future market returns and milk collection costs. While the values used are not expected to change rapidly they are reviewed annually prior to sire proof calculations in June. The most important point about the Payment Breeding Index is that it shows a bull’s value according to the income which his daughters produce. It does not take account of any of the costs of production.
TOTAL BREEDING INDEX

In 1988 the Total Breeding Index was introduced with the objective of assessing a bull according to the contribution his daughters make to farm profit. To do this the index accounts for income from milk sales and costs of feeding.

The Total Breeding Index was developed under the direction of the Traits Other Than Production (T.O.P.) Advisory Committee which contains representatives of breed associations, the Livestock Improvement Corporation, and other artificial breeding organisations.

Development of the Total Breeding Index was made possible by four breakthroughs. First was the introduction of a linear scoring system for assessing seventeen traits other than production on all two-year-olds in progeny test herds. The seventeen traits include four assessed by the farmer milking the cow and thirteen assessed by trained inspectors. Amongst those traits assessed by the inspectors are a range of conformation traits including size and height.

Second was the development of a method for evaluating the economic importance of live weight under New Zealand conditions. This project was carried out by Dr Leo Dempfle while working with us in Hamilton. Dr Dempfle is Professor of Animal Breeding at a major agricultural university in West Germany. His work predicted the change in farm income expected to result when average live weight increased by 1 kg. This was established using a computer model in which account was taken of stocking rate, feed utilisation, milk income, beef income, and replacement rearing costs. He found that extra live weight, without an increase in per cow production, resulted in a reduced net income because the heavier cows required more feed for maintenance and did not produce enough extra income from bobby calf and cull cow sales to compensate. The results of Dempfle's research study have been used to provide the economic weighting factor for size in the Total Breeding Index.

Thirdly, the development of a method for establishing economic weighting factors for the other non production traits. This was was carried out by Dr Stephen Bishop who was part of the Livestock Improvement Corporation's research group in Hamilton. He showed how relative survival rates could be converted to production differences. The key components were:

- The influence of differences in a trait, such as shed temperament on survival, can be found from examining culling in commercial herds. This gives a relative survival for all values of each trait.
- A change in survival means a change in production. If a bull’s daughters are more likely to be culled at the end of the first lactation then they will have less chance of demonstrating any production superiority they may have.

Fourthly, the development of the Genetic Summary (Figure 1). This one page report for each progeny tested bull provides a clear and complete summary of all the factors that influence the Total Breeding Index. It contains a consolidated summary which not only provides breeding indexes for all traits but also a graphical summary of the extent to which the bull is changing each trait in his daughters.
Figure 1: Genetic Summary for MARTINS PARK.
The grey triangles predict the distribution of 95% of the daughters of an average bull for the breed mated to average cows of the same breed. The black mangles however show the predicted distribution of 95% of MARTINS PARK daughters if this bull were mated to average Holstein-Friesian cows. This concept may become clearer if one attribute in a genetic summary is considered, for example udder support (Figure 2), one of the thirteen traits assessed by trained inspectors.

![Figure 2: Genetic summary for udder support.](image)

Such an assessment predicts that the mean score for the breed concerned is 5, with 95% of daughters of an average bull predicted to have a score between 3 (weak support) and 7 (strong support). The shaded mangle predicts that the daughters of one particular bull, generated from average cows for the breed, would have a mean score of 5.5 and would thus improve this characteristic (udder support).

The Total Breeding Index has been attacked for giving too much emphasis to reducing cow size. It is easy to find examples of bulls whose daughters have the same level of production but differ by 25 kg in live weight (e.g. Table 1).

The bull in Table 1 with the lighter daughters (MARTINS PARK) has Total Breeding Index 5 points higher than the one with the heavier daughters (LAWRENCES PARDON) but producing less concentrated milk. The index is thus saying, that for cows having the same level of production, a 25 kg live-weight reduction is equivalent to an extra 5% of production. Perhaps the best way of illustrating this is to think of the extra 25 kg of live weight across a whole farm. On a 200 cow farm this is equal to 5,000 kg of live weight or an additional requirement of approximately 1 kg DM/cow/day. This additional feed required by the heavier cows could be allocated either to feed more cows of a lighter weight or to improve the feed intake of lighter cows. The farmer with the lighter cows has the chance to either feed the same number of cows better and thus get extra production or to run more cows and get extra production. Either way it is easy to see why the heavier cattle would be less profitable.
**Table 1:** Total Breeding Indexes for two bulls.

<table>
<thead>
<tr>
<th></th>
<th>MARTINS PARK</th>
<th>LAWRENCES PARDON</th>
</tr>
</thead>
<tbody>
<tr>
<td>fat</td>
<td>151</td>
<td>150</td>
</tr>
<tr>
<td>protein</td>
<td>126</td>
<td>134</td>
</tr>
<tr>
<td>milk</td>
<td>118</td>
<td>135</td>
</tr>
<tr>
<td>PAYMENT</td>
<td>143</td>
<td>144</td>
</tr>
<tr>
<td>Management</td>
<td>+0.48</td>
<td>+0.15</td>
</tr>
<tr>
<td>Efficiency</td>
<td>+2.34</td>
<td>-2.50</td>
</tr>
<tr>
<td>Conformation</td>
<td>-0.19</td>
<td>-0.53</td>
</tr>
<tr>
<td><strong>TOTAL BREEDING INDEX</strong></td>
<td><strong>146</strong></td>
<td><strong>141</strong></td>
</tr>
</tbody>
</table>

Of course there are bulls whose daughters are both heavier and higher producing. The Total Breeding Index is the best way of deciding which bull will produce daughters giving the greatest contribution to farm profit.

**CONCLUDING REMARKS**

Cattle breeding in New Zealand has changed over the last few years and less emphasis is now placed on fat yield. Selection for production should now be based on the Payment Breeding Index. However, this will not result in major changes in milk composition as fat is still the major milk solid of value and it is strongly correlated with protein.

Dairy farmers need to be very conscious of the need to breed cattle which will contribute to overall farm profitability. This requires a consideration of both costs and returns. The Total Breeding Index has been developed to provide a summary of the overall economic contribution made by a bull’s offspring and for this reason is the best available guide to bull selection under New Zealand conditions.

Further research is underway to develop improved indexes for selecting cows. The production and breeding indexes which are being developed will be similar to the Payment Breeding Index for bulls and at a later date I expect to see a breeding index for cows similar to the Total Breeding Index.
EFFECTS OF FEEDING ON THE COMPOSITION OF MILK AND ON THE YIELDS OF ITS COMPONENTS

C.W. HOLMES
Department of Animal Science,
Massey University, Palmerston North.

SUMMARY

- Short term underfeeding during lactation causes increases in the fat % but decreases in the protein % of milk.
- Fatter body condition at calving causes increases in the fat % of milk, particularly during early lactation.
- The feeding of supplements generally causes a small decrease in fat % but a small increase in protein % (due to an increased level of feeding). Concentrates generally cause a specific decrease in fat %. Fat % is sometimes depressed slightly by certain feeds, e.g. red clover, lucerne. Protein yield can be increased preferentially by the feeding of ‘rumen modifiers’.
- Despite these immediate effects of feeding on milk composition, wide differences in feeding and management over whole lactations (e.g. due to differences in calving date, or differences in stocking rate) generally have only small effects on the composition of milk averaged over a whole lactation.
- Therefore, the feeding techniques which have in the past maximised the yield of milk fat per ha, will probably be appropriate for the future maximisation of the yield of protein (and milk) per ha.

INTRODUCTION

The dairy farmer’s gross income from milk will in future be determined by the yields of milk fat and protein.

In general, a ‘feeding factor’ which affects the yield of fat will also affect the yields of milk and protein. However, if the composition of milk is changed by the feeding factor, then the yields of fat, protein and milk will not all be affected to the same extent.

Therefore it is important to understand the effects of feeding on both the yield and the composition of milk. These latter effects were reviewed by Bryant (1979). The important effects of feeding on fat yield have been widely studied (see reviews by Grainger & McGowan, 1982; Trigg & Bryant, 1982; Wilson & Davey, 1982).

A PHYSIOLOGICAL BACKGROUND

The main solid components of milk (fat, protein and lactose) are manufactured in the udder from nutrients provided by the blood. These nutrients are derived mainly from feed digested in the cow’s digestive tract.
Underfeeding causes a decrease in the supply of these nutrients, and therefore it causes a decrease in the yields of milk, fat, casein and lactose.

However, the cow can also produce some milk fat from her reserves of body fat, e.g. during short periods of underfeeding.

Casein is produced from amino acids. These amino acids can also be used to maintain the cow's vital supply of glucose. Therefore during periods of underfeeding the supply of amino acids available to the udder is reduced both by the scarcity of amino acids from the digestive tract and by the diversion of the scarce amino acids into manufacture of glucose.

The combined effects of these events are that during a short period of underfeeding (one day to several weeks):
- casein % decreases
- fat % increases
- yield of casein decreases to a greater extent than milk yield
- yield of fat decreases to a smaller extent than milk yield.

In addition, the chemical composition of milk fat is changed by underfeeding. This happens because, in the underfed cow, a greater proportion of the milk fat comes from body fat rather than from digestive tract nutrients.

These events can explain some of the effects seen in short term feeding experiments which will be discussed below.

**SHORT TERM EFFECTS**

The effects of underfeeding on milk composition can occur very quickly, as shown by the data below for a period of 24 h starvation (Bartsch et al., 1981):

<table>
<thead>
<tr>
<th>Measurements during the final 3 h of a 24-h period of starvation</th>
<th>Milk (kg/cow in 3 h)</th>
<th>Fat %</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows fed normally</td>
<td>2.2</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Cows not fed during the 24-h period</td>
<td>1.3</td>
<td>4.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

In addition, the starved cows also showed major changes in the chemical composition of their milk fat, changes which started about 12 hours after starvation began.
Body condition at calving

During the early part of lactation, cows which have calved in fatter condition produce more milk, fat and protein, and their milk has a higher fat %, than cows which have calved in thinner condition. Therefore, thin condition at calving causes a larger decrease in fat yield than in protein yield (e.g. see Table 1).

Table 1: Effects of body condition at calving on milk production in the first 100 days of lactation, and in the whole lactation (Rogers et al., 1979).

<table>
<thead>
<tr>
<th>Live weight before calving (kg)</th>
<th>Body condition at calving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fatter</td>
</tr>
<tr>
<td>Live weight before calving (kg)</td>
<td>405</td>
</tr>
</tbody>
</table>

0 to 100 days of lactation:

<table>
<thead>
<tr>
<th>Daily yield (kg/cow)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milk</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>fat</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>protein</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Concentration (%)

|                       | fat  | 4.5  | 4.2  |
|                       | protein | 3.6  | 3.6  |

Whole of lactation:

<table>
<thead>
<tr>
<th>Total yield (kg/cow)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milk</td>
<td>3430</td>
</tr>
<tr>
<td></td>
<td>fat</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>protein</td>
<td>121</td>
</tr>
</tbody>
</table>

Concentration (%)

|                       | fat  | 4.5  | 4.3  |
|                       | protein | 3.6  | 3.6  |

These effects occur because the fatter cows are able to use their larger reserves of body fat for the manufacture of milk and in particular, milk fat.

Level of feeding in early lactation

The effects of a four week period of underfeeding, in the second month of lactation, are illustrated by the data in Table 2.
Table 2: Effects of a short period (4 weeks) of underfeeding of cows in early lactation (Mitchell, 1985).

<table>
<thead>
<tr>
<th>Measurements in 2nd week:</th>
<th>Generously fed</th>
<th>Underfed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily yield (kg/cow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>23.9</td>
<td>16.5</td>
</tr>
<tr>
<td>fat</td>
<td>1.04</td>
<td>0.83</td>
</tr>
<tr>
<td>protein</td>
<td>0.88</td>
<td>0.56</td>
</tr>
<tr>
<td>Composition (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.4</td>
<td>5.0</td>
</tr>
<tr>
<td>protein</td>
<td>3.7</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Measurements in 4th week:

<table>
<thead>
<tr>
<th>Daily yield (kg/cow)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>milk</td>
<td>21.5</td>
<td>11.6</td>
</tr>
<tr>
<td>fat</td>
<td>0.96</td>
<td>0.54</td>
</tr>
<tr>
<td>protein</td>
<td>0.77</td>
<td>0.36</td>
</tr>
<tr>
<td>Composition (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td>protein</td>
<td>3.6</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Underfeeding, during its second week, caused decreases in milk yield and in protein %, but an increase in fat %. However, by the fourth week, the effect on fat % was much smaller than in the second week, perhaps because by that time the body fat reserves had been exhausted in the underfed cows. Similar results have been reported by Grainger & Wilhelms (1979) (see Table 3).

Table 3: The effects of underfeeding during weeks 0-10 of lactation, on milk production of cows during the same period and during the whole lactation (Grainger & Wilhelms, 1979).

<table>
<thead>
<tr>
<th>Results for weeks 0-10 of lactation:</th>
<th>Generously fed</th>
<th>Underfed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily yield (kg/cow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>18.6</td>
<td>11.5</td>
</tr>
<tr>
<td>fat</td>
<td>0.80</td>
<td>0.49</td>
</tr>
<tr>
<td>protein</td>
<td>0.69</td>
<td>0.40</td>
</tr>
<tr>
<td>Concentration (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.4*</td>
<td>4.3**</td>
</tr>
<tr>
<td>protein</td>
<td>3.7</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Results for whole lactation:

| Total yield (kg/cow)                |               |          |
| milk                                | 3000           | 2140     |
| fat                                 | 133            | 90       |
| protein                             | 111            | 76       |
| Concentration (%)                   |                |          |
| fat                                 | 4.5            | 4.3      |
| protein                             | 3.7            | 3.6      |

* 4.4 % in weeks 0-5; 4.3 % in weeks 5-10
** 4.8 % in weeks 0-5; 4.0 % in weeks 5-10
Feeding of supplements

(i) Hay and silage:
These are the most commonly used supplements, and they are generally fed only when pasture is relatively scarce, and when the cows would have been underfed if no supplements had been fed. The feeding of supplements will generally reduce the extent of the underfeeding, but will not prevent it entirely because the feeding value of supplements is lower than that of pasture.

The effects are illustrated by data in Table 4 which show that, for cows on restricted pasture, the feeding of silage caused increases in the yields of milk, fat and protein, with a small decrease in fat % and a small increase in protein %. All of these changes are consistent with an increased level of feeding for the cows given silage.

Table 4: Effects of underfeeding and supplementary feeding of silage on milk production of cows (Bryant, 1979).

<table>
<thead>
<tr>
<th></th>
<th>Generously fed on pasture</th>
<th>Restricted pasture with silage</th>
<th>Restricted pasture without silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily yield (kg/cow)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>21.5</td>
<td>19.3</td>
<td>17.5</td>
</tr>
<tr>
<td>fat</td>
<td>1.03</td>
<td>0.94</td>
<td>0.86</td>
</tr>
<tr>
<td>protein</td>
<td>0.72</td>
<td>0.61</td>
<td>0.55</td>
</tr>
<tr>
<td>Composition %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.80</td>
<td>4.86</td>
<td>4.92</td>
</tr>
<tr>
<td>protein</td>
<td>3.36</td>
<td>3.17</td>
<td>3.13</td>
</tr>
</tbody>
</table>

However, the data also show that the cows given restricted pasture plus silage were relatively underfed compared with the cows given generous pasture.

(ii) Cereal-based concentrates:
The feeding of concentrates generally causes a specific decreases in the fat % of milk, due to changes in the rumen’s fermentation characteristics. However, use of concentrates generally increases the cow’s level of feeding, and will therefore cause increases in the protein %, and in the yields of milk, fat and protein. These effects are illustrated by the data in Table 5. Similarly, seven trials in which oats were fed (3 to 4 kg/cow daily) showed figures of 14 l milk (4.4% fat) and 12 l milk (4.6% fat) from the supplemented and unsupplemented cows respectively during the period of supplementation (Rogers, 1985).
Table 5: Effects of concentrates given as a supplement to cows grazing on pasture (from Suksombat, 1988).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Daily yield (kg/cow)</th>
<th>Concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pasture only</td>
<td>Pasture plus concentrates*</td>
</tr>
<tr>
<td>milk</td>
<td>12.8</td>
<td>15.0</td>
</tr>
<tr>
<td>fat</td>
<td>0.62</td>
<td>0.69</td>
</tr>
<tr>
<td>protein</td>
<td>0.45</td>
<td>0.58</td>
</tr>
<tr>
<td>Concentration (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.9</td>
<td>4.8</td>
</tr>
<tr>
<td>protein</td>
<td>3.5</td>
<td>4.0</td>
</tr>
</tbody>
</table>

* These cows each ate 7 kg/day of concentrates, but reduced their consumption of pasture by 2 kg/day compared with the pasture only cows.

Increased protein % in the concentrate may cause increase in milk yield for cows on grass (Rogers, 1985) or on silage (Gordon & McMurray, 1979). Milk protein % was also increased in the latter study. The type of concentrate (starch or fibre) had no effect on the composition of milk (Meijs, 1986).

**Rumen modifiers**

Substances are available which can modify the types of fermentation occurring in the rumen. These changes can lead to increased growth rate, or improved efficiency in beef cattle.

One of these substances, monensin, caused increases in protein yield with no increase in fat yield when given to cows fed on pasture (Pankhurst & McGowan, 1978). Similar results have recently been reported at Massey (G. Lynch, personal communication). Use of these substances may become increasingly attractive if protein becomes increasingly valuable relative to fat.

**Different pasture plants**

The concentration of milk fat can be reduced slightly by grazing on red clover (Brookes & Wilson, 1983), lucerne (Bryant 1978), Matua prairie grass or Tama ryegrass (Wilson & Grace, 1978). However, yields of milk, fat and protein were sometimes increased by these feeds, because of their relatively high feeding values.

**Hypomagnesaemia**

Magnesium (Mg) is deficient in some soils and in some pastures. Supplementation with Mg can sometimes cause increases in the yield of fat, due at least partly to increases in fat % (Young & Rys, 1977). The reduced fat % in milk from cows grazing on Matua and Tama was also linked to low values for Mg concentration in the herbages (Wilson & Grace, 1978).
Despite these long-term differences in level of feeding and level of milk production, the average composition of milk was similar at both stocking rates with a small increase in fat % at the higher stocking rate. Therefore the long-term effects of an increase in stocking rate, with all its many consequences for feeding and management throughout the year, were to decrease yields per cow but to increase yields per ha for all components of milk. The relative size of these increases and decreases were similar for all four components (e.g. milk fat, protein and lactose per ha increased by 19 to 22% at the higher stocking rate).

Similar conclusions were reached by analysis of data for full lactation trials on farmlets with different stocking rates, different pastures and different management systems (Thomson, 1988).

Therefore systems which have in the past successfully maximised yield of fat per ha, will probably also maximise yields of protein and milk per ha.

**INCREASES IN MILK YIELD, IN RESPONSE TO INCREASES IN FEEDING**

**Extra feed during lactation**

The general nature of the increases have been illustrated in the previous tables. However, the milk producer must know how much extra milk is likely to be produced if extra feed is given, in quantitative terms.

In theory the consumption of an extra 1 kg DM (11 MJ ME) of feed, should produce:

- either: an extra 2 l of milk, containing about 90 g fat + 75 g protein
- or: an increase in live weight of 300 g.

The actual responses measured in a large number of experiments are summarised in Table 8. These suggest that the average response to 1 kg leafy DM extra is likely to be:

- an extra 400-500 g milk (containing 20-30 g fat and 17 g protein)
- plus 150-200 g extra live weight
- but a decrease in the quantity of pasture consumed, usually between 0.4 to 0.6 kg pasture DM for every 1 kg of supplement DM eaten.

The highest responses in milk production will be obtained in early lactation and with cows on relatively low levels of feeding.
### Table 8: Immediate, short-term, increases in milk yield caused by increased levels of feeding.

<table>
<thead>
<tr>
<th>Type of feed</th>
<th>Change, per 1 kg DM* extra feed eaten</th>
<th>Milk (g)</th>
<th>Fat (g)</th>
<th>Protein (g)</th>
<th>Live weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td></td>
<td>approx.</td>
<td>30</td>
<td>-</td>
<td>174</td>
</tr>
<tr>
<td>Trigg &amp; Bryant, 1982</td>
<td></td>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td></td>
<td>380</td>
<td>19</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Grainger, 1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td></td>
<td>-</td>
<td>17</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wilson &amp; Davey, 1982</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay and silage</td>
<td></td>
<td>530</td>
<td>21</td>
<td>-</td>
<td>150</td>
</tr>
<tr>
<td>Trigg &amp; Bryant, 1982</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay and silage</td>
<td></td>
<td>-</td>
<td>17</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wilson &amp; Davey, 1982</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td>540</td>
<td>17</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rogers, 1985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 11 MJ ME per kg DM

The values shown in Table 8 are for immediate effects, measured during the period of extra feeding. Usually the extra feed continues to cause an increase in production after the period of extra feeding, so that the total effect of the extra feed is about 1.5 to 2.0 times larger than the immediate effect (e.g. the total effect was approximately 2 times the immediate effect in Table 3).

**Extra body condition at calving**

Extra body condition at calving is caused by extra feed given at some time before calving. Subsequent yield of milk fat is increased by 5 to 10 kg by an increase of 1 unit in condition score at calving (Grainger and McGowan, 1982).

**REFERENCES**

LONG TERM EFFECTS

The short-term effects on milk composition, described above, are interesting but it is the long-term effects, if any, which will be of crucial importance to the herd's overall productivity.

Body condition at calving
The effect of calving in thin condition is to reduce total lactation fat yield to a slightly greater extent than yields of milk or protein, due to small decrease in fat % measured over the whole lactation (Table 1).

Underfeeding in early lactation
The effect of severe underfeeding (for 10 weeks) in early lactation is to reduce lactation yields of both fat and protein to a slightly greater extent than milk yield, due to small decreases in fat % and protein % measured over the whole lactation (Table 3).

Production by cows which calve in autumn or spring
Cows which calve in autumn are likely to be fed less pasture and more supplements during early lactation than cows which calve in spring. The autumn calvers are also likely to be relatively underfed in early lactation, to a greater extent than spring calvers. However, data from New Zealand and Tasmania (Table 6) suggest that total lactation yields of milk, fat and protein were all reduced to similar extents in the autumn calvers, with little differences in milk composition, averaged over the whole lactation, between the two groups.

Table 6: Effects on milk production of calving in autumn or in spring.

<table>
<thead>
<tr>
<th></th>
<th>Autumn</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Massey University:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield (kg/cow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>4030</td>
<td>4380</td>
</tr>
<tr>
<td>fat</td>
<td>165</td>
<td>177</td>
</tr>
<tr>
<td>protein</td>
<td>137</td>
<td>145</td>
</tr>
<tr>
<td>Composition (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>protein</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Tasmania:</strong> (Fulkerson et al., 1987)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield (kg/cow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>3600</td>
<td>3740</td>
</tr>
<tr>
<td>fat</td>
<td>157</td>
<td>164</td>
</tr>
<tr>
<td>protein</td>
<td>113</td>
<td>121</td>
</tr>
<tr>
<td>Composition (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>protein</td>
<td>3.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Therefore the wide differences in feeding and management between the autumn and spring calvers had little effect on the composition of their milk, averaged across the whole lactation.

**Different stocking rates (cows/ha during the whole year)**

Differences in stocking rate between farms, or increases in stocking rate on an individual farm, cause many differences in feeding level, and feed quality over the period of a year (Holmes and MacMillan, 1982).

Data are presented in Table 7 from a full-lactation trial with two widely different stocking rates. The higher stocking rate caused large decreases in the yields per cow of milk, fat and protein, due to a large decrease in the average level of feeding over the period of the trial.

**Table 7:** Effects of different stocking rates on yields per cow and per ha by Jersey cows of High Breeding Index measured over 36 weeks of lactation.
(Data from Dr A.M. Bryant, personal communication.)

<table>
<thead>
<tr>
<th>Stocking Rate (cows/ha)</th>
<th>2.8</th>
<th>4.3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield per cow (kg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>3,650</td>
<td>2,850</td>
</tr>
<tr>
<td>fat</td>
<td>205</td>
<td>163</td>
</tr>
<tr>
<td>protein</td>
<td>143</td>
<td>111</td>
</tr>
<tr>
<td>lactose</td>
<td>188</td>
<td>146</td>
</tr>
<tr>
<td><strong>Yield per ha (kg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td>10,217</td>
<td>12,234</td>
</tr>
<tr>
<td>fat</td>
<td>574</td>
<td>701</td>
</tr>
<tr>
<td>protein</td>
<td>400</td>
<td>477</td>
</tr>
<tr>
<td>lactose</td>
<td>526</td>
<td>628</td>
</tr>
<tr>
<td><strong>Concentration (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>5.62</td>
<td>5.73</td>
</tr>
<tr>
<td>protein</td>
<td>3.92</td>
<td>3.90</td>
</tr>
<tr>
<td>lactose</td>
<td>5.15</td>
<td>5.13</td>
</tr>
</tbody>
</table>


INTRODUCTION

It is necessary for farmers to identify and focus on the key issues under the new payment system. The issues which I will address in this paper are:

- You should still farm for yield (kilograms) of milkfat
- If you are maximising milkfat you are maximising protein and income.
- You should ignore protein to fat ratios and protein percent.

I work with the suppliers of the Egmont Dairy Company. Last year Egmont started paying on the A + B - C system. Some farmers, particularly the Jersey owners, were concerned that they were going to lose out under the new system. This prompted me to collect the data used in this paper.

I will use a series of graphs to illustrate the key issues you need to address under the A + B - C payment system. The graphs are based on data from 223 farms in the Egmont area. First we will look at protein to fat ratios and protein tests then at protein and fat yields.

(The values I have used here are A = $3.16, B = $4.21, C = - $0.04, this is equivalent to $5.50 for a kg of milkfat).

![Graph](image)

**Figure 1:** Percent change in income per hectare.
RATIOS AND PERCENTAGES

Figure 1 shows how income changes when payment basis changes (from solely fat to the A + B - C system) for milk of different protein to fat ratios. Those with low ratios lose between one and two percent. Those with a very high protein to fat ratio gain three to four percent, but the bulk of farmers will be in the plus or minus one percentage range.

It is best that you accept this fact then forget it. Farming to maximise the protein to fat ratio is a red herring as you will see in the following graphs.

Figure 2: Protein to fat ratio vs protein per cow (223 farms).

Figure 2 shows the relationship between protein production per cow and protein to fat ratio. There is no relationship.

Figure 3: Protein to fat ratio vs protein per hectare.

Figure 3 shows the relationship between protein production per hectare and per fat ratio. There is no relationship.
Figure 4: Protein percent vs protein per cow.

Figure 4 shows the relationship between protein percent and protein production per cow. Again there is no relationship.

YIELD AND INCOME

Figure 5: Fat per cow vs protein per cow (223 farms).

Figure 5 shows the relationship between fat per cow and protein per cow. As fat per cow increases so does protein per cow. Management that maximises fat per cow will also maximise protein per cow.
Figure 6: Fat per hectare vs protein per hectare.

Figure 6 shows the relationship between fat per hectare and protein per hectare. As fat per hectare increases so does protein per hectare. Management that maximises fat per hectare also maximises protein per hectare.

Figure 7: Fat per cow vs dollars per cow.

Figure 7 shows the relationship between fat per cow and dollars per cow, under the A + B - C system. It is very clear that management which maximises fat per cow also maximises income per cow.
CONCLUSION

The data in these graphs (Figures 1-8) show the following points.

- Under the A + B - C system most farmers income will be within plus or minus two percent of that which they would receive under a fat only payment system.
- The protein to fat ratio is a poor indicator of profitability because it bears no relationship to yield (kilograms) of protein or fat.
- Aim to maximise the yield of fat and protein (not ratio or test).
- Management which maximises fat per cow and fat per hectare will also maximise protein per cow, protein per hectare, income per cow and income per hectare.
INTRODUCTION

There is considerable confusion about the term pasture quality. Most of this confusion arises through inadequate description of what is meant by quality. Ideally an assessment of pasture quality should allow farmers to predict animal responses when this pasture is offered to cows at any stage of lactation or in the dry period. While there is general agreement on quality evaluation of non-grazed supplementary feeds based on their nutritional status (e.g. MJME/kg DM) many assume such a system suffices for the grazing situation as well. Unfortunately because grazing intake is often highly correlated with measures of the nutritional status of the pasture being grazed it is assumed that this signifies cause and effect. A very good example of this is the relationship between pasture digestibility and intake (Hodgson, 1975). The relationship between intake and digestibility is linear, i.e. the incremental increase in intake is the same for each unit increase in digestibility right up to the highest levels possible (85% digestibility). However if such pastures are not of sufficient height and density intake is impaired by pasture characteristics, the relationship between nutrient status of the pasture (digestibility) and intake is poor or non-existent. Too often the poor performance of cows grazing swards to very low post-grazing residual heights or masses is assumed to be due to the low digestibility of the material in the base of the sward rather than the problems associated with harvesting. Except during September and October, when for short time periods the cow may be fed to appetite, some form of restricted feeding is practiced to optimize output per hectare. Any definition of quality for pasture must therefore consider sward factors influencing intake as well as the availability of nutrients and the efficiency with which they are used.

The aim here is to review factors influencing pasture intake and nutrient supply (i.e. factors determining pasture quality) and to discuss how this information can be used in developing grazing management systems. This review will encompass recent relevant New Zealand research and provide the basis for day-to-day guidelines for grazing management.

GRAZING BEHAVIOUR

In order to identify which pasture characteristics were influencing the intake of cows Hancock (1952) divided intake into its behavioural components. Daily intake is dependent on the length of time the cow grazes over the day (grazing time, GT) and its rate of intake whilst grazing, made up of the weight of grass harvested per bite (bite weight, BW) and the rate of biting (number of harvesting bites per minute spent grazing, RB). Thus intake \( I = BW \times RB \times GT \). This approach enabled these three components to be measured over a wide range of pasture conditions. Except in exceptional circumstances cows rarely graze less than 7 hours or more than ten (Poppi et al., 1987). The scope for altering the rate of biting is also very limited even though the range of
pasture conditions imposed have been extreme (Hodgson, 1985). Cows do not exceed 70 bites per minute (Phillips & Leaver, 1985). There appears to be an upper limit to the number of bites cows can take in a day. Sward conditions determine the ratio of these bites spent harvesting to those spent adjusting feed prior to swallowing. On short swards there is little necessity for manipulative bites and it is thought that the high ratio of harvesting bites may cause grazing fatigue and a complete cessation of grazing. Bite weight was found to be extremely sensitive to sward characteristics and to be without question the major determinant of intake (Mayne & Wright, 1988). Such consistent findings have led researchers to look at the important sward and animal components determining bite weight. The weight of pasture harvested per bite is the product of the volume of the bite and the density of the pasture components within it. Bite volume is determined by bite area (the catchment area of the tongue) and the depth into the sward at which the bite is taken (bite depth). The behavioural/mechanistic components of intake are summarized in Figure 1.

Every major review of feed intake of cattle (e.g. Hodgson, 1985) has noted the overwhelming influence of pasture height on intake. It is therefore not surprising that the only detailed studies on the bite dimensions of cattle have found, for the range of pasture heights commonly encountered on farms (5 - 20 cm), that sward conditions determining bite depth are the major determinants of bite weight and therefore intake (Anwar et al., 1989). Cattle appear to have limited ability to alter bite area for swards above 5 cm where they are using their tongue as a harvesting mechanism rather than teeth and dental pad. Even though density of pasture components decreases as pasture heights increase, the scope for greater bite depths more than compensates and bite weight increases (Table 1).
Table 1: Mean bite weight and bite dimension of yearling Friesian cattle derived from the 20 bite technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-grazing height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Bite weight:</td>
<td></td>
</tr>
<tr>
<td>fresh (g/bite)</td>
<td>2.20</td>
</tr>
<tr>
<td>DM (g/bite)</td>
<td>0.38</td>
</tr>
<tr>
<td>Bite depth (cm)</td>
<td>2.50</td>
</tr>
<tr>
<td>Bite area (cm²)</td>
<td>43.80</td>
</tr>
<tr>
<td>Bite volume (cm³)</td>
<td>110.00</td>
</tr>
<tr>
<td>Bulk density of grazed horizon (mg/cm³)</td>
<td>20.94</td>
</tr>
</tbody>
</table>

*** = significant differences between 5 and 10 and 15 cm

At present there is no published information on how variation in muzzle width or tongue length may influence intake. Possible factors influencing bite depth are discussed next.

**SWARD AND ANIMAL FACTORS WHICH INFLUENCE BITE DEPTH**

There are four major factors that may be influencing bite depth:

- ease of breaking off a bite
- diet selection
- height, density and composition of sward
- milk producing ability of the cow.

Bite depth and therefore bite weight may be determined by the maximum force the cow is able to exert in breaking off a bite. As mentioned earlier the cow grazes for a minimum of 7 hours a day and usually considerably longer. In the process of evolution it is conceivable that, to avoid the onset of grazing fatigue from exerting varying amounts of force to harvest individual bites, an upper limit was set to the amount of force that could be exerted per bite. For such a mechanism to function the cow would have to alter bite dimension so that the force exerted per bite stayed within the evolved range. A grazing rhythm would ensue. The grazing process could be likened to a person given a machete and sent out to cut sugar cane for 8 hours. They would quickly work out to the number of canes that could be comfortably cut with each swing. In addition, if they were being paid for what was cut, they would soon determine that it is far easier to cut up the stem from the base where the cane had a smaller diameter and was less fibrous and thus would optimize the amount harvested per comfortable swing. The grazing cow may well use similar criteria to establish how deeply into the sward it will bite. Such a scenario suggests that cows would discriminate between plant components based on the relative breaking strengths of the latter. This may explain why higher intakes are obtained on tall leafy swards and animals apparently select leaf versus pseudostem (what is often called **
stem but which in reality is leaves rolled up like a newspaper). Pseudostems of differing diameter and therefore breaking strength can be found in pastures of a similar height depending on stage of maturity and previous grazing management. Such differing heights of pseudostem may influence the height to which a cow prefers to graze. Where cows are forced to graze pseudostem, pseudostem diameter may influence bite depth and, as a consequence, bite size. Pasture height alone is not therefore always an accurate determinant of bite size and intake.

The current consensus among researchers studying grazing is that cattle are not particularly selective, either in choosing the site where they will graze or the bite within this site. This is not to suggest that cattle do not avoid pasture recently fouled with dung, urine and soil and prefer longer pasture. The drive to optimize intake is the vogue hypothesis used to explain both the choice of grazing site and bites within this site. Unfortunately there is no published evidence to substantiate this concept with grazing cattle. Cattle appear to be 'horizon grazers', starting from the top of a uniform sward and grazing down. They do not appear to selectively graze particular horizons. The diet consumed by cows contains a greater proportion of green leaf and less pseudostem and dead material than the pasture as a whole (see Table 2). Even where post grazing heights and residuals are extremely low the diet is predominantly green material. If the animal is indeed able to select it may do so by restricting bite depth to avoid dead material in the sward base. It is claimed that high BI cows graze to lower post grazing residual masses and heights thus consuming greater amounts of pseudostem and dead material where pasture is being rationed. This suggests that a desire for nutrients may alter diet selection and bite depth.

Table 2: The composition of a ryegrass sward and of the diet selected by grazing cows (Forbes, 1982).

<table>
<thead>
<tr>
<th></th>
<th>Whole sward composition</th>
<th>Diet selected by cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenleaf (g/kg)</td>
<td>500</td>
<td>830</td>
</tr>
<tr>
<td>Stem (g/kg)</td>
<td>270</td>
<td>180</td>
</tr>
<tr>
<td>Dead (g/kg)</td>
<td>230</td>
<td>Trace</td>
</tr>
</tbody>
</table>

At present, pasture height appears to be the best predictor of bite size and intake. Taller swards have a greater depth of leaf which influences the depth of bite and intake. Density of leaf also is likely to influence the depth of bite in that it determines the number of plant units to be broken. Common pasture grass plants have at most four leaves and more often only three. The youngest and least structurally strong leaves are found in the surface horizon of the sward. Progressively older and structurally stronger leaves are found below the pasture surface. Tall swards provide the animal with greater opportunity to avoid structurally stronger leaves as well as parasite larvae and fungal spores which are generally found in the base of swards. However intake declines on very tall swards (season dependent but above 25 cm) and is likely to vary considerably between grass dominant and clover dominant swards at the same height. The latter effect has been measured for sheep but there are no published data for cattle.

Overseas research suggests that cows with high yield potential respond differently to their herd mates depending on pasture conditions (Figure 2). On short swards high and low yielding cows have similar intakes probably because the high yielders can not increase
their grazing time sufficiently to compensate for the small bite weights on short swards. As discussed earlier cows rarely are able to graze longer than 10 hours per day. In contrast on tall swards high yielding cows had higher intakes and were able to exhibit their true potential. These results need to be confirmed with high and low BI cows.

Figure 2: The effect of sward height on herbage intake of high (●●) and low (○○) yielding cows (rotationally grazed). (Mayne, unpublished observations).

NUTRITIONAL FACTORS AND INTAKE

The relationship between all forms of pasture allocation and intake is curvilinear (Figure 3). Although not ideal, pasture allocation is generally made in units of mass (kg DM/cow/day) as pasture available above ground per hectare, and pasture growth rates are measured in mass terms. In the ascending part of the curve cows respond to increasing pasture allocation. This response is altered by factors already discussed which influence the ease of harvesting. In the plateau region, nutritional factors such as digestibility, the time feed stays in the rumen, the available nutrients and the relative balance of these factors influence intake. Digestibility is the proportion of a feed eaten which is absorbed and is not therefore excreted in faeces. It is always assessed in dry matter terms, because although water is essential for the well being of the cow water does not provide any energy. Digestibility also has a major influence on the M/D value (MJME/kg DM) of a pasture in that M/D = digestibility x 0.82. Even when animals are offered unlimited access to a feed (ad lib. feeding) there are large differences in intake between feeds of the
same digestibility, with the intake of legumes up to 40% greater than grass and intake of leaf 100% greater than stem. Such differences are related to different rates of digestion and passage of the feeds from the rumen. There are two possible mechanisms at work controlling intake under *ad lib.* feeding; physical distension and metabolic feed back. In the first intake is controlled through gut or rumen fill; the more rapidly a feed is cleared from the rumen by a combination of digestion and passage, the sooner the cow can refill the rumen and the greater the daily intake. This concept can not explain why the rumen of the grazing animal is only full after the evening grazing period and not at the end of all grazing periods throughout the remainder of the day. In addition it is hard to imagine how this mechanism can manipulate intake so that intake increases during lactation and pregnancy (Hutton, 1964). It is well known that rumen fill is lower (approximately 25%) when animals graze legumes compared with grass (Poppi *et al.*, 1987). This implies that the intake of legumes could be increased before a physical limit to intake was reached. Even though cows increase yields by up to 30% they still do not attain their genetic potential, which can be demonstrated by feeding balanced concentrate rations. Factors other than physical factors are implicated. Such factors are termed metabolic, where the nutrients available from a feed and their balance are monitored relative to the tissue needs of the animal. Where pasture conditions are not restrictive, intake is determined by the integration of physical and metabolic factors. In such circumstances digestibility and physical characteristics determining rate of passage and the type and quantity of nutrients released upon digestion will determine intake.

**PASTURE GROWTH**

![Image of grass tiller]

**Figure 4:** A cross section through a grass tiller.

Before the interactions between the pasture and an animal are considered the fundamental growth units of pastures will be briefly described. Pastures are made up of a mass of unique growth units; tillers in the case of grasses and rooted stolons for white clovers. Grass plants usually have only three or four leaves with the youngest at the top of the plant and the oldest nearest the ground. The exception to this rule are the stoloniferous grasses (e.g. brown top and twitch). The growth point of the tiller, the apical region, is found in the base of the pseudostem. It is from here that new leaves and tillers originate (Figure 4). Below the apical region, normally found at ground level, are nodes and internodes which under hormonal influence in spring elongate to form a stem pushing the apical region up the centre of the pseudostem. This is the reproductive tiller and the elevated apical region on top of the stem becomes the seed head. Reproductive tillers are killed when the developing seed heads are removed and any new growth must commence.
at ground level from intact vegetative apical regions. These vegetative tillers are usually relatively inactive as the reproductive tillers are fiercely competitive for all available nutrients during growth. Tiller numbers in pasture follow distinct seasonal patterns with highest numbers in late-winter to early-spring and lowest numbers in late autumn. Winter tillering has been emphasized in the past for establishing a dense pasture for spring growth but summer tillering, which is important for replacing tillers lost during reproductive growth in spring, has received little or no emphasis. With their later spring calving, South Island dairy farmers rely on summer and autumn production for high yields. Therefore this late-spring early-summer tillering is crucial to success. Importantly death rates and, therefore the balance between appearance and deaths, can be manipulated by grazing management, particularly stocking rate and grazing interval (see Figure 5). As discussed earlier new tillers arise from the base of existing tillers and are therefore very susceptible to shading. Intense or frequent grazing avoids this impediment to growth and enhances tiller survival. These developing tillers are also very susceptible to draught.

The other major growth component of pasture is the clover stolon. Each stolon consists of nodes and internodes (true stem material) with a leaf bud and sometimes associated roots (see Figure 6). An apical region (new growth region) is located at the tip of the stolon which produces new leaves, internodes and buds. Stolons may branch as well as elongate, are most active in summer and least active in winter when they are most commonly found below the surface of the soil. In spring new stolons grow rapidly to the soil surface and establish a new network of stolons, the majority of those buried then die.

![Figure 5: Rate of appearance of new and death of existing ryegrass tillers (Bryant & L’Huillier, 1986).](image)

![Figure 6: A white clover stolon.](image)
RESPONSE OF PASTURE TO GRAZING

Figure 7: The fate of pasture.

Pasture is a dynamic community of grass and legume plants, with new tissue continually being formed through growth and old tissue disappearing through the process of senescence (aging), death and decay. Pasture utilized or measured as pasture production only represents part of new tissue growth (Figure 7). Pasture does not accumulate over the years if it is not grazed in the way that a tree might grow, in that new tissue growth is balanced by decay but in the short term it will change if growth is not equal to decay. When the grazing animal is introduced to such pasture it is competing with the process of senescence and decay. Pasture production, as it is currently measured, is the difference between new pasture growth and decay and is determined therefore by the stocking rate (level of pasture consumption) as this determines, along with grazing frequency, the amount of ungrazed pasture that can decay. High stocking rates are therefore necessary for high milk and pasture yields per hectare. The natural life cycle of tillers and stolons sets a limit to the period when they can be utilized by grazing. All leaves have limited life spans and once they reach mature size they remain for a period and then die. Ryegrass tillers produce new leaves every 8 to 10 days in spring and every 20 days in winter. As discussed above most tillers only support three leaves so the average life span of a leaf in spring is 24 days and in winter it is 60 days (Korte et al., 1987). White clover leaf has an average life span of about 30 days in summer.

Figure 8: Effect of pasture mass (= herbage mass) on the rates of new pasture growth and pasture production. The shaded area represents losses through decay and increases with pasture mass (Bircham & Korte, 1984).
When pastures are grazed the rate of growth of new pasture initially is rapid. This growth slows progressively as pasture mass, leaf area and light interception increase (Figure 8). Pasture mass is used as the principal measure even though it is a poor predictor of pasture and animal performance because of variation in: species composition, leaf to stem ratio, and proportion of living to dead tissue. Its major redeeming feature is that it has been widely used in experimental work. When pasture masses are below 1200 kg DM/ha there is insufficient leaf to capture light so new pasture growth declines. Such swards also limit bite size and therefore intake. At pasture covers above 3000 kg DM/ha the rate of new tissue growth is matched by that of decay (pasture production is zero). Again such swards restrict intake by cows because of the high levels of dead and pseudostem material. When such rank pastures are grazed hard, tiller and stolon deaths can occur and regrowth is slow until new tiller and stolon numbers recover. Such sward conditions can occur towards the end of the first post calving grazing round on South Island dairy farms where the average cover at calving is greater than required for the stocking rate and calving spread. This is usually the end result of wintering off. When lax grazing persists through the spring subsequent growth rates of pasture suffer (see Table 3). Pasture production in December suffers after lax grazing in spring as there are inadequate tillers or stolons for rapid growth.

Table 3: Growth rates of pastures grazed with different intensities during spring (Holmes & Hoogendoorn, 1985).

<table>
<thead>
<tr>
<th>Grazing intensity</th>
<th>kg DM/ha daily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>November</td>
</tr>
<tr>
<td>Hard</td>
<td>56</td>
</tr>
<tr>
<td>Moderate</td>
<td>71</td>
</tr>
<tr>
<td>Lax</td>
<td>103</td>
</tr>
</tbody>
</table>
EFFECTS OF PASTURE QUALITY ON MILK PRODUCTION

Research at Ruakura in the early 1980s demonstrated that wide variations in grazing management produced limited or no effect on per cow or per hectare production of milk solids. This study looked at the effect of different pasture covers at calving and the influence of early and late spring pasture management on production. While production differences arose at different stages of lactation there were no overall differences in yield. This suggests that trying to predict final yield from peak lactation is fraught with difficulties. Differences in average cover at calving had limited effect as the amounts involved are minute compared with that grown in the first 5 months of lactation. The effects of differing winter rotation lengths were shown by Bryant and L’Huiller (1986). When feed was short in the spring (from calving until the end of September) maintaining a rotation of at least 20 - 30 days was critical. It is better to look after the pasture than the cow at this stage although it must be stressed that in the trial work only high BI cows capable of responding when fed well were used. From late September until late November pasture production normally exceeds cow requirements and the management of this surplus is essential to ensure high subsequent pasture growth (see Table 3) and milk production (Holmes & Hoogendoorn, 1985). The composition of two pastures designated low and high quality generated by lax and hard spring grazing were compared in December (Table 4). Even though the mass of the low quality sward was more than double that of the high quality sward (2480 vs 5260, or 112% greater), leaf has only increased by 409 kg (or 37%) but the stem component has increased by 1562 kg (or 263%). This huge increase in pseudostem and very small increase in leaf as swards increase in mass from 2500 kg DM/ha is a very common finding. Short term responses in milk fat production followed the trends expected from feeding such pasture (Table 5). Generous feeding of the poor quality sward (post grazing residual of 3540 kg DM/ha) could not overcome its inherent intake-limiting properties. The fall in production was even greater when intake was restricted (allowance of 12 kg DM/cow/day).

Table 4: Composition of two pastures (high and low quality) in December after different spring grazing intensities.

<table>
<thead>
<tr>
<th></th>
<th>High quality</th>
<th>Low quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total herbage yield (kg DM/ha)</td>
<td>2480</td>
<td>5260</td>
</tr>
<tr>
<td>Digestibility of DM</td>
<td></td>
<td>65</td>
</tr>
<tr>
<td>Composition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(kg DM and % of total ())</td>
<td></td>
<td></td>
</tr>
<tr>
<td>leaf</td>
<td>1116 (45)</td>
<td>1525 (29)</td>
</tr>
<tr>
<td>stem</td>
<td>595 (24)</td>
<td>2157 (41)</td>
</tr>
<tr>
<td>clover</td>
<td>174 (7)</td>
<td>630 (12)</td>
</tr>
<tr>
<td>dead</td>
<td>248 (10)</td>
<td>894 (17)</td>
</tr>
<tr>
<td>weed</td>
<td>99 (4)</td>
<td>105 (2)</td>
</tr>
</tbody>
</table>
Table 5: Apparent intake and performance of identical twin cows grazing high and low quality pasture at generous and low allowances.

<table>
<thead>
<tr>
<th></th>
<th>High level of feeding</th>
<th>Low level of feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High quality</td>
<td>Low quality</td>
</tr>
<tr>
<td>Herbage allowance (kg DM/cow/day)</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Allowance of leaf (kg DM/cow/day)</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Apparent herbage intake (kg DM/cow/day)</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Post grazing residual yield (kg DM/ha)</td>
<td>1460</td>
<td>3540</td>
</tr>
<tr>
<td>Milkfat Produced (kg/cow/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- before experiment</td>
<td>0.86</td>
<td>0.89</td>
</tr>
<tr>
<td>- 2nd week of experiment</td>
<td>0.80</td>
<td>0.67</td>
</tr>
<tr>
<td>- change</td>
<td>-0.06</td>
<td>-0.22</td>
</tr>
</tbody>
</table>

CONCLUDING REMARKS

Maintaining high quality pasture will ensure high production from both animals and pastures. The basics are relatively simple. Assess average pasture cover regularly over the property and take the necessary action to ensure that the average cover does not fall below 1000 kg DM/ha except when restricting intake in the dry period. Keep the percentage of the farm with pasture cover above 3000 kg DM/ha to a minimum as this will restrict intake and reduce the rate of subsequent regrowth. Ensure that swards are not over-grazed in the early spring (which influences tiller growth and survival) but are hard grazed in the late spring to optimize summer and autumn production. The key component of such a management practice is the ability to assess pasture mass, a skill taken for granted by researchers who suggest that grazing management has little influence on production. Of the common techniques of assessing pasture mass (pasture probe, rising plate meter, sward height, visual) the least variability is associated with use of the pasture probe or visual assessment, both calibrated by regular cutting (L'Huiller & Thomson, 1988).
REFERENCES


USE OF SUPPLEMENTARY FEEDS

A.R. SYKES
Animal and Veterinary Sciences Group,
Lincoln College, Canterbury.

INTRODUCTION

There are two central issues related to supplementation:
1. supplementation of dairy cattle to maintain or enhance milk production; and
2. variation in milk composition and the extent to which this can be manipulated by supplementary feeding at pasture.

DESCRIPTION AND COSTS OF SUPPLEMENTS

The value and costs of any feed which might be used to supplement pasture is a primary consideration. The metabolizable energy (ME) system provides assessment of the ability of feed to supply nutrients (energy) to the tissues. Digestibility has greatest impact but losses of the energy through rumen fermentation and in urine are accounted for. Some typical ME values are given in Table 1 expressed on the conventional dry matter (DM) basis.

Table 1: Feeding value and relative costs of some common feed supplements.

<table>
<thead>
<tr>
<th>Feed Type</th>
<th>ME/kgDM</th>
<th>$/MJME</th>
<th>$/kg milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass grazing - well controlled</td>
<td>12.0</td>
<td>0.75</td>
<td>3.98</td>
</tr>
<tr>
<td>- for cutting</td>
<td>10.2</td>
<td>0.88</td>
<td>4.67</td>
</tr>
<tr>
<td>Grass-silage* (highest quality)</td>
<td>10.2</td>
<td>1.98</td>
<td>10.6</td>
</tr>
<tr>
<td>(medium quality)</td>
<td>9.0</td>
<td>2.30</td>
<td>12.3</td>
</tr>
<tr>
<td>(poor quality)</td>
<td>7.6</td>
<td>2.67</td>
<td>14.2</td>
</tr>
<tr>
<td>Grass-hay* (highest quality)</td>
<td>10.2</td>
<td>4.80</td>
<td>25.6</td>
</tr>
<tr>
<td>(medium quality)</td>
<td>9.0</td>
<td>5.40</td>
<td>28.8</td>
</tr>
<tr>
<td>(poor quality)</td>
<td>7.6</td>
<td>6.40</td>
<td>34.1</td>
</tr>
<tr>
<td>Barley ($230/tonne)</td>
<td>13.7</td>
<td>1.68</td>
<td>9.0</td>
</tr>
<tr>
<td>Maize grain ($250/tonne)</td>
<td>14.2</td>
<td>1.76</td>
<td>9.5</td>
</tr>
<tr>
<td>Peas/beans ($350/tonne)</td>
<td>13.0</td>
<td>2.63</td>
<td>14.0</td>
</tr>
<tr>
<td>Kale/cabbage - greenfeed (2-16 tonne/ha)</td>
<td>10.5</td>
<td>30-3.5</td>
<td>160-19.0</td>
</tr>
</tbody>
</table>

* Contracting charges added to grazing cost.
When combined with typical market prices for milk the costs of production for these supplements provide a first basis for their efficient use. The large range in cost of ME for forages reflects the extreme variation in DM yield, a function of timeliness of cultivation and season.

SUPPLEMENTS TO MAINTAIN MILK YIELD

Whenever a supplement is fed a complex five-part question must be asked.
1. What yield do I want to stimulate/maintain with the supplement?
2. What total ME intake does this require?
3. How much feed do I expect the animal to receive from grazing?
4. How much supplement do I need to feed?
5. Will I get an economic response?

A simple enough set of individual questions, but 3 and 5, in particular, are rather difficult to answer precisely.
The key issue, assuming adequate availability of a suitable supplement, is to assess the chances of maintaining herbage intake when feeding the supplement.

A useful approach is to ask two further simple questions:
1. How difficult is it for the animal to maintain intake from herbage rather than to simply eat the supplement instead of herbage.
2. What effect will stage of lactation have on the response?

MAINTENANCE OF HERBAGE INTAKE

Bite size and intake decline as degree of difficulty of maintaining bite size increases with declining pasture mass or height (see Hughes). Under these circumstances of low herbage mass or poor herbage quality the animal readily accepts a supplement of better nutritional value as an alternative to pasture. Introduced feeds therefore become replacement rather than supplement feeds (see Figure 1).

![Components of feed intake as proportions of requirement to meet target production](image)

**Figure 1:** Feed intake response to supplementation.
Conversely, under very good sward conditions when intake is readily maintained animals will often refuse the forage supplement, particularly if it is not of high quality. With very high density concentrate feeds offered together with high quality - highly available herbage, enhancement of total intake will occur and milk production will be stimulated; the European system is a prime example. There is evidence that with low quality feeds, such as low ME density hays, concentrate feeding will actually reduce hay intake. This probably reflects differences in optimum rumen fermentation pattern for the two feed types. Brassica supplements generally support only modest intakes in the initial stages of feeding and provision for substantial herbage intake during the early stages should be made. Gradual introduction to such forages is important also for health reasons. Brassicas, particularly if grown on high sulphate soils with significant N fertilizer application may contain high levels of S-methyl-l-cysteine (SMCO), a compound which after breakdown in the rumen yields compounds harmful to red blood cells. Red cell breakdown leads to haemoglobinuria (red coloured urine) with the common name - red water. This can be avoided by ensuring gradual introduction of the feed but feed planning must allow this. The practical implications are that forage supplements designed to optimise intake are most effective when offered before pressure on grazing becomes too intense. They should therefore anticipate a feed deficit. A second advantage is that in anticipating feed shortages and buffer feeding at an early stage, pasture mass can be maintained which will optimise rate of pasture recovery.

**EFFECT OF STAGE OF LACTATION**

The probability of response in milk yield to effective supplementation is also affected by stage of lactation or physiological status of the animal. In effect, as lactation progresses less of the supplement will go to support milk production and more will be used to deposit body tissue. This is described in Figure 2 which shows that greatest response to supplementation can be expected (a) in early lactation, (b) in cows in good body condition and which are (c) currently well fed. As lactation progresses there is an increasing tendency for supplementary feed to be incorporated into body tissue rather than milk, a trend which is exaggerated by delayed feeding of supplements. High breeding index (BI) cows would tend to follow the upper, and low BI index cows the lower line in Figure 2. The effect of this is that if a supplement is offered when less than 100% of the additional ME is used for milk production, the effective cost of the supplement for milk production (Table 1) is increased. For example, at 50% efficiency the cost is doubled.

**Figure 2:** Effect of stage of lactation on response to increase in feed intake or feed supplementation. (--- well fed high BI cow, ---low BI cow or cow in poor condition)
SUPPLEMENTATION TO MODIFY MILK COMPOSITION

There is a large literature on the manipulation of milk composition by dietary methods, reviewed recently by Thomas and Martin (1988). Many factors influence milk fat and protein content, but lactose shows very little variation. Since the amount of lactose secreted is the major determinant of milk volume little variation in concentration would be expected. Milk compositional responses to nutrition reflect, therefore, changes in the rate of synthesis of milk fat and protein relative to that of lactose.

EFFECT OF TOTAL ME INTAKE

It is important to recognise normal variation in milk fat composition during lactation which shows a typical pattern - higher in early lactation, lower in mid-lactation and higher again in late lactation. In early lactation when cows normally lose weight, the mobilization of body fat leads to increased fat precursor substrates (acetate) in the bloodstream. Milk fat synthesis is thus favoured relative to lactose. A positive relationship between rate of body fat mobilization and milk fat concentration exist in sheep (Geenty & Sykes, 1986). During mid-lactation milk yield is determined primarily by nutrient intake and is not buffered by body reserves; cows tend to maintain zero energy balances, fat mobilization is minimized and lower fat synthesis relative to lactose occurs. During late lactation milk yield is controlled physiologically rather than nutritionally (see Figure 2). Increased feeding at this stage will increase availability of all the nutrient precursors in the bloodstream. Since milk lactose synthesis (milk volume) shows only a small response at this stage, a relative increase in milk fat synthesis without increase in milk volume will result in an increase in milk fat concentration.

EFFECT OF FEED QUALITY

The major end-products of digestion of energy in forages and grain feeds in ruminants come from carbohydrate and comprise, essentially, three fatty acids - acetic, butyric and propionic acid. The molar ratio of these major nutrients varies with the ME density or digestibility of the feed (see Figure 3) molar proportions of acetate tending to be higher with feeds of low ME value and lower with feeds of high ME value. There have been many experiments in which these constituents have been varied by infusion of a particular nutrient or group of nutrients into animals consuming otherwise adequate diets. Generally speaking, infusions of acetate (simulating increased intake of poor quality feed) have increased milk yield (+8%), milk fat content (+9%), as would be anticipated from the discussion above, and have had little effect on milk protein or lactose content. Propionate infusion (simulating higher quality feed) has had little effect on milk yield but has increased protein content (+6.5%) and reduced fat content (-8%); glucose infusion has increased yield and reduced fat content slightly while protein infusion increased yield (7%), protein content (5%), decreased fat content (2.5%) and had no effect on lactose content. Butyrate has reduced yield (-5%) and markedly increased fat content (+14%). These have tended to encourage us to think that milk composition can be modified by diet. In practice it is difficult to change only one constituent by change of diet. For example, reduction in ME value of herbage, as when grazing rank herbage, might be anticipated to result in increase in milk fat content and in volume as a result of
increase in acetate production. However, reduction in protein supply would undoubtedly also occur which would tend to negate the increase in milk yield, part of the increase in milk fat content and, independently, lead to a reduction in milk protein. The net effect would be a very much smaller change in composition than would be anticipated from change in acetate production alone.

Figure 3: Effect of feed quality on volatile fatty acid (VFA) end products of digestion of energy in ruminants.

In practice major changes in milk composition attributable specifically to diet have generally been achieved in situations of depressed milk fat production as a result of feeding diets with very very high proportions of concentrates (> 600 g/kg diet DM). Increasing the intake of starch by use of cooked cereals, such as flaked maize, has increased milk fat and protein content under these circumstances, presumably by increasing rumen propionate production.

The responses of milk protein or fat content to supplementary starch in cattle offered forage diets has been negligible. Indeed, there is a general consensus that the opportunity to manipulate composition by supplementing forage diets ranging in M/D from 9-11, the change commonly experienced on pastoral dairy farms, with concentrate feeds is very small. This is the case largely because, at the modest levels of feeding that we could anticipate, the pattern of rumen fermentation would not be significantly affected.

The argument applies even more forcibly to the situation of silage supplements: these are typically made from high quality grass and, as a consequence, promote a similar pattern of rumen fermentation to the herbage from which they were made. This is shown in Table 2. Paradoxically poor silages, with high butyrate content would enhance milk fat percentage, though low DM intake would undoubtedly reduce yield and total fat and protein production. Silages are generally, however, poorer in protein content than the grasses from which they were made, particularly if unwilted, or if made under adverse weather conditions and not protected by formaldehyde treatment at ensiling (Rogers et al., 1979b & c). Silage supplementation is therefore only likely to enhance milk protein production by increasing total DM intake and stimulating total milk production.
Table 2: Proportions (% of total) of volatile fatty acids in rumen liquor from cattle offered grass or grass silage (from Rogers et al., 1979a).

<table>
<thead>
<tr>
<th></th>
<th>Silage</th>
<th>Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>66</td>
<td>63</td>
</tr>
<tr>
<td>Propionic acid</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>10</td>
<td>17</td>
</tr>
</tbody>
</table>

PROTEIN SUPPLEMENTS

Even the highest quality pasture, perhaps surprisingly, is deficient in the supply of amino acid (protein) for milk synthesis. Casein supplementation will increase both milk yield and protein production (Rogers et al., 1979c; Chrisp et al., 1988). The former authors, however, obtained only a 19 g/d increase in milk protein production from 300 g/d of casein infused into the abomasum of dairy cows. There are, moreover, major difficulties in developing a practical delivery system which will achieve greater protein supply to the site of absorption - the small intestine. In New Zealand this must come from improved plant varieties which protect their cell proteins from breakdown in the rumen. Overseas work has investigated low degradability proteins such as fish meal and meat meals (which incidentally have flavour and health risks), or plant proteins protected by heat or chemical treatment. Economic responses have still to be achieved even in that financial environment!!

NON-NUTRITIONAL SUPPLEMENTS

Recently, interest has arisen in the use of rumen stabilizers such as bicarbonates to modify rumen pH, the pattern of volatile fatty acid production and hence milk composition. Some beneficial effects have been obtained in the amelioration of low milk fat syndrome on diets comprising 80-90% grain (Wheeler, 1981 cited by Block, 1988). There is no evidence that they will have any effect under the normal rumen conditions experienced in pastoral systems of production.

There is some evidence that responses of milk volume and milk fat production can occur to Mg supplementation in moderate yielding dairy cows with blood magnesium concentration below 15 mg/l (Young, et al., 1981). It is important that these data are substantiated.

REFERENCES


SUMMARY

Among the factors influencing productivity and profitability in the dairy industry, animal diseases deserve special attention because they diminish the capacity of the animal to achieve its inherent potential level of production, for any given feeding and management regimen. Introduction of the new scheme of payment for milk will inevitably place a greater emphasis on prevention of diseases which affect milk quality. Among diseases that affect the yield and quality of milk mastitis is the most economically important. Other disease conditions in New Zealand are milk fever (hypocalcaemia), grass staggers (hypomagnesaemia), ketosis, bloat, reproductive disorders, deficiencies of selenium, cobalt, copper, iodine and sodium, mycotoxic diseases (e.g. facial eczema, ryegrass staggers), nitrate toxicity and intestinal parasitism. In addition, palatability and wholesomeness of milk may be affected via undesirable contamination by pesticides and antibiotic residues.

Many of these conditions can be controlled by proper nutrition, timed vaccination, sound management and good hygiene. For dairy farmers who maintain sound husbandry practices veterinarians will be required mainly in an advisory capacity rather than for therapeutic activity.

INTRODUCTION

Milk is a complex mixture of lipids, carbohydrates (lactose), proteins (casein and whey protein) and many other organic compounds, inorganic salts and vitamins, dissolved or dispersed in water. Many of the milk components vary quantitatively and qualitatively, both between (Table 1) and within breeds. A marked deviation in the major milk components or presence of any undesirable contaminants will result in a lowering of the nutritive value, palatability, stability and wholesomeness of milk and may cause downgrading.

Table 1: Average gross composition of milk\(^a\) of New Zealand dairy cattle. (Adapted from Holmes & Wilson, 1984.)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Fat</th>
<th>Crude protein</th>
<th>Lactose</th>
<th>Minerals (ash)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayrshire</td>
<td>47.4</td>
<td>36.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friesian</td>
<td>45.4</td>
<td>34.7</td>
<td>46.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Friesian-Jersey</td>
<td>47.8</td>
<td>35.8</td>
<td>to</td>
<td>to</td>
</tr>
<tr>
<td>Jersey</td>
<td>55.7</td>
<td>39.2</td>
<td>52.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

\(^a\) Values are expressed as g/l
Some milk constituents are synthesized in the mammary gland from precursors in the blood; others are transferred directly from the blood to the milk through cell membranes. Consequently, all the physiological and biochemical phenomena that influence the composition of blood may affect the composition of milk (Edelsten, 1988). Furthermore, substances such as hormones (e.g. prolactin, thyroxine, corticosteroids, insulin, glucagon, growth hormone, catecholamines, oestrogens, progesterone) that are capable of influencing glandular and mammary biosynthesis can also modify milk composition. Disturbances in animal health even if they do not directly affect the bovine udder may also result in a lower production of milk, affect blood composition, change the permeability of the blood-milk barrier and hence indirectly affect the quality of milk.

The composition and quality of milk is largely influenced by such factors as genotype, stage of lactation, age, quantity and quality of feed, season, milking procedure, infection of mammary glands (mastitis), diseases other than mastitis, and undesirable contaminants in milk. The present discussion will concentrate primarily on the last three factors. Many diseases discussed here are clinically recognizable, but some diseases such as those caused by mycotoxins, organochlorine insecticides (e.g. DDT) and polychlorinated biphenyls, subclinical forms of mineral and vitamin deficiencies and subclinical mastitis, lead to suboptimal production and may lower milk quality without readily identifiable symptoms and/or lesions.

**INFECTION OF THE MAMMARY GLAND (MASTITIS)**

Among several diseases of the bovine udder, mastitis is the most economically important. The exact cost of mastitis to the dairy industry is not known, but it may be as high as 10% of the annual cost of production (Hoare, 1982). The aetiology of mastitis is complicated and in many instances multi-factorial. The most common infective agents are *Staphylococcus aureus* and *Streptococcus agalactiae*. Mastitis can occur at any stage of lactation but is most common just prior to calving or in early lactation. Clinical mastitis can be acute or chronic. In acute mastitis the gland is hot, tender to touch and swollen, and the cow may have an elevated temperature and depressed appetite. Sometimes the disease can result in gangrene and a part of the udder may be sloughed off. More frequently the disease becomes subacute or chronic. In chronic mastitis, lumps may be palpated in the udder and the milk may contain clots. Subclinical mastitis shows none of these detectable signs and can only be diagnosed by special tests (e.g. somatic cell counts; changes in electrical conductivity, increase in the enzyme N-acetyl-β-D glucosaminidase). It is estimated that there are usually 20-30 cases of subclinical mastitis for every clinical case.

Generally, the composition of milk from cows affected by mastitis tends to approach that of blood. This is thought to be a result of impaired synthetic and secretory activity of epithelial cells of the udder, as well as other pathological changes which occur during the infection. For instance, alterations to blood capillary permeability occur and the tight junctions between epithelial cells open up. This results in an increase in the influx of ions and proteins from blood into milk.

In mastitic milk the concentrations of fat, lactose, and casein are lowered but the concentration of total whey protein is variable. Of the individual whey proteins, the concentrations of those synthesized by the mammary gland, β-lactoglobulin, and α-lactalbumin are lowered while those of blood, serum albumin and immunoglobulins, are
increased. The mineral constituents, potassium, calcium and phosphorus are present at lower concentrations while the concentrations of sodium and chloride are higher. Table 2 gives an example of the effect of mastitis on the levels of some milk constituents.

**Table 2:** Effect of mastitis on composition of milk. (Adapted from Holmes & Wilson, 1984.)

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>NORMAL MILK (Concentration)</th>
<th>MASTITIC MILK (Change from normal milk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (g/l)</td>
<td>30-60</td>
<td>slightly ↓</td>
</tr>
<tr>
<td>Lactose (g/l)</td>
<td>44-49</td>
<td>30% ↓</td>
</tr>
<tr>
<td>Total casein (g/l)</td>
<td>26-38</td>
<td>50% ↓</td>
</tr>
<tr>
<td>Total whey protein (g/l)</td>
<td>30-48</td>
<td>slightly ↓</td>
</tr>
<tr>
<td>Protein components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>β-lactoglobulin (g/l)</td>
<td>3-5</td>
<td>30% ↓</td>
</tr>
<tr>
<td>α-lactalbumin (g/l)</td>
<td>1-3</td>
<td>50% ↓</td>
</tr>
<tr>
<td>serum albumin (g/l)</td>
<td>0.08-0.30</td>
<td>50-fold ↑</td>
</tr>
<tr>
<td>immunoglobulins (g/l)</td>
<td>0.20-1.4</td>
<td>20-fold ↑</td>
</tr>
<tr>
<td>Sodium (mmol/l)</td>
<td>12-25</td>
<td>2-fold ↑</td>
</tr>
<tr>
<td>Potassium (mmol/l)</td>
<td>30-45</td>
<td>slightly ↓</td>
</tr>
<tr>
<td>Calcium (mmol/l)</td>
<td>28-40</td>
<td>markedly ↓</td>
</tr>
<tr>
<td>Magnesium (mmol/l)</td>
<td>4-6</td>
<td>markedly ↓</td>
</tr>
<tr>
<td>Chloride (mmol/l)</td>
<td>25-35</td>
<td>2-fold ↑</td>
</tr>
<tr>
<td>pH&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.65</td>
<td>slightly ↑</td>
</tr>
<tr>
<td>Somatic cells (no./ml)</td>
<td>20,000-300,000</td>
<td>25-fold ↑</td>
</tr>
</tbody>
</table>

<sup>a</sup> From Kitchen (1981)
Problems with manufacturing properties and product defects have been observed for most dairy products made from mastitic milk (Mitchell et al., 1985). Pasteurised milk has shown reduced flavour and quality, skim milk powder has decreased heat stability and the keeping quality of butter is reduced. The effects on cheese manufacture have been longer rennet time, lower yields, higher curd moisture and higher fat loss in the whey.

Mastitis can be controlled by regular monitoring of somatic cell counts, sanitation and hygiene, evaluation of milking machines and treatment of cows during the dry period. If a cow is treated with antibiotics during lactation, attention should be paid to the recommended withholding time before milk from an infected quarter can be put into the bulk supply.

DISEASES OTHER THAN MASTITIS

Although sporadic diseases such as salmonellosis may cause crippling damage on a farm, their overall impact on the dairy industry is quite small (Blood et al., 1983). The most frequently occurring diseases in dairy cattle other than mastitis are reproductive disorders (leptospiral abortion, retained foetal membranes, cystic ovaries, uterine infections), frothy bloat, grass staggers (hypomagnesaemia), milk fever (hypocalcaemia), ketosis, facial eczema, Johne’s disease, feet problems, and pneumonia (Blood et al., 1983). Pneumonia occurs more frequently in younger than in older cows, whereas the remaining diseases seem to occur more frequently as age increases. The occurrence of these according to stage of lactational cycle (Radostits & Blood, 1985) is outlined below.

A. PERIPARTURIENT COW (1 week before and immediately after calving).

Diseases which occur at this time include milk fever (hypocalcaemia), udder oedema, dystocias (difficult births), retained foetal membranes, mastitis, Downer cow syndrome and reduction in appetite due to simple indigestion associated with a change in diet.

**Milk fever (hypocalcaemia)** The most common disease at this stage of lactation is milk fever and this is characterized by hypocalcaemia (low blood calcium), general muscular weakness, drop in blood pressure and unconsciousness. Hypocalcaemia occurs mostly in high producing milking cows due to a failure to cope with greatly increased demand for calcium following the initiation of lactation. Affected animals respond readily to intravenous calcium therapy. Total milk removal should be avoided for 3 days post treatment to avoid a relapse.

B. EARLY LACTATION (calving to 2 months afterwards)

Incidence of disease in dairy herds is high during the 30 days immediately after calving and continues to increase until the time of maximum milk yield. A high incidence of production diseases such as milk fever, grass staggers (hypomagnesaemia), ketosis, and postparturient haemoglobinuria occur during this time.

**Grass staggers (hypomagnesaemia):** Grass staggers is characterized by hypomagnesaemia (low blood magnesium) often accompanied by hypocalcaemia, and clinically by unusual alertness, muscular spasms and convulsions. If clinical cases are not
treated death occurs due to respiratory failure. Hypomagnesaemia is a major cause of lowered milk fat production in dairy herds in New Zealand. A survey (Feyter et al., 1986) has shown that 30-50% of the dairy herds in New Zealand could be affected. During early lactation, the concentration of magnesium in and its availability from forage are low, often due to high potassium content following potash and/or high nitrogen application. As a preventative measure supplements of magnesium may be provided by dusting pasture with magnesium oxide, by drenching individual cows with magnesium as oxide, sulphate or chloride or by adding magnesium sulphate to water troughs. Magnesium supplementation during the first 3 to 4 months of lactation has been shown to increase milk fat production in deficient cows by 10-15% (Young et al., 1981). Estimates suggest that over 70% of New Zealand dairy farmers are now supplementing cows with magnesium (Holmes & Wilson, 1984).

**Ketosis:** Ketosis is caused by impaired metabolism of carbohydrate and volatile fatty acids and is a common occurrence in high producing cows in early lactation. It is less likely to occur in cows which are not too fat at calving and which are well fed in early lactation. Signs of ketosis include depression, a staring expression, loss of appetite, constipation, and loss of weight but a few may show signs of frenzy as though the cow is drunk. Biochemically, it is characterized by ketone bodies in blood and urine, low blood sugar, and low levels of liver glycogen. Affected cows may be treated with intravenous glucose and glucocorticoids followed by a drench of glycerine or molasses in water. Preventive measures include avoiding excessive fatness and provision of a rising plane of nutrition during late pregnancy and early lactation.

**Post-parturient haemoglobinuria:** Post-parturient haemoglobinuria is a disease of high producing dairy cows occurring soon after calving and is characterized by red blood cell rupture, haemoglobinuria (blood in urine) and anaemia. Diets low in phosphorous are usually associated with this disease. In New Zealand, copper deficiency is also considered to be an important factor in post-parturient haemoglobinuria because copper supplementation has been shown to reduce the incidence of disease in herds of marginally copper deficient areas (Smith & Coup, 1973). An adequate intake of phosphorus for maintenance and milk production should be ensured particularly in early lactation.

**C. MID AND LATE LACTATION** (after 2 months of lactation)

Although the incidence of damage to udders and teats increases with lactation length its occurrence is of least importance among those diseases affecting the quality of milk. During mid and late lactation, suboptimal milk yield and drop in milk fat may occur due to insufficient or an imbalance in dietary intake of energy, protein or minerals.

**DISEASES AT ANY STAGE OF LACTATION**

The following diseases can affect dairy cattle at any stage of lactation and can be categorized into those that are: nutritionally related, infectious, mycotoxic and parasitic.

**A. NUTRITIONAL AND METABOLIC DISEASES**

Nutritional and metabolic diseases occur due to nutritional and/or metabolic disorders and hence can be corrected by proper feeding. The more common disorders are: imbalances in concentrate - roughage feeding (see other authors); selenium, cobalt, copper and vitamin E
deficiencies; calcium, phosphorous and vitamin D deficiencies, hypomagnesaemia, sodium deficiency; iodine deficiency; nitrate toxicity; bloat; simple indigestion; grain overload; rumen tympany; fat cow syndrome. Of these only the disorders of significance to dairy animals in New Zealand are discussed below. Hypocalcaemia and hypomagnesaemia have been addressed above.

**Selenium (Se) deficiency:** Occurrence of Se deficiency in livestock is widespread in New Zealand and this is especially so during early spring. Se concentrations are lower in clovers than grasses and deficiencies are closely associated with a soil concentration of less than 0.5 mg Se/kg. In cattle, Se deficiency is characterized by white muscle disease in newborn calves and ill-thrift, diarrhoea, abortion, retained foetal membranes, subsequent re-breeding problems and low milk production in adult animals. Se deficiency can be prevented by administration of Se (as sodium selenate or selenite) orally or injected, or by topdressing pasture with Se prills. Significant improvements in milk volume and milk fat production in response to Se supplementation have been reported from several dairy herds of low Se status (Fraser et al., 1987).

**Cobalt (Co) deficiency (bush sickness):** Co is a constituent of vitamin B\textsubscript{12} (cyanocobalamin) and its deficiency occurs mostly in animals grazing pasture of high pH, well drained, pumice or granite soils. Co is higher in clover than in grasses and extremely low in cereal straws. In pasture, Co concentration is lowest during spring and summer. Clinical signs of Co deficiency include ill-thrift, anaemia, birth of weak young and reduced milk production. For prevention, application of Co in fertiliser or use of Co bullets is recommended.

**Copper (Cu) deficiency:** Cu deficiency is widespread in New Zealand, especially in animals grazing pasture on volcanic peats, certain pumice soils and sandy soils. High molybdenum (which can occur in pasture or peat soils) depresses Cu availability and may thus produce a deficiency characterized by scouring. High sulphur or sulphate levels in feed exacerbate the effect of molybdenum (Suttle & McLaughlin, 1976). Other signs of copper deficiency include lameness, ill-thrift, faded hair, anaemia, broken bones, poor conception rates and lowered milk production. In the absence of clinical signs of Cu deficiency, reported evidence of effects of low or marginal Cu status on dairy cow milk production and/or fertility is largely circumstantial. Tissue Cu levels suggestive of a likely response to supplementation in dairy cows have not been adequately defined. Cu deficiency can be prevented by supplementation of Cu via fertiliser, by giving it as a salt lick or by administration of 'bullets' or copper oxide needles.

**Iodine (I) deficiency and goitrogens:** Iodine is essential for synthesis of the thyroid hormones. Its deficiency leads to an enlargement of the thyroid glands (goitre). Goitrogens are substances which interfere with iodine uptake by the animal and these are found in a variety of forages (e.g. brassica species) and root crops. Goitrogens in cattle are usually associated with enlargement of the thyroid glands and death of newborn calves. They also appear to lengthen post-partum anoestrus and to limit several production parameters such as body growth and milk production, but our knowledge at present is insufficient to quantify such losses. Supplementation of the diet with iodised salt or use of iodine injection is recommended when deficiency is diagnosed.

**Sodium (Na) deficiency:** Lactation poses a particularly heavy demand for Na which may be exaggerated by mastitis infections where Na secretion has been suggested to increase 5-
fold (Towers & Smith, 1983). Deficiency of Na becomes a major problem when stock are confined to grazing 'natrophobic' plants (those which accumulate Na in roots and not in the stem and leaves) such as lucerne, red clover, timothy, browntop, kikuyu, paspalum and timothy. These plants contain only 0.1 - 0.6 g Na/kg dry matter compared to most of the other common forages such as ryegrass, prairie grass, brassicas and white clover ('natrophilic' plants) which usually contain 1-6 g Na/kg dry matter. High rates of potash application can depress Na concentration, even in natrophilic plants, and predispose cattle to Na deficiency. Rapidly growing stock and lactating cows appear to be most susceptible to Na deficiency. The clinical signs of Na deficiency include lowered growth rate and milk production, loss of appetite, abnormal licking or chewing of wood, soil, and sweat of other animals. Under deficiency conditions, supplementation with Na in the form of licks mixed with concentrate meals or in drinking water is advised.

**Bloat**: Bloat is most prevalent during spring in cattle eating large quantities of lush pasture, particularly if the pasture contains a high proportion of legumes such as white clover, red clover or lucerne. Bloat is caused by formation of stable foam or froth in the rumen which makes it impossible for the cows to get rid of normal rumen fermentation gas by belching. The extra gas in the rumen exerts pressure on the heart and lungs which can cause death. Cows which are affected by bloat but do not die, eat less pasture and produce less milk. Treatment of bloat consists of drenching with 20-30 ml of antifoaming agent or with 100 ml of liquid paraffin. In severe cases it may be necessary to relieve pressure in the rumen by inserting a knife into the rumen through the left flank. Bloat can be controlled during susceptible periods by drenching cows with an antifoaming agent at milking or adding the agent to drinking water.

**Nitrate toxicity**: Many common pasture plants, including ryegrass and immature brassica crops, are likely to accumulate nitrates, particularly on high fertility soils during warm, wet conditions as in autumn. Nitrates are present in high concentrations in immature plants. This year's drought in Canterbury has resulted in late development of plants and hence an increase in the incidence of nitrate toxicity. After ingestion, plant nitrate is reduced to nitrite in the rumen but normally this is further reduced to ammonia. However, if the production of nitrite is too rapid, acute toxicity may occur. Clinical signs of nitrate toxicity include trembling, staggering, rapid respiration, chocolate brown blood, and possibly death. A concentration in excess of 1% nitrates in feed (on a dry matter basis) is considered to be acutely toxic. A lower concentration of nitrate intake may not produce the classical clinical signs outlined above, but may affect milk production and cause abortion (Osweiler et al., 1985). A feed concentration of less than 0.5% (dry matter basis) is considered safe. Treatment in early stages is extremely effective and consists of intravenous administration of a solution of methylene blue.

**B. INFECTIOUS DISEASES**

The most common infectious diseases are leptospirosis, Johne's disease and foot rot. Of these leptospirosis can be controlled by vaccination.

**C. MYCOTOXIC DISEASES**

Cattle are exposed to mycotoxins from fungi growing on dead leaf litter in pasture, in endophytes of pasture grasses and in infected grains and stubbles of forage crops. Several mycotoxins have been shown to affect milk yield in dairy herds (Fisher et al., 1967).
thought to be due to plants are turning out to be mycotoxic. A recent example is myrothecitoxicosis on kikuyu grass. Mycotoxic diseases frequently arise as veterinary problems whose true cause has not been readily identified. These disorders are neither infectious or contagious, but are associated with particular weather conditions (usually warm and humid). Mycotoxins are rarely responsible for acute disease. Many mycotoxic problems may be present as vague chronic conditions related to poor performance, low milk yield, ill-thrift and suppression of the immune system (hence increased susceptibility to infectious diseases). Cause for concern in the livestock industry is the possibility that the toxins will 'carry over' into the milk or other animal products used as human food. This fear applies to all toxins, but is understandably greater with carcinogens (cancer producing agents). With the possible exception of aflatoxin in cow’s milk, there is no identified occurrence of such human mycotoxicoses. Experimental administration of toxin T-2 in large doses has resulted in detectable toxins in cow’s milk, but at levels not considered to be dangerous for men (Blood et al., 1983).

A summary of common mycotoxicosis that affect cattle is provided in Table 3. Among these facial eczema and ryegrass staggers are the most common in livestock in New Zealand.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Toxin</th>
<th>Source</th>
<th>Fungus</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>ryegrass staggers</td>
<td>lolitrem B</td>
<td>perennial ryegrass</td>
<td>Acremonium jolise</td>
<td>severe incoordination</td>
</tr>
<tr>
<td>facial eczema</td>
<td>sporidesmin</td>
<td>perennial ryegrass, white clover</td>
<td>Pithomyces chartarum</td>
<td>photosensitization, liver damage</td>
</tr>
<tr>
<td>fusariotoxicosis</td>
<td>zearalenone</td>
<td>corn, maize, barley, sorghum</td>
<td>Fusarium roseum</td>
<td>oestrogenic effects, infertility, enlarged udder, teats and vulva</td>
</tr>
<tr>
<td>paspalum staggers</td>
<td>paspalinines</td>
<td>paspalum</td>
<td>Claviceps paspali</td>
<td>ataxia, muscle tremors, convulsions</td>
</tr>
<tr>
<td>tremorgen intoxication</td>
<td>penitrem A</td>
<td>grasses &amp; stored feeds</td>
<td>Penicillium spp.</td>
<td>ataxia, muscle tremors, convulsions</td>
</tr>
<tr>
<td>lupinosis</td>
<td>phomopsins</td>
<td>lupins</td>
<td>Phomopsis</td>
<td>jaundice, liver damage; drop in milk production</td>
</tr>
<tr>
<td>mouldy corn disease</td>
<td>trichothecenes (T2 toxins)</td>
<td>stored grain, pasture</td>
<td>Fusarium spp.</td>
<td>feed refusal, weight loss, immunosuppression, diarrhoea, haemorrhages, necrosis of mouth and gut</td>
</tr>
<tr>
<td>aflatoxicosis</td>
<td>aflatoxin</td>
<td>stored grain, peanuts</td>
<td>Aspergillus flavus</td>
<td>poor feed conversion, reduced weight gain, drop in milk production</td>
</tr>
<tr>
<td>myrotheciosis-toxicosis</td>
<td>trichothecenes (T2 toxins)</td>
<td>kikuyu grass, clover &amp; stored feed</td>
<td>Myrothecium roridum, M. verrucosum</td>
<td>haemorrhage in gut - especially abomasum, reduced weight gain</td>
</tr>
<tr>
<td>stachybotryosis</td>
<td>satratoxins</td>
<td>hay, straw</td>
<td>Stachybotrys alereasa</td>
<td>low platelet count, bloody enteritis.</td>
</tr>
<tr>
<td>fescue foot toxicosis</td>
<td>butenolide</td>
<td>fescue grass or hay</td>
<td>Fusarium triticum</td>
<td>reddening of coronary band and interdigital area, death of tissue and sloughing of extremities</td>
</tr>
<tr>
<td>slaframine toxicosis</td>
<td>slaframine</td>
<td>red clover hay</td>
<td>Rhizoctonia leguminicola</td>
<td>excessive salivation, lacrimation (tears), bloat</td>
</tr>
<tr>
<td>rubratoxin poisoning</td>
<td>rubratoxin</td>
<td>stored feeds</td>
<td>Penicillium rubrum</td>
<td>liver damage, haemorrhage</td>
</tr>
</tbody>
</table>

**Facial eczema:** Facial eczema may affect all ages of cattle but is primarily a disease of lactating dairy cows. It is caused by the toxin sporidesmin which is produced by the spores of a fungus (Pithomyces chartarum) that grows on dead grass at the bottom of pasture. When conditions are warm and moist massive numbers of spores are produced. The toxin produces liver damage, with resultant jaundice and sensitivity of the skin to sunlight. On exposure to sunlight areas of skin, particularly on the head, back, udder and
legs, become swollen and cracked, exude serum and finally peel off. The affected animals suffer extreme discomfort, reduced appetite and become weak and thin. Milk production drops dramatically. Facial eczema can be prevented by controlling the fungus on pasture and by regular dosing with zinc.

**Ryegrass staggers:** Ryegrass staggers is a nervous disorder characterized by severe incoordination. It normally occurs in late summer and early autumn when the fungal endophyte (*Acremonium lolii*) infestation of perennial ryegrass is highest. The toxic agent is lolitrems B, a tremorgen produced by this fungus. Early symptoms in stock at rest are fine muscle tremors, but when disturbed they stagger badly, go down on their brisket and remain in a splayed-leg position until recovery. Severely affected stock lose condition through an inability to graze. Subclinical effects of the disease in sheep include a reduction in plasma prolactin concentration (Fletcher and Barrell, 1984) and if this occurs in cattle it will result in a drop in milk production.

**Diseases caused by tricothecenes:** Fusarium species are a group of fungi which infect grains and pasture and cause a number of diseases in domestic animals. These fungi are common in North Island pastures, especially from February to April (Di Menna & Parle, 1970). The most important mycotoxins produced by Fusarium species are the trichothecces. These tend to attack rapidly dividing tissues in the body such as gut epithelium, bone marrow and lymphoid organs. They are also potent inhibitors of DNA and protein synthesis.

Treatment for most mycotoxicosis is not available at present but production of vaccines against mycotoxins may be possible in future.

**D. PARASITIC DISEASES**

Parasitic diseases include intestinal helminthiasis, fascioliosis, coccidiosis and external parasites. Significant increases in milk production (of up to 250kg) have been reported in New Zealand dairy cattle following dosing with levamisole at different stages of lactation (McQueen *et al.*, 1977). A more recent study from Ireland has extended these findings and reported increases in both milk fat and milk proteins after anthelmintic treatment of dairy cattle (O'Farrell *et al.*, 1986). Internal parasitic disease can be controlled by sound pasture management and the sensible use of anthelmintics.

**UNDESIRABLE CONTAMINANTS IN MILK**

Prevention of contamination of milk should be a top priority in the dairy industry since concern about pesticide, drug and other residues ranks high among consumers. Contamination of milk may occur from the environment or from drugs administered to cattle for control of diseases. The most common contaminants in milk are pesticides, polychlorinated biphenyls and antibiotic residues. The major problem with the above residues in the milk is their toxicological significance to man.

**A. ANTIBIOTIC RESIDUES**

Antibiotics are used extensively in the dairy industry to treat and control mastitis and other diseases and their residues in milk are encountered routinely. This is mostly due to indiscriminate use of antibiotics and non-adherence to proper dosage and withdrawal times. Of great consequence is the effect of antibiotics in milk on the manufacture of
dairy products (e.g. cheese, yoghurt) and development of sensitivity problems in humans.

B. PESTICIDES

Among the three groups of synthetic insecticides (organochlorines, organophosphates, carbamates) organochlorines pose a special problem to the dairy industry because of their affinity for fat, slow degradation, and biological magnification (accumulation of greater quantities in fat at each level in the food chain). DDT (which is an organochlorine) was used extensively in New Zealand from 1945. Although its use was discontinued in the 1960's it still appears in milk today. This is because it still occurs in soils and pastures. Milk contains fat (derived from the diet and from fat stores in the cow) and the secretory cells of the mammary gland do not have any means to keep DDT and other fat soluble components out of milk. DDT is excreted in milk of dairy cows in amounts proportional to the quantities ingested in their feed. The threshold level of DDT residues in milk set by the EEC is 1 ppm (in butter fat). This is lower than the tolerance level in New Zealand which is 1.25 ppm. Recent data from New Zealand indicate that cattle grazing on farms with soil concentrations of less than 0.2 ppm of DDT residues are unlikely to have butter fat residues above 0.6 ppm. The other pesticides and herbicides, although still widely used, are not common residues in milk because they are rapidly degraded.

C. POLYCHLORINATED BIPHENYLS (PCBs)

PCBs have been used extensively since 1929, primarily in electrical equipment such as transformers and capacitors, and in hydraulic fluids and lubricants. PCBs are also extremely stable and parallel DDT in action in many ways. Like DDT, PCBs are also excreted in the milk fat. It is believed that the levels of PCBs in New Zealand milk are low compared with levels as high as 1.80 ppm found in European milk (Niewidowska & Juszkiewicz, 1978).

D. RADIOACTIVE MATERIALS

Environmental contamination by radioactive materials (radionuclides) is a subject of public concern at the present time. Although radionuclides can reach man via many different foods and pathways, milk appears to be extremely efficient in the uptake of the fallout radionuclides most hazardous to man such as strontium (90Sr), caesium (137Cs, 134Cs), and iodine (131I). Despite its short radioactive half-life (8 days) 131I is of greatest concern since physiological mechanisms exist in animals to concentrate iodine in thyroid and mammary secretions. Radionuclides of caesium being longer-lived (>30 years) are the more important nuclides in terms of long-term contamination of milk. It is estimated that on the average 7.5-10% of the ingested radionuclides are excreted into milk (Langmann et al., 1974). In New Zealand there are no nuclear power stations, other nuclear reactors or any major sources of radioactivity. Fortunately New Zealand is also isolated from much of the global fallout of radionuclides. Nevertheless the prominence of milk as a vehicle for transmission of these contaminants indicates that this issue must be kept in mind by the dairy industry.

REFERENCES


INTRODUCTION

There is little quantitative information on performance of pasture species under dairying from South Island research. We therefore have to extrapolate from results obtained in the cooler regions of the North Island and use data from South Island sheep pastures in deciding on the merits of species and cultivars. Observations and experiences of dairy farmers are also very important.

South Island dairying areas have a wide diversity of climate types, from cool moist Southland to warm moist Golden Bay and wet West Coast to irrigated Canterbury. Soils also vary widely in their fertility and physical characteristics. Drainage and soil texture in relation to winter pugging and water holding capacity on summer-dry irrigated farms are regionally important. Some general recommendations can be outlined here but farmers have to modify and adapt advice to suit their own individual properties.

Perennial ryegrass and Huia white clover are the dominant species in South Island dairy pastures. Some farmers will be content with their present pastures and production level. Others who are dissatisfied with their pastures or those who wish to increase their production targets will be seeking new answers. One way to achieve higher production targets is to grow more feed using species other than traditional ryegrass and white clover. This section presents information and opinion on pasture species to help South Island farmers make good choices from the wide range of cultivars and species which are available.

PERENNIAL RYEGRASSES

Perennial ryegrass is strongly favoured by most intensive pastoral farmers because of its resilience under a wide range of establishment conditions and its tolerance of intensive grazing and winter pugging. In general it is the most versatile grass available.

There are, however, some doubts about perennial ryegrass. In some cultivars there is concern about the apparent loss of vigour and ability to persist. Other cultivars are perhaps too aggressive, while they are persistent they also appear to suppress white clover and cause some reduction in animal performance. The presence or absence of the ryegrass endophyte Acremonium lolii appears to be the reason for inconsistencies in ryegrass performance and an understanding of its influence has been growing over the last eight years.
The endophyte dilemma

The endophyte story is the most important aspect of new pasture knowledge to affect New Zealand agriculture in the 1980s. The advantageous links between ryegrass endophyte and ryegrass persistence, vigour, and yield, together with its adverse effects on white clover content in pastures and on stock health have all made the interpretation of the results of many earlier trials on ryegrass uncertain.

The presence of fungal hyphae of ryegrass endophyte (*A. loli*ii) growing inside ryegrass leaf tissue was first reported in New Zealand by Neill (1940). At that time it was not regarded as a problem. It was concluded that such a widely distributed fungus could not be responsible for localised outbreaks of ryegrass staggers.

The first indication that ryegrass endophyte was important came when Fletcher and Harvey (1981) reported a direct link to ryegrass staggers. Since then the story has unfolded to show that *A. loli*ii gives infected ryegrass much greater persistence because of its resistance to Argentine stem weevil (ASW) (Prestidge et al., 1982). The endophyte produces an appetite inhibitor which affects feeding and egg laying by adult weevils. Ryegrass infected with endophyte (+E) is higher producing and more vigorous than plants of the same cultivar without endophyte (-E) (Latch et al., 1985). In addition to causing staggers, animal performance is also reduced because +E ryegrass is less palatable (Fletcher, 1986) and pasture quality is further reduced because of lower clover contents. It has also been noted that +E ryegrass causes more dags in sheep and possibly similar problems in cows.

The reduced clover content in +E ryegrass pastures has very serious soil fertility implications because less nitrogen is fixed for the pasture or subsequent crops. Sutherland and Hoglund (1989) showed that fewer white clover seedlings survived competition for light, water and mineral nutrients from +E ryegrasses than -E ryegrasses. An allelopathic toxin effect was also demonstrated where +E ryegrasses caused an additional inhibition of white clover seedlings.

Cultivars and seed quality

The results of endophyte tests have only short term validity because endophyte level declines under normal seed storage conditions. Only fresh seeds of high endophyte lines can be guaranteed to have high endophyte. If the seed is stored for about 18 months endophyte status can drop to unacceptable levels. Seed stored in a cool store (5°C) will retain its endophyte fungus for much longer than 18 months (Rolston et al., 1986). This means that to ensure perennial ryegrass contains high levels of endophyte a farmer should buy only new seed from a recently released variety. Otherwise a recent endophyte test is required.

Basically the endophyte question breaks down to deciding whether to go for high pasture production from persistent +E ryegrasses and accept reduced pasture quality and nitrogen fixation, and increased animal health problems - or to risk poor persistence by sowing -E ryegrasses in an effort to grow higher quality, healthy pasture with good clover content and nitrogen fixation. On dairy farms in high rainfall areas or on irrigated farms where drought stress and overgrazing of pastures is less likely, -E ryegrass have a better chance to survive the summer attacks of ASW. Nevertheless ASW is still likely to cause
considerable tiller deaths in areas where ASW is active and animal production per ha may be reduced. In moist, cooler regions such as Southland, where ASW is believed to be a minor problem, there seems to be no reason for farmers to sow +E ryegrass. It should also be recognised that dairy pastures tend to be more open than sheep pastures with higher clover contents. Recent observations of 30% clover in +E Yatsyn perennial ryegrass pastures does not indicate a strong inhibitory effect on white clover. Reduced seeding rates of +E ryegrasses (e.g. 12 kg/ha) may be a useful strategy if problems are experienced in establishing white clover.

While there are about 10 perennial ryegrass cultivars on the market there is really an even wider choice because some cultivars have seedlines which have lost the endophyte. The varieties which have been on the market for a long time such as Ruanui usually have low endophyte content (Table 1). Nui which has been on the market for approximately 15 years has about half of its seedlines without endophyte. The newest varieties such as Yatsyn are universally high in endophyte content. It is imperative that farmers make a conscious decision whether or not they want high or low endophyte contents. They should put pressure on seed firms to identify the endophyte status of the seed they are supplying.

Table 1: Endophyte incidence in fresh seed lines of commercial cultivars. (Adapted from Thom, Prestidge & Barker, 1987.)

<table>
<thead>
<tr>
<th>Acremonium lolii endophyte</th>
<th>(% infection of seeds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mean)</td>
</tr>
<tr>
<td>Perennial ryegrasses</td>
<td></td>
</tr>
<tr>
<td>Grasslands Nui</td>
<td>39</td>
</tr>
<tr>
<td>Ellett</td>
<td>80</td>
</tr>
<tr>
<td>Yatsyn</td>
<td>90</td>
</tr>
<tr>
<td>Droughtmaster</td>
<td>80</td>
</tr>
<tr>
<td>Uncertified Permanent Pasture</td>
<td>36</td>
</tr>
<tr>
<td>aGrasslands Ruanui</td>
<td>5</td>
</tr>
<tr>
<td>aGrasslands Ariki</td>
<td>0</td>
</tr>
<tr>
<td>bGrasslands Marsden</td>
<td>high</td>
</tr>
<tr>
<td>(low leaf strength Ariki)</td>
<td></td>
</tr>
<tr>
<td>bGrasslands Greenstone</td>
<td>0</td>
</tr>
<tr>
<td>(tetraploid Ariki)</td>
<td></td>
</tr>
</tbody>
</table>

* Latch & Christenson 1982
* New cultivars

Italian and hybrid ryegrasses

Italian ryegrasses (*Lolium multiflorum*) and short rotation ryegrasses (*Lolium hybridum*) such as Manawa have little or no infection with *Acremonium lolii*. They are therefore
very prone to attack from ASW. The presence of an acremonium-like endophyte in most New Zealand ryegrass cultivars was reported by Latch et al. (1988) and work on manipulating endophyte species in ryegrasses is continuing. Insect resistance may eventually be achieved without ryegrass staggers and other adverse effects.

The hybrid perennial ryegrasses (*Lolium (multiflorum x perenne) x perenne*) normally have high endophyte content. Grasslands Ariki was a very successful cultivar when first released in 1965 but its reputation declined rapidly as its seedlines gradually lost endophyte viability. All this happened before 1981 and the reason for Ariki’s decline in vigour was not understood. There is an option of returning to the original Ariki by multiplying the small amount of +E Ariki seed still existing.

There is, however, a newly released, high endophyte, hybrid perennial ryegrass, called ‘Grasslands Marsden’, which was selected for low leaf strength and low cellulose content which in turn should give better animal performance. Over three seasons at Palmerston North mean annual pasture production from Marsden was 10100 kg DM/ha, compared with Nui +E 10500, Ark +E 9700 and Ruanui 8500. Marsden was more productive in summer and autumn than the other three cultivars but produced 12% less than Nui in winter and 7% less in spring. It is expected that Marsden will give superior animal performance in spite of its high endophyte.

The winter active annual and biennial ryegrasses have higher feeding value than perennial ryegrasses and are oversown with great advantage by dairy farmers for enhanced winter and spring pasture production. Some of the newer cultivars such as Grasslands Moata and Concord have the ability to persist for at least two winters (Hickey & Baster, 1989). A new tetraploid hybrid ryegrass (*Lolium hybridum*), named Grasslands Greenstone, will soon be available. It has agronomic characteristics like short rotation ryegrass (Manawa) but is lower growing with larger leaves and has double the seed weight. Grasslands Greenstone promises to be as persistent as Ariki and have greater cool season activity than Nui. The lack of endophyte gives Greenstone high palatability. Vulnerability to ASW is increased when nitrogen fertiliser is applied to -E ryegrasses in spring (Hunt et al., 1988) so it is strongly recommended that the nitrogen fertiliser applications on -E ryegrasses such as Greenstone should be only be done in autumn.

**ALTERNATIVE GRASSES**

**TALL FESCUE**

Tall fescue has been regarded as a weed in Northland because the wild tall fescue contains an endophyte similar to that in ryegrass. This causes ill thrift in cattle. The cultivar Grasslands Roa and American cultivars such as AU Triumph have lost the harmful endophyte and are quite different grasses from the old wild types.

Once established, tall fescue can be managed in a similar way to ryegrass and farmers do not need to change their management style. Tall fescue has several advantages over ryegrass which may encourage farmers to change. It has greater tolerance of grass grub and Argentine stem weevil. It associates with clover better and usually has twice as much white clover as +E ryegrass pastures. Tall fescue has higher production in summer than ryegrass because of its greater tolerance of high temperatures and has similar productivity.
in other seasons. Its disadvantages, apart from current high seed price are that it needs to be sown in spring to allow the slow establishing seedlings a better chance to grow vigorously with increasing spring temperatures. Autumn sowings in Canterbury after mid March are usually unsatisfactory because of slow emergence and smothering by cold tolerant weeds. Because of its weak seedling growth it is most unwise to sow ryegrass with tall fescue. Other similarly slow establishing grasses such as cocksfoot, timothy or phalaris may be compatible with tall fescue.

When farmlets with tall fescue and phalaris pastures were compared with farmlets growing old ryegrass pasture, the tall fescue and phalaris treatments showed a substantial increase in dry matter production (17%) but it was only in dry seasons that the fescue/phalaris farmlets gave better milk production (Thomson, 1988). Work is continuing in an effort to explain why milk production was not increased as much as expected from the extra pasture production, higher cow condition score and longer lactation.

A five year grazing trial which was partially irrigated at Lincoln compared +E Ariki ryegrass/white clover farmlets with Roa tall fescue/white clover. Tall fescue gave a 15% - 20% increase in wool and lamb production. This is a convincing demonstration of the superiority of Roa tall fescue. However, dairy farmers in wetter climates or those who would normally irrigate fully may not see such large advantages of tall fescue. The three possible reasons for the superiority of tall fescue in this D.S.I.R. study are the much higher clover content of the fescue pastures, the greater grass production in summer (under some water stress) and the possibility of lower animal intakes on the high endophyte ryegrass.

PRAIRIE GRASS

Matua prairie grass has been available to farmers for about 15 years. Farmers are divided in their attitudes to it: some are intolerant of its special needs while others are very keen on its production advantages.

Initially it was difficult to sow evenly but recently de-awned seed has made conventional drilling possible. The problem of uneven sowings was underestimated because it was claimed that the free-seeding grass would thicken up naturally. However, many farmers have found that most of the seedlings resulting from self seeding do not survive after their first grazing. It is the original mother plants which dominate in the sward and drill rows may be obvious for several years. Prairie grass is sensitive to treading and the usual policy is to capitalise on its higher winter growth rate by avoiding winter grazing. Associated with the potential pugging problems is its intolerance of heavy soils and its need for good drainage.

Prairie grass suffers from the seed-borne disease, head smut, and all seed should be treated with fungicide before sowing. The production of the grass is reduced by about 20% once the head smut fungus invades a stand. This can largely remove the productive advantage of prairie grass over ryegrass (Falloon et al., 1988).

The grazing management requirements of Matua prairie grass have also resulted in some difficulties. Prairie grass cannot be set stocked and it requires longer spelling periods to ensure its persistence than other grasses. This results in a loss of quality with the development of dead leaf material in the base of the sward and a tendency to smother
clover. The larger-leafed white clover cultivars Pitau and Kopu are therefore recommended rather than Huia. Pawera red clover with its taller growth habit associates well with prairie grass. Recent work at Massey University (Black & Chu, 1989) has shown that prairie grass can be hard grazed more frequently without sward decline, provided that new replacement tillers can be seen at the base of larger mature tillers. This should give higher quality forage from prairie grass pastures and a better clover content.

In spite of all these problems and apparent disadvantages the enthusiasts for prairie grass capitalise on its superior summer/autumn and particularly winter, growth rate (Penny, 1987). Some farmers regard it as a perennial winter green feed which can also contribute strongly to the normal grazing rotation during lactation. Most recommendations for prairie grass have been to use it as a specialist pasture. However, on dairy farms where rotational grazing has been followed as a matter of course, prairie grass will thrive in mixtures with ryegrass. Its seedling is vigorous and can cope with ryegrass competition better than other species. A number of farmers have overdrilled ryegrass into weakening prairie grass pastures to obtain a very productive pasture mixture.

**COCKSFoot, TIMOTHY AND PHALARIS**

Cocksfoot and timothy have often been included in pasture mixes in the past but the vigour of associated ryegrass has resulted in very limited production from the timothy and cocksfoot. Ryegrass seeding rates must be reduced so that these species with slower growing seedlings can establish and demonstrate their productive capabilities.

Grasslands Kahu timothy is a very palatable grass which produces well in spring and summer under rotational grazing in dairy pastures. It is tolerant of winter treading and is best adapted to wet sites. The most suitable cocksfoot cultivars for dairying are Grasslands Kara and Saborto. Both were bred for improved cool season growth and are superior to the older Grasslands Apanui cocksfoot. Like most cocksfoots, Kara and Saborto should do well in summer and their improved cool season activity should provide valuable feed in autumn to help extend duration of lactation.

Grasslands Maru phalaris is strongly winter-active (Hume & Lucas, 1987) and is very persistent. It is resistant to grass grub and Argentine stem weevil. Under irrigation it is a high producer in summer and autumn but without irrigation it is dormant during summer drought. This Mediterranean grass is an ideal complement to summer-active species such as red clover, lucerne or chicory. Because it has a reputation for causing phalaris staggers it has not been widely sown in New Zealand. It is widely used in southern Australia and there could be positive advantages in learning more about its use in New Zealand for both sheep and dairy production. In the short term it would seem prudent to take a cautious approach and sow it with at least one other grass, such as tall fescue or cocksfoot, to dilute the possible toxic effects. Thomson (1988) observed phalaris staggers in autumn when cows grazed Maru phalaris/white clover pastures for more than four days.

**LEGUMES**

The maintenance of legumes in pastures is the key to success for New Zealand’s pastoral industries. Huia white clover has been the main cultivar providing high quality feed and fixing adequate quantities of nitrogen necessary for grass productivity. The larger-leafed
white clovers (Pitau and Kopu) have higher winter production than Huia and are more competitive in rotationally grazed, high fertility, lowland pastures (Brock et al., 1989).

It is very important that competitive clover cultivars are sown in dairy pastures if the predominant grasses are high-endophyte ryegrass cultivars. There is, however, a considerable difficulty in establishing new cultivars by oversowing into old pastures because surviving stolons of resident white clover and germinating hard seed tend to dominate after oversowing (Francis & Merrick, 1989). Full cultivation is therefore a more successful technique for the introduction of new cultivars than spraying and overdrilling.

Pitau seed prices are now similar to those of Huia, so Pitau and should be sown in dairy pastures as a matter of course. When Kopu seed prices become competitive it too should be included with dairy pasture seed mixtures. Several research findings from dairy farms have shown Kopu to be superior to Huia white clover (e.g. Moloney et al., 1988). In Southland, a white clover has been bred which is regionally better adapted than Huia. When it is released it may prove to be the best choice for both sheep and dairy pastures in the south (Widdup et al., 1989). The Mediterranean characteristics of the large-leafed varieties are not as well expressed in Southland (Ryan, 1989).

Where an extra boost of high-quality summer feed is required red clover has an important contribution to make. The late-flowering tetraploid, Pawera red clover, is the most productive and persistent cultivar available and lasts at least four years under rotational grazing (Hay & Ryan, 1989). A new medium flowering cultivar, Grasslands Colenso red clover, is due for release. It has superior autumn/winter production compared with other red clovers and lower oestrogen content than Pawera.

Lucerne gave Central North Island dairy farmers an opportunity to increase milk fat production because of its superior summer dry matter production and resistance to grass grub damage (Mace, 1982). Lucerne does, however, pose significant management problems for dairy farmers. In the South Island lucerne is only used as a specialist hay crop on a few dairy properties. This is because calving time would have to be at least one month later after poor winter growth. The need for strict rotational grazing with long spells of 35 - 50 days and pests and diseases have also contributed to the perceived unsuitability of lucerne.

The pest and disease problems which were emphasised in the wet years of the late 1970s led to a decline in the area of lucerne pastures on sheep farms. However, recent droughts and the possibility of warmer conditions in a changed climate should lead to an increase in the area under lucerne in eastern districts. The availability of resistant cultivars and the success of the sitona weevil parasite in reducing sitona populations to 10% of previous levels (Goldson, personal communication) should assist this trend.

The use of lucerne in mixtures may be an option for dairy farmers who wish to take advantage of its superior summer production. Winter active grasses (e.g. Maru phalaris) sown with lucerne should give an improved seasonal distribution of pasture production (Fraser, 1982).

**CHICORY**

Grasslands Puna chicory is an extremely high-producing, summer-growing herb which is proving very popular since seed became available in 1988. It is a perennial that is winter-
dormant, which needs high fertility, well-drained soils and rotational grazing. Very high lamb growth rates have been reported from chicory (Fraser et al., 1988). It is very palatable and high in mineral content. So far, this herb, which looks similar to large, erect dandelion plants appears to have no pest or disease problems. Chicory has a deep tap root which allows the plant to continue growing through dry periods.

Puna chicory may be used on dairy farms as a specialist break-fed, summer green feed in a pure stand or it can be sown in a pasture mixture with a winter active grass such as phalaris or prairie grass together with a legume such as Pawera red clover and/or Pita white clover. Because chicory is a member of the daisy family it does not fix its own nitrogen and, if grown in a pure stand, one of the large-leafed white clovers should be shown with it to maintain fertility. Heavy winter treading should be avoided as death of plants can result from diseases invading damaged crowns.

There are no published reports of milk production from chicory but there is no apparent reason for it not to be a successful species on dairy farms where extra, high quality, dry matter production is desirable to maintain milk production in summer and autumn.

WHAT TO SOW: SIMPLE OR COMPLEX MIXTURES

It has been fashionable for many years for some advisers to advocate simple mixtures of one grass and one legume - usually a perennial ryegrass cultivar with Huia white clover. Special purpose pastures using single grasses such as Matua prairie grass with one or two clovers have also been strongly advocated. There is, however, a swing in opinion away from simple mixtures towards more complex pastures in an effort to capitalise on the seasonal production advantages of different species. For example, if the grazing system used on a dairy farm allows an average of 20% prairie grass to be maintained in all pastures then the benefits of improved autumn and winter growth rates should be similar to having 20% of the farm area in specialist pure Matua. The ryegrass/prairie mixture is easier to fit into the routine grazing pattern than an area of pure prairie.

The spring vigour of Italian ryegrasses such as Concord and Grasslands Moata or hybrids such as the new tetraploid Grasslands Greenstone help to overcome the lack of vigour of Matua in spring. Such mixtures give a very high quality, high producing pasture for at least four years. When the grasses run out, overdrilling with +E perennial ryegrass is a reliable, relatively cheap option. The new improved clovers would have been well established with full cultivation when initially sowing the short rotation ryegrasses plus Matua prairie grass.

The initial establishment of pasture mixtures is the key time when the success or failure of the component species is determined. Farmers should be wary of the vigour of ryegrass seedlings when sowing mixtures and keep ryegrass seeding rates low (5 kg/ha); or better still leave ryegrass out altogether. Sowing time is also important. Most species other than ryegrasses do best when spring sown. As most dairy farmers renew only a small proportion of their pasture each year it does not seem particularly daring to advocate that they spread the risks associated with monocultures and take a chance on the benefits of more complex mixtures.
CONCLUSIONS

There is considerable evidence that several pasture species can produce significantly more high quality dry matter than perennial ryegrass and white clover. However, evidence for increases in farm milk production from other species is not as widespread. In addition changing species is not without risk as alternatives may have:

- slow establishment
- high seed cost
- different grazing requirements
- poor persistence
- a preference for spring establishment
- a need for thorough cultivation.

Nevertheless where farmers wish to meet the challenge of converting extra feed into milk, or where there are reasons for dissatisfaction with ryegrass, then higher yielding pasture species should be sown when paddocks come up for renewal. It is important to make a good job of any change as alternative species to ryegrass soon get a bad name when recommended establishment and management procedures are ignored. Most species cannot be forced into the ryegrass mould. With ryegrasses, it is important to ensure that high quality seed of known age and endophyte status is used.

Previous experience with pasture pests and diseases suggests that it is ecologically unsound to rely exclusively on one grass species. Serious consideration should therefore be given to the use of more diverse pastures.

REFERENCES


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