FeedRight Information Sheet

Protein to fat ratio

- P:F ratio can be influenced by diet. In particular, cows consuming starch will have a higher P:F ratio than cows consuming fibre.
- P:F ratio is not a sensitive measure of energy status and should not be used alone to make decisions on whether or not to supplement cows.
- P:F ratio can be used in conjunction with post-grazing residuals and milk yield/cow to determine, if it is appropriate to provide cows with a supplement.
- Although a high P:F ratio is associated with increased pregnancy rates, there is no evidence that increasing P:F ratio through nutrition has this effect; in fact, there is compelling evidence of a negative effect of starch-based feeds on pregnancy rates.

Is protein to fat ratio a measure of adequacy of feeding?

The average protein to fat (P:F) ratio is 0.77 nationally. It has increased 0.01 per decade since 1992/93, primarily because of genetic selection for milk protein.

A greater P:F ratio has been suggested as an indicator that cows are 'better fed'. Although true that nutrition influences the P:F ratio, it is not a sensitive measure of cow nutritional status. This is because carbohydrate type affects milk protein %, irrespective of energy balance, and the effect of nutrition on milk fat % is inconsistent.

There are examples where P:F ratio has reflected underfeeding (See Technical Information). In general:

- Feeding a starch-based supplement (e.g. cereal grains) will increase P:F ratio; for every 1 kg starch eaten, P:F ratio increases 0.02. This means feeding 3.5 kg maize grain will increase P:F ratio from 0.75 to 0.80.
- Feeding a fibre-based supplement (e.g. palm kernel, soyhulls) tends to reduce P:F ratio.

In summary:

- P:F ratio is not a sufficiently sensitive measure of energy balance to judge whether cows are underfed or whether supplementation will improve energy balance.
- Look at post-grazing residuals and milksolids yield in conjunction with P:F ratio. This will help determine if cows are underfed and would benefit from additional feed.

Are milksolids worth more when protein to fat ratio is greater?

Protein is worth more than fat in most milk payment systems; therefore, value of milksolids increases with increased P:F ratio.

However, the change in value is not large. For example, increasing P:F ratio from 0.75 to 0.80 increases milksolids price from $5.93 to $5.99 at a payout of $6/kg MS milk price and from $7.90 to $7.99 at a payout of $8/kg MS. In experiments undertaken in NZ and internationally, such a change in P:F ratio would require cows to consume 3.5 kg cracked maize or 4 kg of cracked barley/day; therefore, 1 kg maize or barley will only increase the value of milksolids by 1.50-1.70c at a $6 payout, and by 2.25-2.6c at a $8 payout

As milksolids price declines, so does the price advantage of a high P:F ratio.

Does P:F ratio influence reproduction?

- There is evidence that cows with a higher milk protein % and, therefore,a higher P:F ratio, are more likely to get pregnant. The reasons for this are not known
- Feeding cows to increase P:F ratio does not improve reproduction, if the cows are not underfed.
- In fact, there is evidence that the dietary changes required to increase P:F ratio (i.e. a high starch diet) negatively influence in-calf rate by increasing the risk of early embryo loss.

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Technical Information

Background

In recent years, farmers have been encouraged to consider the protein to fat (P:F) ratio of milk, particularly during early lactation. The P:F ratio is calculated by dividing the milk protein % by the milk fat %. There are three main reasons why P:F ratio is considered important:

1. Protein to fat ratio is considered by some nutritionists as an indicator of energy balance, with a lower than average ratio reflecting underfeeding and a higher than average ratio reflective of a well-fed cow.
2. Milk protein is worth approximately twice as much as milk fat in current milk payment systems, primarily because of the value of milk powders relative to butter and cheese. Therefore, a higher P:F ratio will result in a greater milksolids price.
3. Cows with a higher P:F ratio are more likely to get pregnant.

The following article considers the importance of P:F ratio for New Zealand dairy farmers.

Diet and protein to fat ratio

Energy balance: Although the P:F ratio can be altered by dietary changes, it is not sufficiently sensitive to indicate whether cows are well-fed or underfed. There is plenty of New Zealand-based research evidence to support this. For example:

- In a multi-year farm systems experiment, there was no difference in P:F ratio between cows stocked at 2.2, 2.7, 3.1, 3.7, or 4.4 cows/ha (Macdonald et al., 2008); this is despite a 30% difference in feed intake and a 28% difference in milksolids production/cow.
- Feeding cows one third of their diet as a maize- and barley-based concentrate increased P:F ratio from 0.7 to 0.8, even though cows were consuming the same amount of metabolisable energy, producing the same amount of milksolids, and losing the same amount of body condition score (Roche et al., 2010).
- Feeding cows a maize grain-based concentrate instead of a fermentable fibre-based concentrate (i.e. wheat middlings) increased P:F ratio from 0.78 to 0.91 even though body condition score loss was very similar (Higgs et al., 2013).
- A 50% feed restriction only reduced P:F ratio from 0.80 to 0.76. Therefore, although the feed restriction reduced P:F ratio, it was a very small change for a very large feed restriction (Burke et al., 2010).

Collectively, these data indicate that the P:F ratio at a point in time is not a sensitive indicator of the herd's energy status. This is primarily because the effect of feeding level on milk fat % is inconsistent, even though milk protein % generally declines when cows are restricted.

Diet composition: The composition of the diet does affect P:F ratio. Milk protein % increases linearly with increasing intake of non-structural carbohydrates (i.e. starch and sugar), provided protein intake is not limited, and, in general, milk fat % declines (Bargo et al., 2003; Roche et al., 2006). Therefore, when cows are supplemented with a cereal grain-based concentrate, their P:F ratio generally increases; in comparison, when cows are supplemented with a fermentable fibre-based concentrate, P:F ratio declines (Higgs et al., 2013). On average, P:F ratio increases by 0.02 for every 1 kg starch consumed (Roche et al., 2006), although this can be as high as 0.05 for every 1 kg starch (Higgs et al., 2013). This means that P:F ratio will increase, on average, by approximately 0.05 when cows consume 3.5 kg maize or 4 kg barley.

The changes in milk composition and P:F ratio with alterations in diet composition are due to changes in the products of rumen fermentation: more propionate is produced when starch is consumed and more acetate is produced when fibre is consumed (Van Soest, 1994). When propionate is absorbed into blood, it causes an increase in insulin, which stimulates an increased uptake of protein by the mammary gland (Rius et al., 2010). Therefore, P:F ratio increases when cows are fed cereal-based concentrate feeds. In comparison, acetate is the building block for milk fat; therefore, feeding a fibrous diet, which directs rumen fermentation towards more acetate production, will increase milk fat. This change in milk composition will occur irrespective of the energy status of the cow.

Value of milksolids and protein to fat ratio

In current milk pricing systems, the price paid for milk protein is approximately double that paid for milk fat. Therefore, a higher P:F ratio results in an increase in the value of a kg of milksolids. However, it takes a considerable change in P:F ratio to result in a small change in the milksolids price (Table 1 and 2).

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For a $6 payout:

- Increasing P:F ratio from 0.75 to 0.80 would increase milksolids price from $5.93 to $6.00 at an average payout of $6/kg MS
- Cows would have to consume 3.5 kg of a maize grain-based concentrate or 4 kg of a barley-based concentrate to increase P:F ratio by 0.05.
- By extension, milksolids price would be expected to increase by 1.75-2.00 cent for every kg maize- or barley-based concentrate consumed.

*Table 1: Effect of change in P:F ratio on milksolids price.**

P:F ratio	0.75	0.8	0.85	0.9
Milksolids (%)	8.5%	8.5%	8.5%	8.5%
Protein (%)	3.65%	3.78%	3.91%	4.03%
Fat (%)	4.86%	4.73%	4.60%	4.48%
Value of 1 kg MS	5.93	6.00	6.06	6.11
Difference per 5 % increase	$0.07		$0.06	$0.05

*Based on milksolids price of $6/kg and on national average of 3.79% protein, 4.72% fat.

For a $8 payout:

- Increasing P:F ratio from 0.75 to 0.80 would increase milksolids price from $7.91 to $8.00 at an average payout of $8/kg MS
- Cows would have to consume 3.5 kg of a maize grain-based concentrate or 4 kg of a barley-based concentrate to increase P:F ratio by 0.05.
- By extension, milksolids price would be expected to increase by 2.25-2.57 cents for every kg maize- or barley-based concentrate consumed.

*Table 2: Effect of change in P:F ratio on milksolids price.**

P:F ratio	0.75	0.8	0.85	0.9
Milksolids (%)	8.5%	8.5%	8.5%	8.5%
Protein (%)	3.65%	3.78%	3.91%	4.03%
Fat (%)	4.86%	4.73%	4.60%	4.48%
Value of 1 kg MS	7.91	8.00	8.08	8.15
Difference per 5 % increase	$0.09		$0.08	$0.07

*Based on milksolids price = $8/kg and on national average of 3.79% protein, 4.72% fat.

Protein to fat ratio and reproduction

Some nutritionists encourage farmers to change their cows diet to increase P:F ratio in early lactation. A major reason for this is the belief that cows with a high P:F ratio are more likely to get pregnant. There is certainly evidence to support an association between P:F ratio and reproduction:

- A major survey in Australia reported that cows with a higher milk protein percentage during the first 17 weeks of lactation were more likely to be submitted earlier for insemination and more likely to get back in calf (Morton, 2000).

  In that dataset, 8% more cows were submitted in the first 3 weeks of breeding and 6-week in-calf rate was 20% higher in cows with 3.5% milk protein compared with 3.0% milk protein.

  The author presumed that the greater milk protein % reflected improved nutrition; however, no measures of nutritional state were presented.

- In apparent support of the Australian report, Roche (2003) reported that a higher milk protein % increased the likelihood of New Zealand cows getting pregnant. However, in their study, all cows were grazed together, meaning there was no difference in nutritional status

  The New Zealand data confirm the relationship between reproduction and P:F ratio, but refute that this relationship is associated with nutrition. In fact, there is convincing data that indicate that supplementing cows with starch will increase P:F ratio, but also increase the risk of early embryo loss and reduce pregnancy rate (see review by Roche et al., 2011).

Therefore, it is not advisable to alter P:F ratio through nutrition to improve reproductive performance in early lactation.

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This resource is designed to provide general guidance on particular topics in a timely manner. This DairyNZ information is prepared with due care and based on research to date