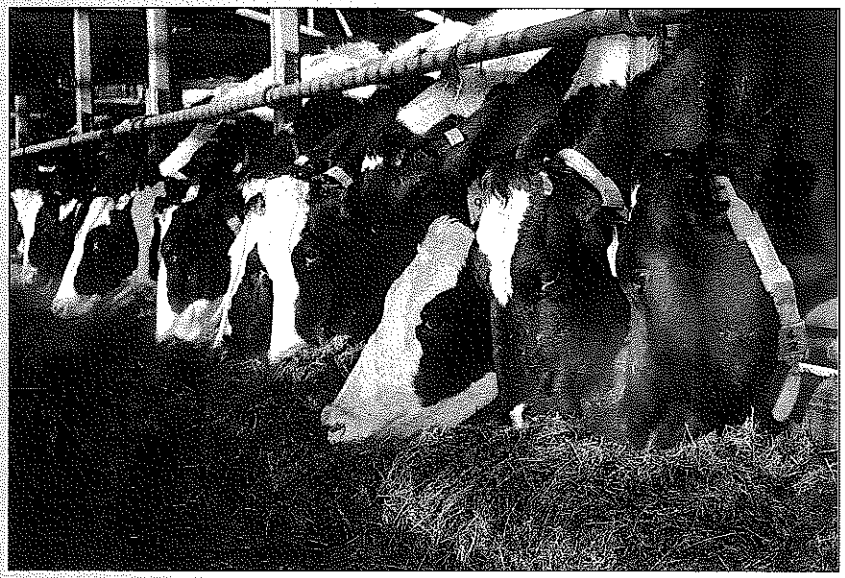
Conrad Ferris

Improving Milk Composition During the Winter Period Through Feeding



AGRICULTURAL RESEARCH & DEVELOPMENT COUNCIL

AGRICULTURAL RESEARCH INSTITUTE NORTHERN IRELAND

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AGRICULTURAL RESEARCH AND DEVELOPMENT COUNCIL FOR NORTHERN IRELAND

This Council was established on 1 April 1997. It was initiated by the representative organisations of producers in Northern Ireland in a direct response to the increasing need to ensure that Northern Ireland producers are at the forefront of production level research and development as the industry strives to stay ahead of its competition.

Producers control both the funds collected via voluntary levies and select the research and development projects which are to be undertaken. The funds collected are used as a lever with which significant complementary funding can be obtained. The beef, dairy and sheep sectors currently participate in the Agricultural Research and Development (NI) Council.

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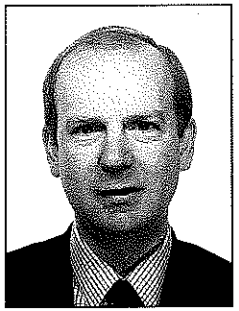
AGRICULTURAL RESEARCH INSTITUTE OF NORTHERN IRELAND

The primary objectives of the milk production research programme at Hillsborough are to enhance the efficiency and profitability of the Northern Ireland dairy industry through the production of milk at least cost, to examine opportunities for improving milk quality, and to examine strategies for reducing the impact of milk production on the environment.

Dr T W J Keady



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Foreword

Improving the protein content of Northern Ireland milk by as little as 0.1% would increase the total value of milk sales off farms by £4.6 million. Given the poor economic returns in dairying at present, even a small improvement in milk protein composition would give a welcome and timely boost to dairy farm incomes.

While much research has been completed on the subject of milk compositional improvement and manipulation, our survey of Northern Ireland's dairy farmers indicated a need for a compilation of current relevant research results to be made available for immediate on-farm use.

This booklet, which is the first in a series, sets out various nutritional approaches, which can be adopted on farm to give immediate and large responses in milk protein and fat content. Up-to-date research results, in an easy to read format, are presented on most nutritional aspects of dairy cow feeding on subjects including grass silages and additives, alternative forages, concentrate type and feeding rates, grazed grass and dry cow feeding.

A new and interesting approach to quota management is also discussed involving the manipulation of milk fat content by feeding dietary oils, fish oil in particular, which could have a major impact on end of year quota planning.

Dr T W J Keady and Dr C S Mayne of the Agricultural Research Institute of Northern Ireland have compiled this booklet for the ARDC.

Ciaran Garvey (Chairman, Milk Advisory Committee)

IMPROVING MILK COMPOSITION DURING THE WINTER PERIOD THROUGH FEEDING

Introduction

Milk composition is important to dairy producers due to current milk pricing schemes and quota constraints. For example, if the milk protein content of the Northern Ireland milk pool was increased by 0.1% it would be worth an additional £4.6 million in milk revenue to dairy producers. Recent studies at Hillsborough have shown that milk protein content can be increased by as much as 0.5% (from 3.04 to 3.56%) solely due to improvements in silage quality and changes in concentrate composition.

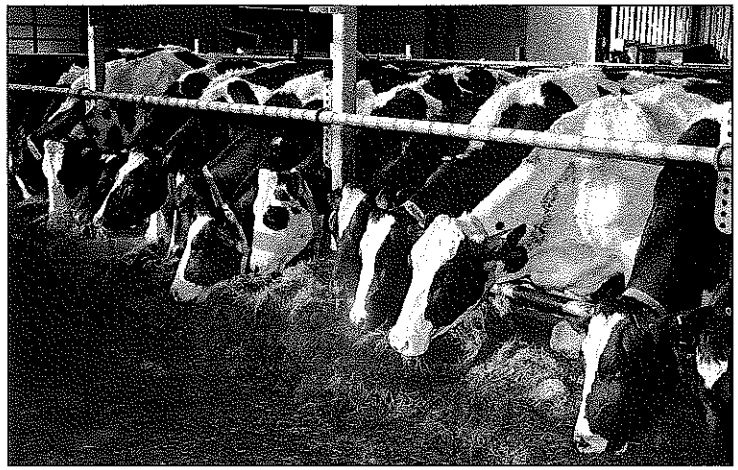
Milk quota limits both milk volume output and the butterfat content of milk deliveries. Recent studies at the Institute have shown that milk fat content can be decreased by up to 1.5% by feeding 450 g of fish oil per cow per day. This reduction would allow an additional 27% more milk volume to be supplied in a given quota situation.

It is recognised that a large number of factors such as stage of lactation, age of cow, cow health and genetics can influence milk composition at farm level. However, the aim of this booklet is to highlight recent research findings on the key **nutritional factors** that influence milk protein and fat contents at farm level during the winter feeding period.

FEED FACTORS INFLUENCING MILK COMPOSITION

Grass Silage

Grass silage forms the basal forage during the winter period on most farms, and consequently changes in silage quality have a major impact on milk composition in Northern Ireland dairy herds.



High feed value grass silage is essential for high protein milk during the winter feeding period

Digestibility

Digestibility is the most important factor affecting silage intake and consequently milk composition and yield from grass silage. The major factors affecting digestibility are:

- *Date of harvest:* Digestibility declines by approximately 0.5% for each day delay in harvest after mid May.
- *Lodging:* Lodging in a crop accelerates the decline in digestibility. In severe cases digestibility may decrease by up to twice the normal rate, e.g. 1% decline for each day delay in harvest.

- *Sward type:* Perennial ryegrass swards normally have higher digestibilities than old permanent pastures. Also the heading date of different perennial ryegrass swards can have a major impact on digestibility.
- *Fermentation:* Digestibility declines as fermentation quality deteriorates

The effects of silage digestibility on milk yield and composition are highlighted in the results shown in Table 1. **For each 5 percent increase in silage D-value (equivalent to cutting the grass crop 10 days earlier), milk protein concentration increased by 0.08% and milk yield increased by 1.2 litres/day.** Silage digestibility has little effect on milk fat content.

Table 1 Effect of digestibility of grass silage on milk yield and composition

	D-value of silage (%)		
	73	70	62
Silage intake (kg DM/day)	10.7	10.0	8.1
Milk yield (litres/day)	28.9	28.2	26.3
Milk composition (%)			
Fat	3.77	3.68	3.68
Protein	3.35	3.22	3.17

(Gordon, 1980)

Ensiling technique

A good ensiling technique is one of the most important management factors in producing high feed value silage and yet this is often a neglected area. The key factors associated with a good ensiling technique are:

(a) rapid ensiling - silo filled within 2-3 days maximum
(b) minimise soil contamination
(c) consolidate well
(d) rapid and effective sheeting.

Additives

Approximately 4 million tonnes of herbage are treated with an additive annually in Northern Ireland, costing in the region of £6 million. A wide range of additives are available with 86 products listed on the most recent UKASTA Forage Additive Approval Scheme list. The main ingredients of the additives currently available include bacteria, enzymes, formic acid, sulphuric acid, molasses and absorbent based products.

Bacterial inoculants and formic acid are the two most commonly used additives in Northern Ireland. A summary of milk yield and composition responses of dairy cows offered additive treated silages is given in Table 2.

Table 2 The effects of formic acid and inoculant treatment on milk yield and composition (average of 11 studies)

	Treatment		
	Untreated	Formic acid	Inoculant
Milk yield (litres/day)	20.7	21.0	21.3
Milk composition (%)			
Fat	3.74	4.07	3.92
Protein	2.76	2.86	2.85

(Mayne and Steen, 1993)

The results shown in Table 2, which represent the average of 11 studies, clearly indicate that the **use of either a proven inoculant or formic acid additive produced small increases in milk yield and increased milk protein content by up to 0.1%.** In this series of studies many different inoculant products were evaluated and the effects on milk protein content varied considerably, ranging from a decrease of 0.01% to an increase of 0.15%. Consequently prior to choosing an inoculant it is important to have evidence from independent research that the particular product in question has increased animal performance under similar conditions to those in which you propose to use it. **This series of studies also clearly indicate that the use of either an inoculant or formic acid additive increases milk fat by 0.18 and 0.33% respectively.** Consequently, in an over quota situation an inoculant additive may be preferred to formic acid, given similar increases in milk protein content with either additive, but larger increases in milk fat content with formic acid.

Molasses, sulphuric acid and enzyme based products are the other types of additive commonly applied to grass at ensiling in Northern Ireland. There is very little evidence to indicate that the use of these additives will improve milk composition or yield of lactating dairy cows.

Wilting

There has been a renewed interest recently among producers in Northern Ireland in wilting grass prior to ensiling. This renewed interest reflects the desire to prevent pollution from effluent run-off, to increase intake and performance from forage, coupled with recent developments in conditioning and tedding equipment.

A summary of the effects of rapid wilting (24-36 hours) of grass to 32% dry matter prior to ensiling on milk yield and composition from 11 studies is presented in Table 3. Rapid wilting dramatically increased silage intake by 17%, but resulted in a relatively small increase in milk yield of only 0.5 litres/day. This low milk yield response reflects the reduction in animal response to marginal increases in energy intake when the basal plane of nutrition is relatively high relative to animal performance. Consequently, **milk output per hectare was considerably reduced with the wilting system.**

Table 3 Effects of rapid wilting on silage intake and animal performance

	Treatment	
	Unwilted	Wilted
Silage intake (kg DM/day)	10.2	11.9
Milk yield (litres/day)	20.7	21.2
Milk composition (%)		
Fat	4.52	4.66
Protein	3.27	3.38

(Patterson et al, 1996 and 1998

Milk protein and fat contents were increased by 0.11 and 0.14% respectively due to rapid wilting. To obtain beneficial responses from wilting it is essential to achieve high rates of drying. Also good management of the silo at ensiling and during feed out is critical when high dry matter silages are ensiled. Poor silo management results in aerobic deterioration and heating at the silo face, which can offset the potential benefits from wilting.

Alternative Forages

Recently there has been a major increase in interest in the production of alternative forages in Northern Ireland, given their potential to increase forage intake of dairy cattle and the possibility of reducing forage costs, particularly if land is eligible for arable aid. However it is also important to examine the effects of the inclusion of alternative forages on animal performance.

Maize

Approximately 250 ha of forage maize are ensiled annually in Northern Ireland. Maize has the potential to produce high yields of high feed value silage. For high feed value maize silage, the crop needs to be harvested at high dry matter (25-30% DM) and starch (greater than 20%of the DM) contents. Data from the literature indicate that low dry matter, low starch maize has no beneficial effect on animal performance relative to good quality grass silage (e.g. ME content above 11.5 MJ/kg DM and intake value greater than 70). **However high starch (greater than 20%) maize silage results in improvements in milk protein content and yield of lactating dairy cattle.** Inclusion of high feed value maize silage in the diet also tends to decrease milk fat content.

Whole crop cereals

Whole crop cereals may be ensiled either fermented (ensiled at 30-45% dry matter) or treated with urea as an additive to achieve an alkaline preservation (ensiled at 50 to 55% dry matter). The effects of including 33% of the forage as fermented or urea treated whole crop wheat, with the remaining 67% as grass silage, on milk yield and composition are presented in Table 4.

Other than high starch (greater than 20%) maize silage, alternative forages have no beneficial effect on milk composition or milk yield relative to good quality grass silage

Kale

Kale is one of the most recent alternative forages to hit the spotlight in Northern Ireland. Kale has the potential to produce high yields of forage in a 12-13 week growing period. The crop can be grown following removal of first cut silage on swards which are to be reseeded in the autumn. Studies undertaken in England and Northern Ireland, using cows in both early and mid lactation, indicate that the inclusion of 30-40% kale silage dry matter in the forage component of the diet had no effect on milk composition or yield of lactating dairy cattle.

Table 4 The effect of including whole crop wheat (33% of forage intake) on milk yield and composition relative to grass silage as the sole forage

	Grass silage	Whole crop wheat (33% forage intake)		
		Fermented	2% Urea	4% Urea
Total silage intake (kg DM/day)	11.7	12.1	12.5	12.5
Milk yield (litres/day)	30.0	29.1	29.4	29.9
Milk composition (%)				
Fat	4.19	4.10	4.07	4.14
Protein	3.25	3.19	3.22	3.25

(Leaver and Hill, 1995)

The results show that when cows are offered similar levels of the same type of concentrate, **inclusion of whole crop wheat, either fermented or urea treated, has no beneficial effects on milk yield or composition, even though it increases forage intake**. The lack of effect of whole crop wheat on milk yield or composition, even though silage intake is increased, is due to a depression in digestibility of the diet, primarily that of the starch component.

Concentrate Factors

Changes in either the level of feeding or type of concentrate offered during the winter feeding period can have a major impact on both milk yield and composition.

Increasing the starch content of the concentrate improves milk protein content

Feed level

Increasing the level of concentrate feeding improves milk protein content and yield due to increased energy intake. These effects are clearly illustrated in Table 5, from the results of a large scale study undertaken over a three year period at Hillsborough. On average, each additional kg of concentrate offered per day increased milk protein content by 0.05%. At low levels of concentrate feeding (less than 7 kg/cow/day) additional concentrates will also increase milk yield and this needs to be taken into consideration in addition to the milk protein effect. However, at higher levels of concentrate feeding, milk yield responses to additional concentrate are usually low, unless silage feed value is poor. These results clearly show that **feeding additional concentrates specifically to increase milk protein concentration is unlikely to be profitable with current milk pricing systems, as the higher bonuses being offered for protein are not sufficient to cover the cost of additional concentrate feeding.**

Whilst it has often been advocated that increasing the level of concentrates results in a reduction in milk fat concentration, the data presented in Table 5 indicate that increasing concentrate feed levels from 4 up to 10 kg/cow/day had little effect on milk fat content. However when concentrates are

offered at very high levels, e.g. above 10 kg/cow/day, milk fat content will be decreased.

Table 5 Effect of concentrate feed level on milk production and composition

	Feed level (kg conc./cow/day)				
	3.8	5.3	6.7	8.1	9.4
Milk yield (litres/day)	20.2	21.2	23.0	23.6	24.0
Milk composition (%)					
Fat	4.00	4.01	3.99	4.03	4.07
Protein	3.08	3.15	3.15	3.29	3.35

(Gordon, 1984)

Concentrate composition

The ingredient composition of the concentrate, particularly starch content, can have a significant influence on milk composition. A summary of the effects of concentrate starch content on milk yield and composition is presented in Table 6. The high starch concentrate in these studies was formulated predominantly from wheat, barley and soyabean, while the low starch concentrate was formulated predominantly from sugar beet pulp, citrus pulp and soyabean. Concentrates were fed at 10 kg/cow/day in four equal feeds, through out-of-parlour feeders, to cows which were offered one of nine contrasting grass silages. Regardless of silage quality, increasing the level of starch (cereal) in the concentrate increased milk protein content, had no effect on silage intake or milk yield and reduced fat content. **Increasing concentrate starch content from 4 to 33% DM increased milk protein by 0.15%, which is equal to the response expected from feeding an additional 3 kg of concentrate per cow per day. With current reductions in cereal price, there is now a real opportunity to increase the protein content of milk cost effectively.** Also milk fat content was reduced by approximately 0.11% by increasing the starch content of the concentrate.

Table 6 Effects of increasing concentrate starch content on food intake and animal performance

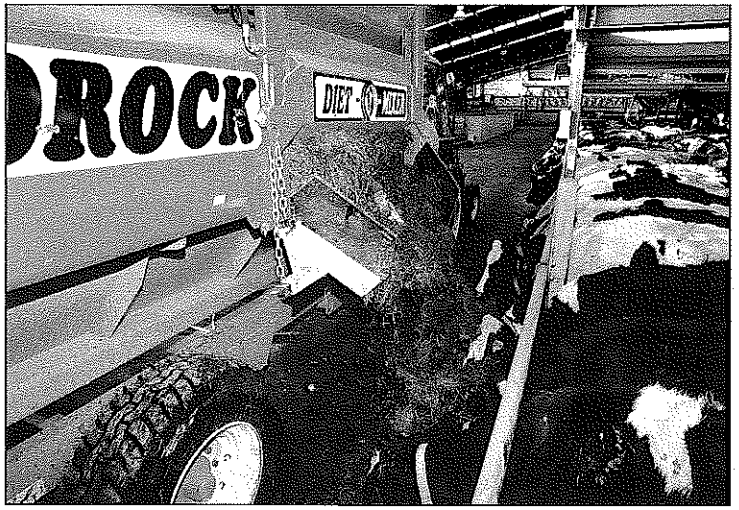
	Conc. starch content (% DM)		
	4	18	33
Silage intake (kg DM/day)	9.9	9.8	9.9
Milk yield (litres/day)	26.8	26.5	26.4
Milk composition (%)			
Fat	4.43	4.38	4.33
Protein	3.21	3.26	3.36

(Keady et al, 1997 and 1998)

Altering the protein content of the concentrate, or protein quality, has little effect on milk protein content at normal levels of concentrate feeding (7 to 10 kg/cow/day).

Concentrate feeding system

Numerous studies have examined the effect of method of concentrate feeding on milk yield and composition with cows offered a range of concentrate feed levels from 2 to 11 kg/cow/day. **Regardless of the level of concentrates fed, feeding the concentrate either as part of a complete diet or in three or four feeds per day through out-of-parlour feeders has had no effect on milk protein content.** However when cows were offered very high levels of concentrates, e.g. 14 kg/day, offering the concentrate as part of a complete diet, decreased milk fat content by 0.08% and increased milk yield by 7%, with no effect on milk protein.



Use of complete diet feeding does not alter milk composition when feeding less than 11 kg concentrate per cow per day

Supplements to depress milk fat

Inclusion of oils in the diets of dairy cows has been shown to alter diet digestibility and rumen fermentation characteristics. More recently it has been suggested that inclusion of oils containing long chain fatty acids, in the diet e.g. fish oil, may alter mammary gland function.

Soya oil. Soya oil is a vegetable oil and is readily available to the compound feed industry in Northern Ireland. The effects of inclusion of soya oil in the diet of dairy cows on subsequent milk composition and yield are presented in Table 7. Including soya oil at 0.5 kg/cow/day, within the dairy cow concentrate, depressed milk fat by 0.28%, allowing an additional 5% more milk volume to be supplied in a given quota situation. Inclusion of soya oil had no effect on milk yield, but depressed protein content by 0.09%.

Table 7 Effect of soya oil inclusion on milk yield and composition when fed in conjunction with grass silage/concentrate diets

	Treatment	
	Control	Soya oil
Level of oil inclusion (g/day)	0	430
Milk yield (litres/day)	21.5	21.6
Milk composition (%)		
Fat	4.16	3.88
Protein	3.19	3.10

(Keady, unpublished data)

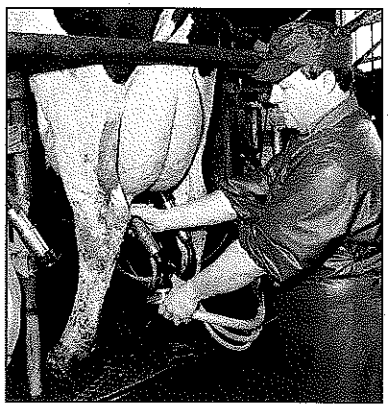
Fish oil. Fish oils are a rich source of long chain polyunsaturated fatty acids and omega-3 fatty acids. The effects of including fish oil in the diet on milk composition and yield are presented in Table 8.

Table 8 Effect of fish oil inclusion on milk yield and composition

	Level of fish oil (g/day)			
	0	150	300	450
Milk yield (litres/day)	22.7	25.0	25.2	26.0
Milk composition (%)				
Fat	4.21	4.01	3.69	2.72
Protein	3.27	3.19	3.01	2.88

(Keady and Mayne, 1998)

Increasing the level of fish oil from 0-450 g/day decreased milk fat content. **When the high level of fish oil was offered, milk fat content was decreased by 1.5% allowing an additional 27% more milk volume to be supplied in a given quota situation.** However, on the negative side, increasing fish oil supplementation also depressed milk protein content by up to 0.39%. As most purchasers determine milk price on a combination of volume and the

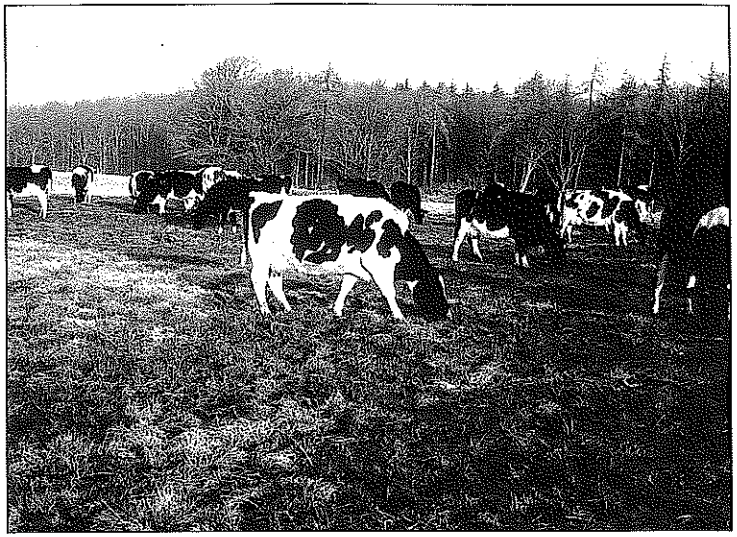


Milk fat content can be depressed by 1.5% by feeding fish oil, consequently 27% more volume may be supplied in a given quota situation

contents of fat and protein, high levels of fish oil inclusion would depress milk price, but would allow an additional 27% more milk volume to be supplied within a given milk quota. The use of fish oil is therefore a useful quota management tool. **However its use is only recommended late in the quota year when the producer is aware, firstly that he is over quota and secondly, that the national butterfat base level will be exceeded.**

Grazed Grass

Grazed grass is the cheapest feed available on-farm. **Increasing the proportion of grazed grass in the diet by extending the grazing season beyond the normal early April to mid October period increases milk yield and protein content.** The response obtained from extending the grazing season depends on the quality and quantity of grass consumed by the cow and the level of feeding given during the indoor period. Improvements in milk protein content of 0.24 and 0.13% have been obtained from spring and autumn calving cows given access to grass for 3 hours daily between 29 October and 26 November. Also, when spring and autumn calving cows were given 2.5 hours access to grass daily between 26 February and 16 April milk protein contents were increased by 0.07 and 0.22% units respectively. In these studies the cows indoors were receiving moderate quality silage ad libitum supplemented with 6 kg concentrates/cow/day. Increases in milk fat content have also occurred with extended grazing, with increases of between 0.34 and 0.48% for cows turned out for 2-3 hours/day in early spring.



Extended grazing for 2-3 hours/day in November and March increases milk protein and fat contents

Dry Cow Feeding

The most important factor in terms of dry cow nutrition is to calve the cow at the right condition. If the cow is either under or over condition at calving, milk protein content will be depressed. The optimum condition score at calving is between 2.5 and 3 on a five point scale, 1 being excessively thin and 5 being grossly fat.

Many recent studies have examined the effects of altering nutrition during the final four weeks of pregnancy. Whilst some studies have shown improvements in milk protein content by feeding low levels of an undegradable protein concentrate during the dry period, others have shown no response. Nutrition during late pregnancy is a complex area requiring further study to elucidate possible effects of changes in nutrition at this stage on milk yield or composition in the subsequent lactation. Further research is currently in progress at Hillsborough to define cow characteristics, e.g. body condition, body weight, etc, under which possible responses to changes in dry cow nutrition will occur.

CONCLUSIONS

There is considerable potential to alter milk composition by feeding during the winter period. Recent studies at Hillsborough have shown that milk protein can be increased by up to 0.52%, from 3.04 to 3.56% by improving silage feed value and increasing the level of starch in the concentrate. The key factors in increasing milk protein content are:

(a) Maximum use of grazed grass.
(b) Production of high digestibility, high intake grass silage.
(c) Feeding high starch (cereal based) concentrates.
(d) Consistent production of high starch (greater than 20%) maize silage.

Similarly, there is potential to reduce milk fat content in a quota situation. For example milk fat content has been reduced by 1.5% from 4.21 to 2.72%, by inclusion of fish oil in the diet, consequently increasing the volume of milk which may be supplied in a given quota situation by 27%. This strategy may be of particular value to control milk supplies in the last few months of the quota year.

The key factors in decreasing milk fat are:
(a) Feed fish or soya oil in the diet.
(b) Supplement with high starch concentrate.
(c) Avoid high dry matter grass silage

Furthermore, good animal husbandry, e.g. ensuring animals have free access to grass silage or well managed grass swards, and avoiding excessive changes in body condition during lactation, is the most important and least expensive factor which affects all aspects of animal performance.

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If the national milk quota is exceeded, the national BF base will be implimented

If the national BF base is exceeded, the individual farmer BF quota will be implimented