STRATEGIES TO PREVENT THE LOW FAT AND LOW SOLIDS-NOT-FAT SYNDROMES IN THE DAIRY COW

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The low milk fat and solids-not-fat (SNF) syndromes in the dairy cow are both largely of nutritional origin. They differ markedly, however, in that whereas the former may occur in well-fed cows given inadequate roughage, low SNF is almost invariably associated with underfeeding. High producing cows appear to be most susceptible.

A. Low milk fat syndrome

Milk fat output may fall abruptly when dairy cows are given food in which the ratio of digestible carbohydrate to roughage is high, or when oils rich in unsaturated fatty acids are added to the ration. The degree of response to these diets is influenced by the physical state of the roughage and cereal components of the ration and by other factors which include the level and frequency of feeding, stage of lactation, level of milk production and condition of the animal (see Davis and Brown 1970). The most important factor in practice is the proportion of coarse roughage in the feed, particularly when high levels of concentrate are fed.

Much experimental data on dairy cows fed diets containing varying proportions of roughage show that the ratio of acetate to propionate in the rumen (the C_2/C_3 ratio), is closely related to milk fat percentage (see Armstrong and Prescott 1971), as illustrated in Fig.1.

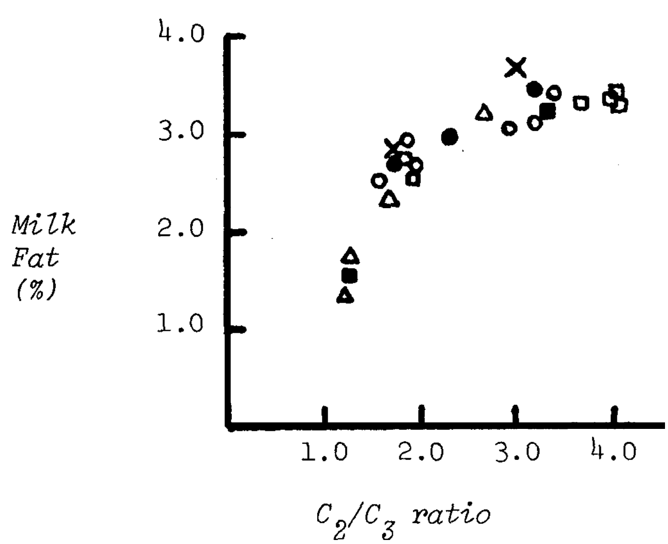

Fig.1 - Relationship between molar ratio of acetate:propionate in rumen liquor and milk fat percentage for dairy cows fed diets containing cereal grain (data from 6 reports).

The proportion of coarse roughage in the ration is known to influence the C_2/C_3 ratio, high roughage diets favouring acetate production. Armstrong and Prescott (1971) analysed the results of 15 investigations with dairy cows in which the effects of a range of diets on the C_2/C_3 ratio and on milk fat percentage were followed. Low C_2/C_3 ratios were associated with low levels of milk fat, particularly when diets based on unheated maize were fed (Fig.1). McCullough (1966) had shown earlier that there was a highly significant relationship between the molar proportion of propionate in rumen fluid and the decline in milk fat percentage.

Propionate is a major precursor of glucose in ruminants (Leng 1970), and McClymont and Vallance (1962) have shown that the intravenous infusion of glucose into lactating cows also reduces the output of milk fat. McClymont and Vallance (1962) suggested that the enhanced gluconeogenesis which accompanies increased ruminal propionate production on low roughage diets suppresses the mobilization of fat from adipose tissue and results in the lowered availability of plasma triglycerides for milk-fat synthesis.

More detailed studies by Annison, Bickerstaffe and Linzell (1974) in cows fed high starch : low roughage diets and producing milk of low fat content confirmed the key role of propionate in the low fat syndrome. Low C_2/C_3 ratios were attributable almost entirely to greatly increased propionate production, and not to a fall in acetate production. Gluconeogenesis was increased, and the higher levels of circulating glucose were associated with significant falls in the concentrations of acetate and β-hydroxybutyrate.

The explanation for the effects of enhanced gluconeogenesis on milk fat percentage almost certainly lies in the response of the animal to the increased levels of circulating glucose. This appears to stimulate insulin release (Walker and Elliott 1972), which in turn promotes lipogenesis in adipose tissue and reduces triglyceride mobilization from adipose tissue as plasma free fatty acids. The end result is the deposition of adipose tissue at the expense of milk fat, as was shown so elegantly by the quantitative energy balance studies of Dr. W.P. Flatt and his colleagues and summarized by Annison and Armstrong (1970).

TABLE 1 Data relating to the mean energy balances of cows eating rations containing 60, 40 or 20 percent lucerne.

Lucerne content of diet (%)	C_2/C_3 ratio	Body tissue gain (+) or loss (-) (g)	Yield of milk fat	Change in body fat (g/24 hr)	Net change in fat yielded
60	3.2	- 1275	714 [a]	- 138 [b]	576 [a,b]
40	2.3	- 575	627	- 62	565
20	1.7	+ 1323	489	+ 144	633

[a] Yield of milk x fat content.

[b] Assuming all body tissue energy to be fat of calorific value 9.21 k cal/g.

When diets containing decreasing proportions of lucerne were fed to lactating dairy cows, total energy retention was largely unchanged, but milk fat production declined and body fat increased (Table 1).

Incidence of the low milk fat syndrome

Some indication of the limited significance of the low milk fat syndrome in the whole milk sector of the N.S.W. dairy industry is illustrated by data kindly provided by the Dairy Industry Authority. These show that during 1976 the producers supplying milk with a fat content below the statutory requirement (3.2%) was about 0.1%. The maximum incidence (0.3%) occurred in September, when pasture would be expected to be young and lush, and of low fibre content.

Prevention of low milk fat syndrome

Problems arise in dairy herds at pasture only when the herbage is young and the fibre content low. The occurrence of the syndrome in cows fed young green oats (fibre content 5-7%), has long been recognised. Experience in N.S.W. has shown that when herbage is the sole feed, the minimum roughage content should be about 20% to avoid milk fat depression and supplementation of lush pasture with a suitable roughage is essential. Roughage chopped to less than 1 cm is ineffective in preventing milk fat depression, so it is important to feed supplementary roughage in long form.

When concentrates are fed, the ideal ratio of concentrates to roughage is about 60 : 40 (Kay 1969). This feeding system, in addition to avoiding milk fat depression, ensures maximum fertility, which may fall if the proportion of concentrates increases to 80% (Kay 1969). Where there is limited grazing and high concentrate rations are fed, a minimum of 10 lb hay/day or roughage equivalent is recommended to avoid milk fat depression.

B. The low solids-not-fat syndrome

The SNF components of milk comprise protein (average value 3.2%; range 2.8-4.0%), lactose (4.7%; 4.5-5.2%), and ash (0.7%; 0.6-0.8%). The statutory requirement for SNF in N.S.W. is 8.50%. Since the lactose content of milk remains almost constant, unless energy is severely restricted, observed changes in SNF largely reflect changes in the amount of milk protein.

Factors which are involved in the occurrence of low SNF include dietary energy supply, age and breed of cow, stage of lactation, heat stress and disease, but the overwhelming cause of low SNF is inadequacy of dietary energy.

Factors affecting SNF content of milk

1. Energy supply

Broster (1970) discussed the need to consider dairy cow feeding over the whole lactation cycle, and during the period before calving. A number of feeding trials were carried out to assess the value of feeding concentrates before calving (steaming up), and the long term effects of feeding different levels of energy in-take during each stage of the lactation cycle were examined. When pregnant animals had adequate body reserves, additional feeding before calving had no effect on milk yield either immediately after calving, or during -the whole lactation provided that the level of feeding post-calving was adequate. Further work showed that the effects on milk production of levels of feeding pre-calving and post-calving were closely related. A high level of feeding post-calving compensated for inadequate body reserves, and conversely, good body reserves ensured a high milk yield even if only small amounts of concentrates were fed after calving (Broster, Tuck and Balch 1964; Broster and Tuck 1967). In early lactation, as in late pregnancy, voluntary food intake is low (Broster et *al* 1964). The level of feeding before calving must therefore be such that after calving the food requirement is not in excess of the intake capacity of the animal. Inevitably, in high yielding cows, the energy demands of lactation cannot be met entirely by feed intake, and consequently body reserves are mobilized. Some guidance on the optimum size of body reserves pre-calving was provided by Broster (1970), who suggested that liveweight gain in late pregnancy should exceed 0.5 kg/day.

The responses to differing levels of dietary energy during lactation depend on the genetic potential of the animal. Energy is used first to meet maintenance requirements, and the remainder is partitioned between milk and body reserves. High yielding cows divert dietary energy to milk production at the expense of body reserves, as discussed by Broster (1970). Total energy balance studies, based on calorimetry, have shown that the total efficiency of food conversion is roughly constant during the lactation cycle (see Flatt et *al* 1972) irrespective of whether dietary energy is used for the synthesis of milk or body tissue.

Diets inadequate in energy may depress milk protein levels by as much as 0.3%. Conversely, an increased energy supply raises the level of milk protein, which is largely synthesized in the mammary gland from amino acids extracted from blood. In ruminants, dietary energy (supplied as carbohydrate or protein) is extensively fermented in the rumen to acetic, propionic and butyric acids, which constitute the most important sources of energy. The energy liberated during fermentation is used for microbial protein synthesis. Acetate and butyrate, in addition to their role in energy metabolism, are important precursors of milk fat, and propionate contributes substantially to the production of glucose. The latter is used by the mammary gland in large quantities for the synthesis of lactose and certain non-essential amino acids, and to provide, with acetate, much of the energy for fat and protein synthesis. Several workers have suggested that a shortage of glucose is the primary cause of low SNF, since the mobilization of body tissue which occurs when dietary energy is inadequate for maintenance and milk production, can make only a small contribution to overall gluconeogenesis.

11. Age and breed of cow

The SNF content of milk is highest in the first lactation and declines at each subsequent lactation by 0.03-0.1% (Rathore 1971; Foley et *al* 1972). In addition to the effect of age, there is substantial variation in SNF content associated with breed of cow. For example, the average SNF contents of milk from four breeds commonly used for the production of milk in N.S.W. are Jersey - 9.6%, Guernsey -

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9.2%, Ayrshire - 8.7% and Friesian - 8.5% (Foley *et al* 1972). Further, within a particular breed there may be considerable variation in SNF. In view of the relatively high heritability *(0.4-0.6)* of SNF it is possible to take SNF into account in breeding programmes. As a general rule, the fat, protein and lactose contents of milk are positively correlated with each other and negatively with milk yield. Consequently, selection for high SNF will adversely affect milk producing capacity (Campbell and Marshall 1975).

111. Stage of lactation

The SNF content of milk is usually high in early and late lactation (Foley et *al* 1972). At parturition, mammary secretion contains very high levels of antibody protein (immunoglobulin) which is derived principally from the blood plasma. The concentrations of immunoglobulin often approach 10 g/100 ml in the colostrum of cows, but within about a week after calving only low levels of immunoglobulin are found in milk (Lascelles and McDowell 1974).

Throughout most of lactation SNF levels are relatively stable provided nutrition is adequate and in the absence of disease and other stresses. Commonly, SNF increases during the last weeks of lactation when milk yields fall to low levels. It appears that much of the increase is due to enhanced transfer of immunoglobulin associated with the decline in milk yield; there appears to be an inverse relationship between milk production and transfer of immunoglobulin (Lascelles and McDowell 1974).

lV. Heat stress

Exposure of dairy cattle to heat stress has a dramatic effect on feed intake and associated with the reduced feed intake there is a decline in both milk yield and in the content of SNF (McDowell 1972). The effect is observed in *Bos taurus* and *Bos indicus* breeds of dairy cattle but it is of greater magnitude in the former breeds (McDowell 1972). It is likely that heat stress effects a reduction in SNF not only by reducing feed intake but also by increasing the expenditure of energy for heat dissipation.

V. Disease

In virtually all disease conditions there is a reduction in both'milk yield and SNF content, presumably as a result of stress and associated changes in energy metabolism. The most significant disease effecting a lowered SNF content of milk is mastitis, the incidence of which in dairy herds in N.S.W. (and indeed elsewhere) is seldom less than 10% of cows and often exceeds *30%* in any particular herd (Beh et *al* 1971; Rathore 1971). Intramammary infections affect SNF by lowering the levels of lactose, casein, non-casein protein and also water soluble vitamins (Schalm, Carroll and Jain 1971). The mechanism by which an intramammary infection effects a reduction in SNF content has not been resolved, but it has been suggested that the inflammatory response leads to a reduction in capillary blood flow within the mammary gland. Consequently, there would be reduced availability of blood-borne precursors of milk constituents for synthesis of milk solids (Schalm *et al* 1971).

Incidence of low SNF

Data provided by the Dairy Industry Authority for the whole milk sector of the N.S.W. dairy industry show that low SNF is a substantial problem to the dairy producer. It may be seen from Fig.2 that 2-12.8% (varying with time of year) of the 3,900 suppliers of whole milk in N.S.W. were producing milk with SNF levels below *8.5%* during 1976. There was a tendency for the incidence of low SNF to be greatest in the late summer months (when pasture was of poor quality) and during the winter months (when pasture supply was limited). The lowest incidence of low SNF occurred during the spring months when pasture supply was plentiful and of sufficient quality to meet energy demands.

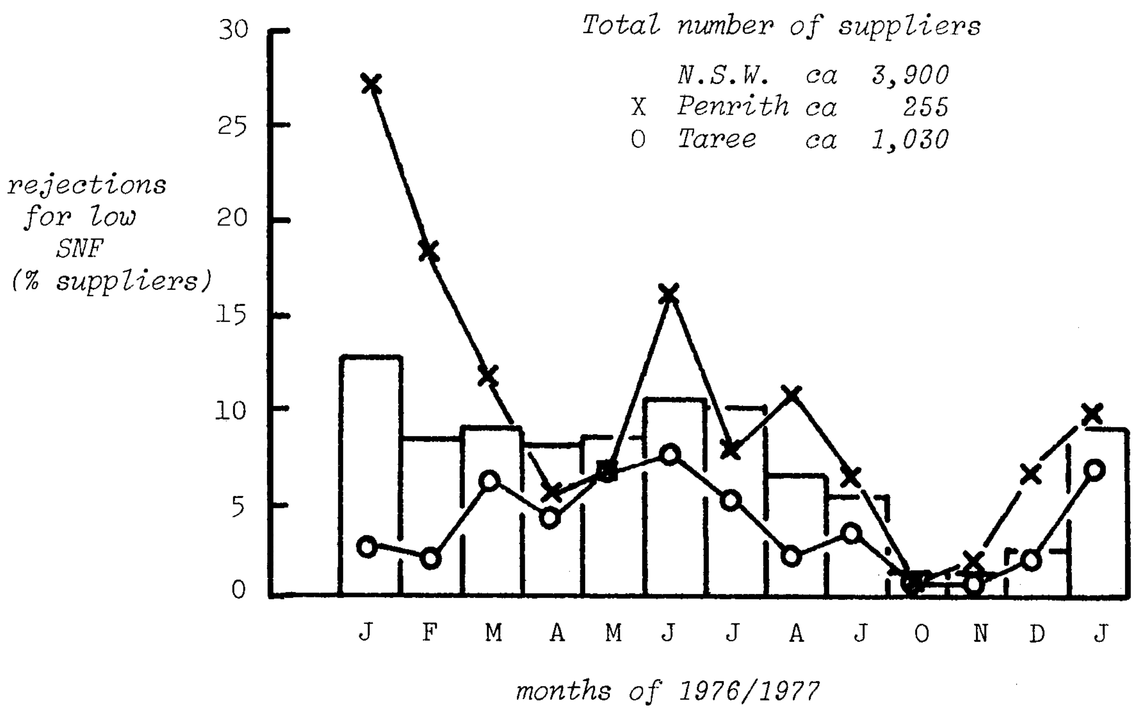

Fig.2 - The incidence of low SNF within the whole milk sector of the N.S.W. dairy industry during 1976 and 1977.

Information for two distinct sectors of the whole milk industry of N.S.W. is also presented in Fig.2 - viz. the Penrith and Taree zones. These data illustrate the effects of a number of the factors which affect the SNF content of milk.

First, the seasonal trend for the incidence of low SNF to be highest during the late summer and the winter months of the year is clearly shown for both zones. Secondly, the effect of breed of cow on SNF content is illustrated. The predominant breeds of cows in the Penrith and Taree zones are the Friesian and Jersey breeds respectively. It is apparent that throughout the year the incidence of low SNF was higher in the Penrith zone where Friesian cattle predominate. Thirdly, the data for the Penrith zone illustrate the effect of disease on the SNF content of milk.

During the early months of 1976 there were quite serious outbreaks of ephemeral fever (three-day sickness) within the Penrith zone. This disease, which is accompanied by a virtual cessation of grazing, together with the low quality of pastures at that time of year gave rise to a very high incidence of low SNF. A total of 27% in January and 17.3% in February of the suppliers had their milk rejected because of low SNF.

Clearly, the data presented in Fig.2 illustrate that the problem of low SNF is of considerable concern to the producers of whole milk in N.S.W.

Prevention of low SNF content of milk

Most problems of SNF in dairy herds in N.S.W. stem from inadequacy of energy intake. A high proportion of herds are maintained at pasture, and it is essential to provide these animals with a plentiful supply of high quality herbage. As discussed earlier, difficulties of energy supply may arise in late summer, or in late autumn and winter. The producer may overcome this problem of deficient feed supply by providing concentrate feeds, or by the provision of suitable fodder crops.

The accurate provision of feed supplements to lactating animals requires knowledge of the energy content and intake of the unsupplemented ration in relation to the level of milk production. This is particularly difficult in grazing animals since we rarely know either the feed intake, or the energy value of the herbage. In practice, provided that the producer responds immediately to the first indication of low SNF, a relatively low level of supplementation with concentrates (1-2 kg/animal/day) will usually restore SNF levels to normal. If the energy deficit was only marginal, an increase in milk output may occur. In serious cases of energy deficiency, which may occur in prolonged wet weather, or drought, higher levels of concentrate feeding are necessary. Gradually increasing levels of concentrate are fed until normal SNF levels are restored. When high levels of concentrate are fed, it should be borne in mind that the ratio of concentrate:forage should not exceed 60 : 40 (Kay 1969).

When expensive energy supplements are fed, it is useful to single out the animals which will derive the most benefit. These are cows in the first 10 weeks of lactation, high producing cows in later lactation and cows in the last 6-8 weeks.of pregnancy. The choice of energy supplement needs careful consideration. The cheapest sources of energy are usually crushed or milled cereal grains, but often it is more convenient to use a pelleted supplement containing the appropriate minerals. When the producer is faced with the choice of commercial concentrates or grain, the protein content of the former is often stressed, but in fact only the energy content of the concentrate is relevant, and the decision should be based largely on the unit cost of the energy. Unfortunately, many manufacturers fail to provide the energy content of the product, and there is a strong case for changing the statutory requirements governing labelling to include energy content.

When strategic cropping to maintain energy supplies is possible, energy demands during the late summer months can be met with crops such as maize, sorghum and sacchaline which grow prolifically during the summer months provided soil moisture and nutrient supplies are maintained. Moreover, the use of irrigated summer-growing pasture species (for example, kikuyu and paspalum), suitably top-dressed, is a very efficient and relatively inexpensive means of providing dairy cattle with good quality feed. The trough in feed supply which occurs in late autumn-winter is commonly corrected by growing oats. This can be achieved by either sod-seeding oat seed into existing pasture, or more expensively, by ploughing up existing pasture. With the former technique, competition from existing pasture species can be minimised by treating the pasture, prior to sod-seeding, with a suitable herbicide. In both instances it is important to top-dress with nitrogen fertilizer because soil nitrification systems are virtually dormant throughout the colder winter months.

Herds with problems of low SNF which fail to respond favourably to increased dietary energy may have a high incidence of sub-clinical mastitis. If confirmed, it is good management practice to cease milking the cows in late lactation. Cows with recurring mastitis should be culled, because they tend to infect non-mastitic cows, and other late lactating cows should be treated with appropriate "dry-period" antibiotics, and dried-off. Further, the N.S.W. Department of Agriculture recommendations for the control of mastitis should be adopted.

In order to maintain SNF levels in periods of nutritional inadequacy, many producers find it efficacious to include a proportion of Channel Island breed cows in their herd.

Finally, it is important to ensure that the overall age of the herd remains low in view of the decline in SNF which occurs with each succeeding lactation.

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