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Factors Affecting the Non-fatty Solids in Milk, with Particular Reference to the New Zealand Town Milk Industry

I. L. CAMPBELL, D. S. FLUX (Massey Agricultural College)
and M. R. PATCHELL (Dairy Research Institute (N.Z.),
Palmerston North.

IN investigational work in the field of dairy production in New Zealand most attention has been focussed on quantitative aspects of butterfat production. This is understandable in view of the fact that payment to the great majority of dairy farmers is on the basis of butterfat supplied to dairy factories. However, the yields of cheese and dried milks are determined in part by the non-fatty-solids in milk. There is also a legal minimum standard of 8.5 per cent for the S.N.F. content of milk sold for liquid consumption. Throughout the country, and notably in the Christchurch milk supply area, a number of town supply farmers have difficulty in maintaining the S.N.F. content of their milk above this legal minimum at all times of the year. It is clearly important that we have information about the variation and causes of variation in the content of the S.N.F. fraction of milk.

At the Dairy Research Institute (N.Z.), Palmerston North, the factors affecting the S.N.F. content of milk have been under study for a number of years and the purpose of this paper is to review some of the data obtained and briefly discuss their relation to relevant town milk production problems.

The results to be discussed refer to milk as it comes from the cow. In the dairy industry as milk is handled and processed it may be subject to adulteration and contamination and its composition thereby altered. These causes of variation would have practically no influence on the results reported. S.N.F. values were calculated from figures for total solids determined gravimetrically and for fat percentages obtained by the Gerber method. The basic data were obtained from analyses of samples of the milk of individual cows made in the majority of cases, on 24 hour composite samples taken twice weekly throughout lactation.

FACTORS AFFECTING THE S.N.F. CONTENT OF MILK.

Genetic Factors.

There is no doubt that a considerable proportion of the variation in S.N.F. values is genetically determined. Supporting evidence obtained at the Institute for this is of three main types—(a) data from cattle of two different breeds being milked on the same farm; (b) repeatability values for individual cows; (c) data from identical twins.

(a) Breed Data

In Table I average fat and S.N.F. percentages for groups of pedigree Friesians and pedigree and high grade Jerseys from the Massey College herds are shown along with an indication of the spread of values.

TABLE I: Average Annual Fat and Solids-not-Fat Content of Milks from Friesian and Jersey Cows (Dairy Research Institute, (N.Z.) Records).

Breed	No. of Cows	Butterfat per cent	Solids-not-Fat per cent
Friesian (pedigree)	64	3.58 + or — 0.30*	8.60 + or — 0.20
Jersey (pedigree and high grade)	274	5.12 + or — 0.50	9.32 + or — 0.30

* Mean + or — standard deviation.

Since the breeding bulls used in these herds have been obtained from a variety of studs and some cows bought in from other farms the results may be taken as reasonably representative for the two breeds in New Zealand.

It is clear that there is a marked difference between the means of the two groups—the breeds standing in the same order for S.N.F. as for fat percentage. Few critical data are available for the two other main dairy breeds in New Zealand—the Ayrshires and Shorthorns, although McLean (1951) records an average figure of 8.92% for the bulk milk of a season from the Lincoln College herd of 25-30 grade and purebred milking Shorthorns.

A limited amount of data from the Institute records illustrates the changes in the average lactational S.N.F. percentages resulting from cross breeding or grading up.

TABLE II.—Average S.N.F. Percentages for Crossbred Cows.

	Ayrshire	JA	J/JA	J/JJA	Jersey
No. of cows	9	37	51	18	274
Av. fat %	4.24	4.84	5.18	5.18	5.12
Av. S.N.F. %	8.93	9.23	9.39	9.40	9.32

(b) **Repeatability**

Average values for both fat and S.N.F. percentages were available in the Institute records for 495 lactations for 161 cows. Repeatability estimates were calculated for fat and S.N.F. percentages. The results using all data were 0.80 for butterfat percentage and 0.76 for S.N.F. percentage. There was thus a strong tendency for cows in our herds to produce milk of similar S.N.F. content in successive lactations. Similar results have been obtained by other workers for fat percentage, but few data for comparison with our figures seem to be available in the literature for S.N.F.

(c) **Identical Twins**

From data recorded during a uniformity trial with ten sets of identical twins it was calculated that 89% of the total variation in average lactational S.N.F. percentages was made up of the between set variation and only 11% came from within sets. Figures of this order suggest that within herds genetic and permanent environmental factors account for a large part of the variation in average S.N.F. figures for whole lactations of individual cows. As we have little evidence that the permanent environmental factors commonly encountered within herds have major effects on average milk composition, it seems likely that genetic factors have the major influence in determining differences between cows in average S.N.F. percentage levels.

We have, therefore, evidence indicating genetically determined variation in average S.N.F. values for individual cows, and the clear indication that these values could be influenced in either direction by breeding.

Environmental Factors.

(a) **Age of Cow**

As is shown in Table II age has little effect on the average lactational S.N.F. percentage. If anything there is a slight decline from first lactation to maturity. Similar results have been reported by Bailey (1952a) in England for Shorthorn cows.

TABLE III.—Average Annual Fat and S.N.F. Content of Milk from Jersey Cows in Successive Lactations.

No. of Cows	Milk Constituent	Age During Successive Lactations (in years) 2	3	4	5	6
19	Fat	5.09	5.02	5.04	—	—
	S.N.F.	9.41	9.37	9.32	—	—
13	Fat	5.15	5.07	4.97	4.89	—
	S.N.F.	9.41	9.36	9.31	9.32	—
5	Fat	5.25	5.14	5.03	5.08	4.82
	S.N.F.	9.24	9.22	9.21	9.27	9.11
24	Fat	—	5.06	5.02	4.90	—
	S.N.F.	—	9.37	9.31	9.31	—

(b) **Seasonal Variation and Stage of Lactation.**

As the cows under test at the Institute have calved at two periods only—the majority in July and August and a minority in the autumn, it has been difficult to separate out in detail the respective stage of lactation and seasonal effects. Certain features of each, however, are readily distinguished, and the figures which follow have been selected to illustrate some of these points. Three seasonal characteristics are marked. S.N.F. values are likely to be relatively low in the late winter-early spring periods—this shows up especially with autumn calving cows as illustrated in Figure I, and again in summer drought periods

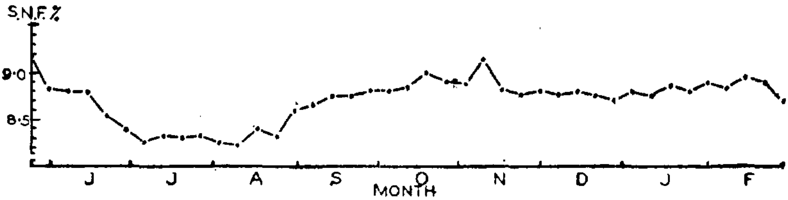

FIG. 1: Average S.N.F. % values for a group of autumn calving cows illustrating lower figures in the late-winter-early-spring period.

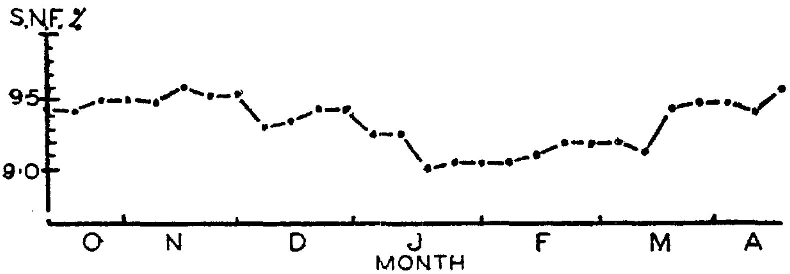

FIG. 2: Average S.N.F. % values for a group of spring calving cows illustrating relatively low figures during a summer drought.

as illustrated for spring calving cows in Figure 2. Values are relatively high during periods when pasture of high quality is abundant as it is for example, on most North Island farms during October and November.

In practice the winter depression of S.N.F. seems of most concern to town milk producers in New Zealand while low values in the summer mean lower cheese and dried milk yields for seasonal producers.

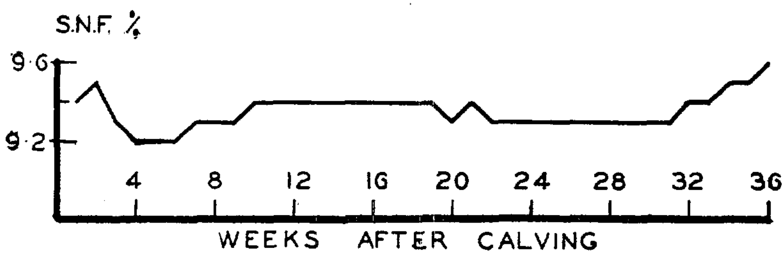

FIG. 3: Average S.N.F. % values for 224 July and August calving Jersey cows plotted according to stage of lactation.

Figure 3 shows for 224 July and August calving Jersey cows lactational trends in S.N.F. percentage. Over the first two weeks of lactation the values drop from high levels. This is undoubtedly a stage of lactation effect. (Early high protein values more than compensate for low lactose percentages giving high S.N.F. figures). By the third week values have fallen to normal levels. Relatively low percentages were recorded during the second month of lactation. This is possibly a reflection of the feeding conditions early in the spring in spite of the fact that at the Institute the standard of nutrition would be better than average. Following this period relatively high values were recorded to the end of the fifth month. The percentages then decline—probably due to summer conditions, and finally rise as lactation concludes.

We have not examined the effect of pregnancy on S.N.F. values, but Bailey (1952b) in England reports that empty cows do not show the slight rise in S.N.F. figures toward the end of lactation which occurs in the milk from pregnant animals.

(c) **Nutrition**

Following early observations that S.N.F. values declined during the feeding of pasture of poor quality, a number of experiments have been carried out at the Institute to determine the effects of low levels of feeding—general under-nutrition on milk composition. The results for S.N.F. have been summarised in TableIV. The numbers of animals involved gives some idea of the scale of these experiments. In the first trial approximately 40 mature cows were used each year for 3 successive years. This was followed by experiments using respectively 7, 14, 15, and 18 sets of identical twins in different years.

TABLE IV.—Summary of the results of experiments at the Dairy Research Institute (N.Z.) on the effects of under-nutrition on the composition of milk.

Treatment	Change in Milk Composition in Early Lactation.		
	B.F. %	S.N.F. %	T. Protein%
Underfeeding 10 weeks before calving—			
(i) Mature Cows	—0.28	—0.11	
(ii) 2 yr. old Heifers	0	0	
Underfeeding for 6 weeks after calving (starting 2 weeks after calving)	+0.50	—0.29	—0.24
Underfeeding for 10 weeks before and 6 weeks after calving		—0.43	
Underfeeding for 6 weeks after calving (starting at calving)		—0.35	

With mature cows, under-feeding during the last 70 days of pregnancy, despite subsequent good feeding, slightly depressed S.N.F. percentages of the milk early in lactation. With two--year-old heifers treated in this way no effect on milk composition was obtained. Underfeeding for 6 weeks early in lactation caused significant declines in S.N.F. content. While a return to full feeding usually resulted in the raising of S.N.F. values, in some animals the percentages did not recover to the levels of the twin pair mates during the remainder of the lactation. A combination of undernutrition before and after calving reduced S.N.F. values markedly, depressing them on the average by 0.43 compared with control animals during the first three months of lactation.

The work at the Institute on undernutrition has been concerned with the effects of a general reduction in reasonably well balanced diets. It is interesting to note that at Reading, England, results of one experiment indicate that either an energy or a protein deficient ration will lower the S.N.F. percentage of milk.

Limited progress has been made in checking the effects of individual foodstuffs or combinations of fodders on the S.N.F. content of milk.

It is clear that when cows are grazed on abundant good quality pasture the S.N.F. values of their milk are normally relatively high. It has been suggested that, as the hormone oestrogen when given in large doses to lactating cows raises the solids content of the milk (Folley et al. 1941) the S.N.F. supporting or stimulating properties of pasture might be related to its oestrogen content. While there is evidence from a few animals that oestrogen has this effect under stall feeding conditions, in work at the Institute we have found no evidence of any effects on milk composition with synthetic oestrogens given by injections (low doses) or with oral doses ranging from low to relatively high levels.

It would be expected from the work cited on undernutrition that any foodstuff or diet which did not supply animals' requirements for energy or protein within the amounts they would eat of it might lower the S.N.F. content of the milk produced. Our experience has been in agreement with this generalisation, except perhaps when the feeding has caused the sudden drying off of a cow.

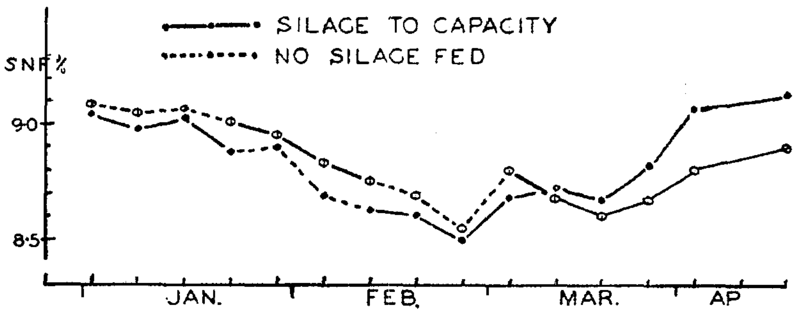

Fig. 4: Ad lib. feeding of silage in relation to S.N.F. content of milk during summer drought.

Pasture silage, of a type considered good in quality, i.e., of leafy material and of good colour, has not had the ability to maintain normal S.N.F. values when used as a sole feed. The results of one trial as illustrated in Fig. 4. The feeding ad lib. of pasture silage during a summer drought, although helping to arrest the rapid decline in milk and fat yields, made little difference to the typical decline in S.N.F. values. In a comparison between three different rations—silage,

silage plus choumoellier and silage plus a good balanced meal, the S.N.F. values from feeding silage alone were significantly below those resulting from the more adequate diet of silage plus meal. The detailed results of this trial have been presented to this Society (Flux and Patchell, 1950). It is interesting to note that a combination of silage and choumoellier also gave results below that of silage and meal which was used in this case as a control ration providing a high feeding level.

Further work is required to give adequate information about the effects of feeding available supplementary foodstuffs along with various amounts of pasture. On the present evidence it seems likely that relative high values for S.N.F. for the animals concerned will be maintained only on high quality palatable foodstuffs capable of supplying adequate nutrients within the limits of cows' appetities.

(d) **Climatic Factors**

In trials at the Institute where heavy meal feeding was employed throughout lactation in an endeavour to hold up S.N.F. values during the summer, S.N.F. percentages were maintained above control values during a drought period. However, meal-fed groups still showed a small decline during this period. These results suggest the possibility of a summer effect of climate apart from level of nutrition. Trials of the effects of hyper- and hypothyroidism induced by feeding thyroprotein and goitrogenic agents respectively gave results which were not in harmony with the concept that summer conditions might depress S.N.F. values through depressing thyroid activity.

Whether or not the characteristics of winter climate have any effect, apart from influencing the amount and quality of feed eaten is not known.

(e) **Disease**

The influence of mastitis and ketosis on S.N.F. content has been demonstrated in work at the Institute.

Some years ago McDowall (1945), chief chemist at the Institute, showed that milk from quarters affected with mastitis as indicated by positive Bromthymol Blue tests had an average S.N.F. percentage of 0.31 below milk from normal quarters. Only in rare cases, however, would the incidence of this disease be high enough for the composition of bulk milk to be significantly affected.

A high incidence of ketosis occurred in the Institute herd in one season and bulk herd milk was relatively low in S.N.F. content until the majority of the animals recovered.

(f) **A.M. and P.M. Milks**

For a period of three years in one herd at Massey College, the S.N.F. content of samples of a.m. and p.m. bulk milk have been determined separately. Little consistent difference is evident from these results.

DISCUSSION:

The problem of the town milk producer who wishes to maintain the S.N.F. content of his milk above the legal minimum appears to be to gauge the variation in S.N.F. values which occurs in his bulk herd milk under the most profitable feeding and management conditions obtaining on his particular farm, and then to adjust the average genetic make-up of his herd by his buying or breeding policy so that minimum values of S.N.F. do not fall below 8.5 per cent—the legal minimum.

At the present time the only S.N.F. data a town milk supplier may have access to are such records as are available for his bulk herd milk in milk treatment stations. At the best these give *him* a fair idea of the general level of S.N.F. and its seasonal variation and indicate the direction of any required change.

The relationship between average fat and S.N.F. percentages for individual cows is a direct one as is shown in Figure 5 based on

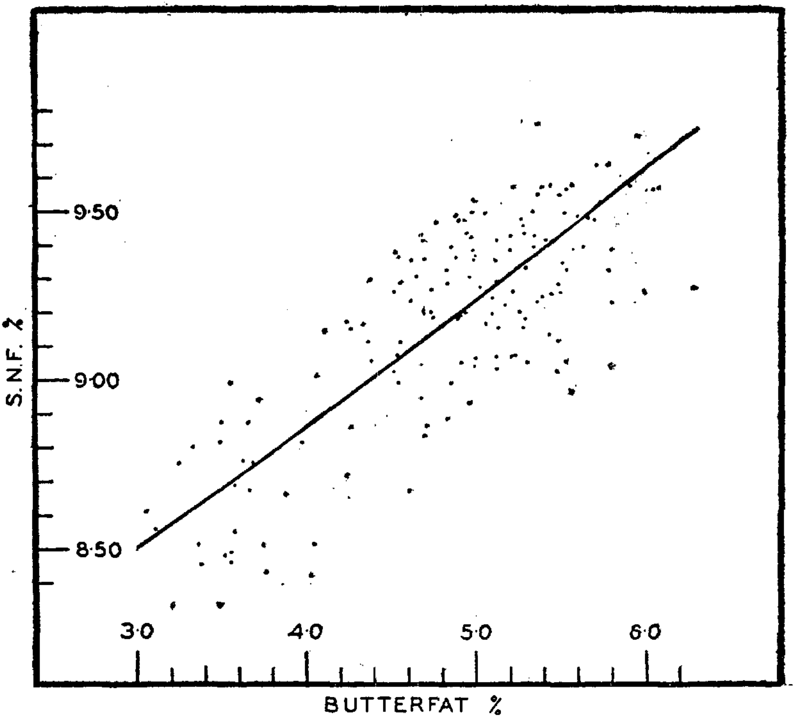

Fig 5. The relationship between average fat and S.N.F. percentages for individual cows.

495 whole lactation records from 161 cows. On the average, as the fat content rises, the S.N.F. content rises also. The breeding of cows for milk of higher fat content will, in general, lead to milk of a higher S.N.F. content. However, because of the variation in S.N.F. at any fat percentage level, dependence on such a policy for improvement would involve some disappointments in small populations.

Individual cow data are necessary for the soundest approach to culling or constructive breeding for definite S.N.F. levels. The lack of a quick, cheap and accurate method for determining the S.N.F. content of milk is a limiting factor here. However, the devising of such a method should not be beyond the capacity of our chemists. A further promising method of approach is shown by the results of calculations from the Institute records of the correlations between the results of a very few accurate tests for S.N.F. and the mean for the whole lactation. Some of these correlations have been high—for example that using a single test made 21-24 weeks after calving in spring calving cows was 0.852. Using multiple regression and combining the results of three tests per lactation, values so estimated had a correlation of 0.958 with averages based on twice weekly testing throughout lactation. The task of supplying S.N.F. data for individual cows for culling and selection purposes may not be quite so difficult as many believe.

It seems reasonable to suggest that before any bull of a breed with a relatively low S.N.F. average is widely used by the Dairy Board in an Artificial Breeding Service to town milk producers, some information concerning the S.N.F. content of the milk of his progeny should be available.

Time does not permit of discussion of the implications of all the results shown, but the authors believe that the data given are sufficient to refute statements commonly heard in town milk circles to the effect that because little is known about the S.N.F. content of milk, nothing can be done about the problem of low S.N.F.

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Discussion

Mr. HOLLARD: To what exent is the Christchurch problem associated with the long winter and poor pasture growth?

Professor CAMPBELL: In New Zealand with our customary dependence on pasture, the longer and harder the winter, the more difficult is it to keep up a high standard of nutrition throughout this period, and therefore the more likely it is that depression in S.N.F. values occurs. Under these conditions, if town milk supply herds are predominantly of a breed which inherently has the capacity for producing milk of low S.N.F. percentage (and this is the situation in Christchurch) it is not surprising to find S.N.F. values fall below the legal minimum in the milks from many herds. A dry summer preceding a long winter, of course, intensifies winter feeding problems.

Mr. SEARS: Could not dried milk solids be added to improve the quality of milk with a low S.N.F. content?

Professor CAMPBELL: This could be done. The difficulties would not be technical so much as legal at the present time. Possibly there would be some consumer resistance at first.

Dr. CUNNINGHAM: Could not the low S.N.F. problem be met better by making a lower payment for milk with lower S.N.F. content than by making the sale of this milk illegal?

Professor CAMPBELL: Payment according to compositional quality does seem the soundest principle to adopt if ways of implementing it can be worked out.