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Herd-to-herd variations in the properties of milkfat

A.K.H. MacGIBBON

Food Science Section, New Zealand Dairy Research Institute, Private Bag 11029, Palmerston North, New Zealand.

ABSTRACT

The solid fat content of milkfat has a major influence on the hardness of butter produced at dairy factories. The aim of this work was to study the variation in the solid fat content of milkfat from thirty herds in the factory collection area on a single day to determine the extent of variation in the milk supply.

The solid fat content of the milkfat at 10°C varied from 49.6% to 59.8% between the individual herds. This variation in the milk from different herds is as large as the entire seasonal change observed in the bulked factory silo milk, indicating significant variation in the properties of the milkfat within the factory supply on a single day.

Low solid fat content at 10°C was correlated with milk of low fat percent ($r = 0.78$, $P < 0.0005$) and high protein-to-fat ratio ($r = -0.75$, $P < 0.0005$). Though there was substantial variation in the solid fat content within the breeds, milkfat from Friesian herds had a significantly lower solid fat content than milkfat from Jersey herds (mean ± S.E., 54.4 ± 0.6 and 57.1 ± 0.6 respectively, $P = 0.004$).

There appears to be considerable potential for exploitation of the natural variation in the properties of milkfat inherent in the New Zealand dairy herds.

Keywords: solid fat content; fatty acids; milkfat; milk fat; milkfat composition; herds.

INTRODUCTION

Very little work has been carried out to study the variation in the characteristics of the milkfat produced by different cow herds. All milk has tended to have been considered the same and equally suitable for use in the production of any product. The sole milkfat property that has been monitored, and used for genetic selection, has been the fat content of the milk, as the fat content is part of the basis of the milk payment system. The aim of this work was to undertake an initial study of the herd-to-herd variation in milkfat characteristics.

The property to be studied was the solid fat content of the milkfat, a characteristic which has a major influence on the functionality of milkfat products, and in particular has a significant effect on the hardness of butter (MacGibbon & McLennan, 1987). The solid fat content at 10°C (SFC_{10}) was used for comparison of the properties of the milkfat as it relates well to the sectility hardness measurement of butter, a major functional property. Thus the performance of milkfat products may be predicted from the characteristics of the milk produced.

METHODS

Collection

Milk was collected from 30 farms as part of the normal dairy factory milk collection, the samples being taken from the sight glass tubing on the farm vats. The milk was collected in March, from herds which covered a range of breeds, production and localities. The breeds are listed in Table 1 and included samples from factory supply and town milk supply herds. The collection was over 2 days due to tanker routing. Samples of bulk milk, used to estimate the typical milk received at the factory over the collection period, were obtained from the factory milk testing unit.

TABLE 1: Number of herds of each breed sampled (with abbreviations used).

Breed		Factory Supply n		Town Milk (TM) Supply n
Ayrshire	A	1		
Friesians	F	11	F TM	6
Friesian cross	FX	1		
Friesian and Jersey mixed herd	J&F	1		
Jerseys	J	8	J TM	1
Jersey cross	JX	1		
Total herds		23		7

Analysis

Fat, protein, lactose, and total solids contents of the milk from each herd sample, were obtained from dairy company records of the milk analyses.

The milk, in 2 L containers, was held at 4°C for one day to allow the cream to rise. The cream was removed and churned into butter in a laboratory mixer. The milkfat was then extracted from the butter as described by MacGibbon & McLennan (1987), by heating, centrifuging and filtering.

The solid fat content (SFC) of the extracted fat was determined by pulsed nuclear magnetic resonance (NMR) and expressed as percentage solid fat (MacGibbon & McLennan, 1987). As the milkfat was melted to remove any thermal history, prior to recrystallization under standard conditions, the SFC simply reflects the chemical composition of the milkfat. The solid fat content at 10½C is designated as SFC_{10}. The dropping point of the extracted fat, equivalent to the temperature (½C) at which about 2.5% of the milkfat is solid, was determined as described by Timms (1978). The fatty acid content of the triglycerides of the extracted milkfat was determined by FAME analysis (MacGibbon, 1988).

Seasonal average values for the farm size, herd size, stocking rate, fat/hectare and fat/cow were obtained from dairy company records, as gross indicators of farm practices and conditions (see Table 2).

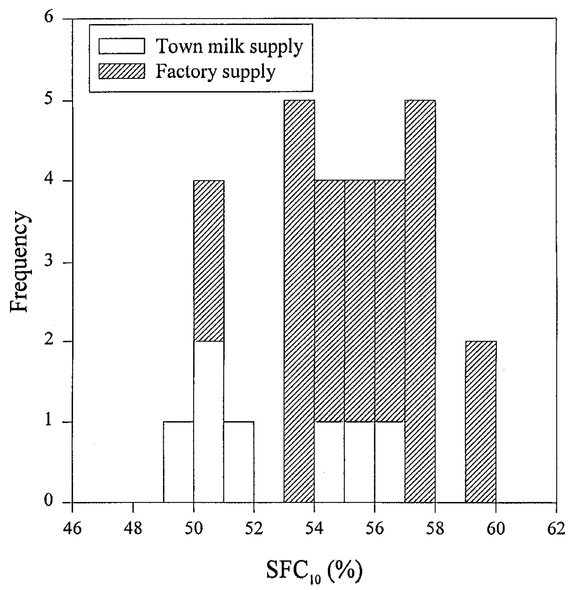
The data was analysed by correlation, regression and analysis of variance using the Minitab V10.5 statistical package.

RESULTS

Solid fat content

Figure 1 shows the SFC_{10} for all the samples collected, the range being from 49.6% to 59.8%, the mean for the factory supply was 55.5% and for the town milk supply was 52.8%. The town milk supply Friesian herds all tended to have low SFC_{10}. The mean value of bulked milk collected at the factory was 54.5% indicating that the factory supply samples were a reasonable representation of the whole supply.

FIGURE 1: Range of SFC_{10} from factory supply and town milk supply herds at a single collection.



The SFC_{10} range for the factory supply herds alone was from 50.4% to 59.8%, which was almost equivalent to the entire seasonal change in the solid fat content of NZ milkfat extracted from patted butters of 48.9% to 61.3% (MacGibbon & McLennan, 1987).

The correlation of the gross composition of the milk with the solid fat content is shown in Table 2. The dropping point of the milkfat showed a high positive correlation with SFC_{10}. The herds with a low SFC_{10} are associated with a low fat and protein contents in the milk (r = 0.78 for all herds, 0.72 for factory supply herds and 0.78 for the few town milk supply herds) and a high protein-to-fat ratio (r = -0.75 for all herds, -0.64 for factory supply herds and -0.83 for the few town milk supply herds). There was no significant correlation between SFC_{10} and the seasonal production statistics; farm size, herd size, stocking rate, fat/hectare and fat/cow.

TABLE 2: Correlation of SFC_{10} and milk composition data.

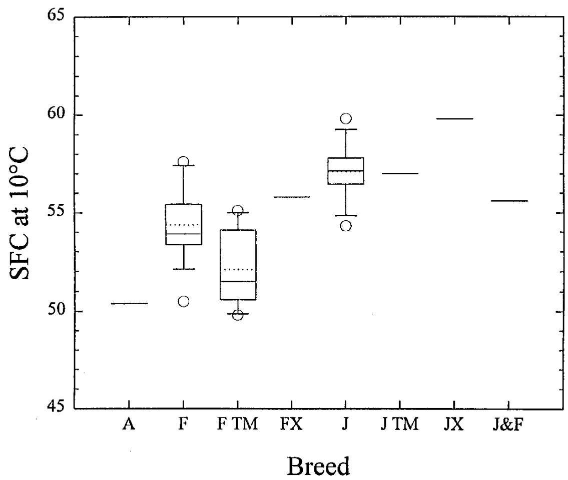
	Correlation coefficients (r)	
	SFC_{10} (All Herds)	SFC_{10} (Factory Supply Herds)
Dropping point	0.90***	0.88***
Fat content	0.78***	0.72***
Protein content	0.68***	0.62***
Lactose content	0.22	0.41**
Total solids	0.74***	0.71***
Protein:fat ratio	-0.75***	-0.64***
herd milk volume	0.02	0.00
Seasonal values		
Farm Size		-0.07
Herd Size		-0.03
Stocking Rate		0.12
Fat/Hectare		0.04
Fat/Cow		-0.08

*P<0.1, **P<.05, ***P<.01

Breeds

Figure 2 shows the box plot of the range of SFC_{10} found for the different breeds. The Friesian herds tended to have a lower SFC_{10} than the Jersey herds. For the two breeds which are represented by more than one herd (Friesian and Jersey), there is a wide variation in the SFC_{10} within the breeds. Though there was substantial variation in the solid fat content within the breeds, milkfat from Friesian herds had a significantly lower solid fat content

FIGURE 2: Distribution of SFC_{10} for milkfat from herds of different breeds. In the box and whisker plot the box represents the 25th and 75th percentiles, the line the 50th percentile, dotted line the mean, capped was the 10th to 90th percentiles and individual points represents data outside the 10th to 90th percentile.

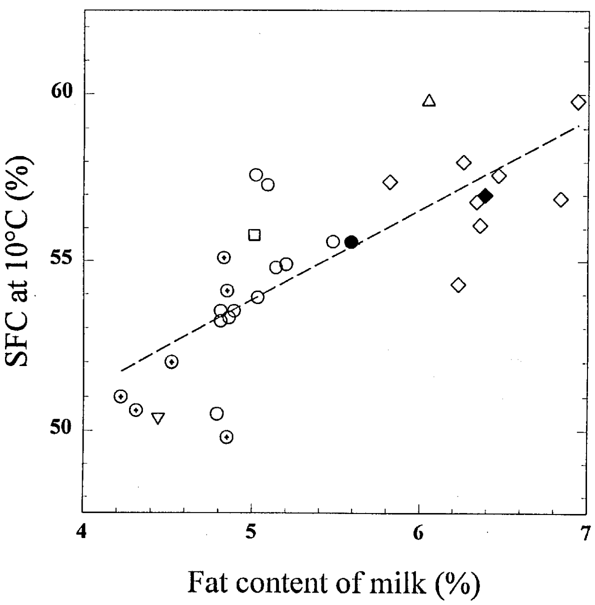


than milkfat from Jersey herds (mean ± S.E., 54.4 ± 0.6 and 57.1 ± 0.6 respectively, P = 0.004).

The town milk supply Friesian cows were found to have a low SFC_{10}. The other breeds are only represented by single herds.

The relationship between the fat content of the milk and the SFC_{10} is shown in Figure 3. There is a significant trend of increasing SFC_{10} as the percentage of fat in the milk increases (r = 0.78, P<0.0005). If the two axes are studied individually, the breed effect on the milkfat content of the milk is absolute, all the Friesians having a lower percentage than the Jerseys. However, the effect of breed on SFC_{10} is less distinct, with substantial overlap between the Friesians and the Jerseys. Thus breed has a larger effect on milkfat content than on SFC_{10}.

FIGURE 3: Relationship between SFC10 and the percentage of fat in the milk. Data designated by breed; A (▽), F(○), F TM(⊙), FX (□), J (◇), J TM (◆), JX (△), J&F (●).



The town milk supply Friesians, which tended to have a low fat content, were found to have a low SFC_{10}. This could in part be due to factors relating to the stage of lactation. The factory supply herds were all spring calving and thus were at a different stage of lactation than the town milk supply herds.

Fatty acids

The correlations of the SFC_{10} with the individual fatty acid content of the milkfat extracted from all herds and factory herds alone are listed in Table 3. The fatty acids are represented by the number of carbon atoms in the chain followed by the number of double bonds. The highest correlations are increases in c8:0 to c14:0 fatty acids with increasing SFC_{10} and decreases in c18:1 and c18:2c fatty acids with increasing SFC_{10}.

Table 4 shows the comparison of the mean fatty acid profile of the factory supply Friesian and Jersey herds. The

TABLE 3: Correlation of SFC_{10} with individual fatty acids.

	CORRELATION COEFFICIENTS (r)	
Fatty acid	SFC_{10} (All herds)	SFC_{10} (Factory herds)
c4:0	0.07	0.23
c6:0	0.52***	0.53***
c8:0	0.60***	0.55***
c10:0	0.62***	0.58***
c12:0	0.59***	0.55***
c14:0	0.76***	0.69***
c16:0	0.44**	0.43**
c18:0	0.23	0.21
c18:1	-0.83***	-0.81***
c18:2	-0.21	0.14
c18:2c	-0.64***	-0.78***
c18:3	-0.01	0.24

P<0.1, **P<.05, ***P<.01

TABLE 4: Mean fatty acid composition of factory supply Friesian and Jersey herds with pooled standard error.

Fatty acid	Friesian	Jersey	SE
c4:0	3.9	3.8	.06
c6:0	2.4	2.5	.03
c8:0	1.3	1.5	.03***
c10:0	2.8	3.4	.07***
c12:0	3.2	3.9	.09***
c14:0	10.7	11.2	.09**
c16:0	29.8	28.7	.29*
c18:0	10.5	12.1	.22***
c18:1	22.1	20.6	.34*
c18:2	1.2	1.3	.03*
c18:2c	1.3	0.9	.04***
c18:3	0.8	1.0	.03**

*P<0.1, **P<.05, ***P<.01

Jersey herds had significantly higher proportions of medium chain length saturated fatty acids (c8:0, c10:0, c12:0) than the Friesian herds, and also had higher c14:0, c18:0, c18:3 and lower c18:2c fatty acid proportions.

DISCUSSION

The SFC was measured at 10°C, the temperature at which the standard method for sectility hardness measurements is performed at the New Zealand Dairy Research Institute (MacGibbon & McLennan, 1987), thus allowing the SFC_{10} to be related to physical properties.

MacGibbon & McLennan (1987), in a survey of the properties of fresh patted butter from 5 factories, found a seasonal variation in the SFC_{10} of the extracted milkfat of 48.9% to 60.1% (mean 56.0%). This seasonal variation is reflected in a three-fold change in the sectility hardness of New Zealand butters, from soft butter at the low SFC_{10} to hard butters at the high SFC_{10}, so the change is important in terms of the physical properties of the butters. The range of SFC_{10} of the patted butter is moderated by the averaging effect of the mixing of the bulk milk and cream in large factory silos. Milk from herds at a single time of the year showed a similar range of SFC_{10} values indicating a large variation in the composition of the milk entering the factory supply. The milk was collected at a time near the end of the season, with some farms on alternate day collection, so there is a need for more information over the period close to the peak of the season.

There are a number of factors, such as breed, genetic make up, plane of nutrition, and the health of the individual cows, which may affect milk properties such as milkfat content and protein-to-fat ratio, and these milk properties are not independent. Typical compositional data for Holstein-Friesian and Jersey breeds are fat (4.41%, 5.59%), protein (3.47%, 4.14%) and protein to fat ratio (0.79, 0.74) respectively (Livestock Improvement Corporation, 1990)

The SFC_{10} has been found to be correlated with the milk composition, and part of the variation in SFC_{10} appears to be associated with the breed of the herd.

The correlations found for milkfat content and protein-to-fat ratio are interesting as these factors will be important in future breeding, with the emphasis on lower milkfat content and higher protein-to-fat ratio. These limited data would suggest that the milkfat from such cows would have a lower solid fat content.

Very little work has been carried out on the detailed milkfat composition in the milk of individual cows or herds. However, studies of the fatty acid compositions have shown that milk with a lower milkfat content tends to contain a lower proportion of short and medium chain fatty acids and more unsaturated fatty acids (Bartsch, 1979). This is consistent with the lower SFC_{10} for the milk containing less fat, and also the lower SFC_{10} values for the Friesian cows. Recently Palmquist *et al.* (1993) and Beaulieau & Palmquist (1995) in studies on the fatty acid composition of individual Jersey and Friesian cows showed that Jerseys had higher proportions of fatty acids synthesised in the mammary gland, particularly c8:0-c12:0 and lower c18:1 than Friesian cows. This is in general agreement with the results found for the herd samples in this study. MacGibbon (1994) described the relationship between SFC_{10} and fatty acid composition. The low melting point short chain fatty acids and unsaturated fatty acids contribute to a lower SFC_{10} while high melting point long chain fatty acids contribute to a higher SFC_{10}.

The effect of genetics and cow metabolism on the SFC_{10} should be the subject of future investigations and provide an explanation of how these factors affect the variation in this milkfat property observed between individual herds.

CONCLUSIONS

Milk entering the factory does not have constant milkfat properties, but varies widely from herd to herd. Advantage could be taken of these variations to select milk for products which require milkfat with specific properties, or for smoothing out seasonal variation for markets which require a consistent product.

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REFERENCES

Bartsch, B.D. 1979. The influence of genetic, nutritional and environmental factors on the composition of milkfat. *In* Proceedings of the Milk Fat Symposium, October 1979, CSIRO, 8- 17.

Beaulieau A.D. & Palmquist D.L. 1995. Differential effects of high fat diets on fatty acid composition in milk of Jersey and Holstein cows. *Journal of Dairy Science,* **78**: 1336-1344.

Livestock Improvement Corporation Limited; Dairy Statistics 1989/90, 1990. Livestock Improvement Corporation Limited, New Zealand Dairy Board, p. 18.

MacGibbon A.K.H. & McLennan W. D. 1987. Hardness of New Zealand patted butter: seasonal and regional variations. *New Zealand Journal of Dairy Science and Technology,* **22:** 143-156.

MacGibbon A.K.H. 1988. Modified method of fat extraction for solid fat content determination. *New Zealand Journal of Dairy Science and Technology,* **23:** 399-403.

MacGibbon A.K.H. 1994. Relationship between SFC and fatty acid composition of milkfat. *Brief Communication of the 24th International Dairy Congress, Melbourne 18-22 September 1994.* Aus-