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# Seasonal variation of the fatty acid composition of milkfat from Friesian cows grazing pasture.

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## ABSTRACT

Information collected at the Dairying Research Corporation milk composition laboratories on the fatty acid composition of milkfat spanning 1994/95 to 1998/99 dairying seasons has been summarised. The data comprised 1350 determinations in 18 different experiments from 965 individual Friesian cows that calved in July/August and grazed solely on pasture. A seasonal effect on fatty acid composition was observed. In general, concentrations of fatty acid groups and individual fatty acids were similar in spring and autumn but differed in summer. The ratio of an estimate of preformed (total fatty acids $>C_{17:0}$) and an estimate of *de novo*- (total fatty acids $<C_{16:1}$) synthesised fatty acids altered during the season. In early lactation (August), the ratio of preformed:*de novo* fatty acids (P:S) was 0.76 declining to 0.51 by December and increasing to 0.80 by late autumn. The concentration of total unsaturated fatty acids followed a similar trend: 30.4% in August, 24.5% in December and 32.8% in April. In early lactation, milkfat from primiparous compared with multiparous cows had higher oleic acid ($C_{18:1}$), total unsaturated fatty acids and P:S ratio, indicating greater mobilisation of body fat. Conjugated linoleic acid (CLA) varied from 1-1.4% through spring, declined to 1.0% in summer and increased to 1.6% by April. The seasonal changes in milkfat composition reflected the seasonal trends in the characteristics of milkfat for processing. For example the softness of milkfat as calculated from a relationship previously established between fatty acid composition and solid fat content at $10^0$C ($SFC_{10}$), varied seasonally. Milkfat was softer in late spring ($SFC_{10}$, 53%) becoming harder ($SFC_{10}$, 61-63%) during December to February and softer ($SFC_{10}$, 54%) in autumn. The healthiness of milkfat, as described by the concentration of unsaturated fatty acids and CLA, varied throughout the season. The lowest concentrations were in summer or in mid-lactation and the highest in autumn or late lactation. The information will be useful to manufacturers of dairy products to target specific milkfat products to particular times of the year.

**Keywords:** milkfat composition; month; cow age; pastoral dairying.

## INTRODUCTION

Milkfat is high in saturated fatty acids and has been claimed to contribute to heart disease (Berner, 1993; Chisholm *et al.*, 1996). For good health and wellbeing, health authorities in most Western countries recommended a reduction in milkfat intake. In recent years, however, there has been an increased interest in milkfat, in particular, the composition of milkfat and the impact of individual fatty acids on human health. Ney (1991), Gurr (1998), and Parodi (1999) have all reviewed the potential for enhancing the composition of milkfat for the benefit of human health. Gurr (1998) concluded that the regular consumption of skimmed or whole milk, or full-fat cheeses had no effect on blood cholesterol concentration and may even lower it. Parodi (1999) reported on many agents in milkfat that have potential anticarcinogenic properties. The physical properties of milkfat products are also influenced by the fatty acid composition of milkfat. For example, the spreadability of butter (MacGibbon and McLennan 1987) and the properties of aerosol creams. In seasonal calving, pastoral dairying, these properties have been observed to vary seasonally (Cullinane *et al*. 1984; MacGibbon & McLennan 1987). Auldist *et al.* (1998) identified that the effects of season on milkfat composition were greater than effects of stage of lactation. This study reports on the average monthly fatty acid levels in the milkfat of spring-calving primiparous and multiparous cows grazed on pasture.

## METHOD

At the formation, in 1994, of the Farm Practices and Milk Properties research programme at the Dairying Research Corporation, a database was established to store all milk constituents analysed by our laboratories. Auldist *et al.* (1998) described the fatty acid components, and the analytical procedures used. The database, covering the 1994/95 to 1998/1999 dairying seasons, was interrogated to determine the seasonal effects on the fatty acid composition of milkfat for spring-calving dairy cows grazed on pasture only.

The database contained in excess of 3500 fatty acid profile (FAP) assessments from individual cows. Cows that received supplements or forages known to effect the FAP of milkfat and those on a restricted pasture allowance (less than 35 kg DM/cow/day), were removed from the analysis. Repeated measures on individual cows were accounted for by either using a monthly average of the repeated data to investigate seasonal variation or a three-monthly average to determine parity effects. Not all individual fatty acids are presented. Fatty acids were grouped into the standard groups: short ($C_{4:0}$-$C_{8:0}$), medium ($C_{10:0}$-$C_{12:0}$), long ($C_{14:0}$-$C_{18:0}$), mono-unsaturated ($C_{12:1}$, $C_{14:1}$, $C_{16:1}$, $C_{17:1}$, $C_{18:1}$), poly-unsaturated (linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) and total unsaturated fatty acids. The individual fatty acids stearic ($C_{16:0}$), oleic ($C_{18:1}$) and conjugated linoleic acid (CLA) *cis*-9-*trans*-11-$C_{18:2}$, are presented together with a prediction of the solid fat content at $10^0$C ($SFC_{10}$) using the formulae established by Mackle *et al*. (1997). Also calculated from the FAP was a ratio to describe the relationship between preformed, fatty acids that originate from the rumen or metabolism of body fat ($C_{17:1}$ and greater), and fatty acids synthesised within the mammary gland ($C_{17:0}$ and shorter chain length) termed the P:S ratio. These data were analysed using residual maximum likelihood (REML) in Genstat. Predicted means generated by the fixed and random model effects are presented.

## RESULTS

Of the initial 3500 observations, 1350 remained and these originated from 965 individual cows (236 primiparous and 729 multiparous cows) managed in 18 different experiments. For all fatty acid groups, there were distinct seasonal trends (Table 1). Concentrations of short- and medium-chain fatty acids were greater during August to December and declined from January to April. Long-chain saturated fatty acids and $SFC_{10}$ increased from August to December/January and then concentrations declined by April to be at similar concentrations to those found in August. The opposite seasonal trend was apparent for mono-unsaturated fatty acids and P:S ratio, these being highest in August and April and reaching the lowest values in December/January. Concentrations of poly-unsaturated fatty acids varied little from August to February but increased during March and April. Seasonal variation in CLA differed from that of total poly-unsaturated acids. Concentrations increased from August to October, declined to lowest levels in December/January and increased again through to April. Stearic and oleic acids showed distinct seasonal trends (Figure 1). Stearic increased from August to December then declined to be similar in concentration in April as in August. The concentration of oleic acid varied in the opposing direction to stearic, being highest in August and April and lowest in December/January. Stearic and oleic acids from primiparous and multiparous cows differed during August and September with primiparous cows producing milkfat with higher concentrations of oleic and lower concentrations of stearic acid.

To test for a parity effect, the data was grouped into three-monthly intervals, covering spring (August-October), summer (November-January) and autumn (January-April). Within parity groups of multiparous cows, no parity effect was observed. However, a difference during spring was apparent between primiparous and multiparous cows for some individual fatty acids and fatty acid groups (Table 2). Throughout lactation the primiparous cow had similar levels of short- and medium-chain fatty acids, poly-unsaturated fatty acids and CLA. Milkfat from primiparous cows in early lactation had higher oleic acid, mono-unsaturated and total unsaturated fatty acids and P:S ratio than milkfat from multiparous cows. The $SFC_{10}$ of milkfat from primiparous cows was lower in early lactation and similar to that of multiparous cows in mid and late lactation.

**TABLE 2:** Parity and time of year effects on the fatty acid composition of milk fat from spring- calving cows offered pasture only.

| Fatty acid group | Parity[1] | Spring[2] | Summer | Autumn |
|---|---|---|---|---|
| Short | 1 | 7.8 | 7.6 | 7.3 |
| | 2+ | 7.9 | 8.0 | 7.3 |
| s.e.d. (cow age) | 0.22 | | | |
| Medium | 1 | 6.9 | 6.7 | 5.6 |
| | 2+ | 7.2 | 7.1 | 5.6 |
| s.e.d. (cow age) | 0.25 | | | |
| Long | 1 | 50.0 | 54.9 | 53.1 |
| | 2+ | 51.7 | 55.3 | 53.3 |
| s.e.d. (cow age) | 1.17 | | | |
| Mono-unsat. | 1 | 27.5 | 23.4 | 25.9 |
| | 2+ | 24.9 | 22.5 | 25.7 |
| s.e.d. (cow age) | 0.83 | | | |
| Poly-unsat. | 1 | 4.2 | 3.6 | 4.5 |
| | 2+ | 4.0 | 3.6 | 4.4 |
| s.e.d. (cow age) | 0.34 | | | |
| Total unsat. | 1 | 31.6 | 27.0 | 30.3 |
| | 2+ | 28.9 | 26.1 | 30.0 |
| s.e.d. (cow age) | 1.08 | | | |
| $C_{16:0}$ | 1 | 24.8 | 29.5 | 28.3 |
| | 2+ | 26.9 | 30.2 | 28.8 |
| s.e.d. (cow age | | 0.93 | | |
| $C_{18:1}$ | 1 | 24.9 | 20.5 | 22.9 |
| | 2+ | 22.0 | 19.3 | 22.7 |
| s.e.d. (cow age) | 0.82 | | | |
| CLA[3] | 1 | 1.11 | 0.96 | 1.22 |
| | 2+ | 1.21 | 1.01 | 1.28 |
| s.e.d. (cow age) | | 0.13 | | |
| P:S[4] | 1 | 0.81 | 0.63 | 0.75 |
| | 2+ | 0.69 | 0.57 | 0.71 |
| s.e.d. (cow age) | 0.04 | | | |
| $SFC_{10}$ | 1 | 50.4 | 60.8 | 57.7 |
| | 2+ | 54.1 | 61.0 | 58.6 |
| | 1.89 | | | |

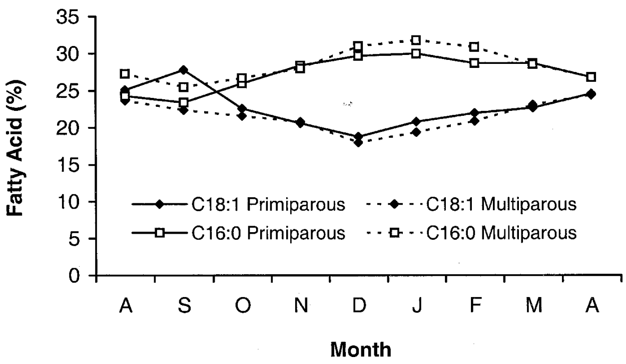
[1] 1= primiparous; 2+ = multiparous
[2] Season; Spring, August-October; Summer, November-January; Autumn, February-April
[3] Conjugated linoleic acid
[4] Preformed:*de novo* synthesised ratio. Fatty acids greater than $C_{17:0}$:fatty acids less than $C_{16:1}$

**TABLE 1**: Monthly averages of milkfat concentration, the concentration of the major fatty acid groups, conjugated linoleic acid (CLA), the calculated solid fat content (SFC) and the ratio of preformed:*de novo* synthesised fatty acids (P:S) in milk from spring-calving multiparous cows grazing pasture only

| Month | Fat (%) | Short $C_{4:0}$-$C_{8:0}$ | Medium | Long $C_{10:0}$-$C_{12:0}$ | Mono-unsat. $C_{14:0}$-$C_{18:0}$ | Poly-unsat. | Total unsat. | CLA | $SFC_{10}$ [1] | P:S [2] |
|---|---|---|---|---|---|---|---|---|---|---|
| August | 4.32 | 7.7 | 6.4 | 51.4 | 26.5 | 3.9 | 30.4 | 1.04 | 52.9 | 0.76 |
| September | 4.55 | 8.1 | 7.5 | 51.0 | 25.1 | 4.0 | 29.0 | 1.10 | 52.4 | 0.72 |
| October | 4.63 | 7.9 | 7.4 | 51.9 | 24.6 | 4.1 | 28.7 | 1.41 | 54.9 | 0.66 |
| November | 4.62 | 7.8 | 7.2 | 53.6 | 24.0 | 3.7 | 27.7 | 1.08 | 57.8 | 0.63 |
| December | 4.62 | 8.3 | 7.6 | 55.9 | 21.3 | 3.3 | 24.5 | 0.96 | 61.4 | 0.51 |
| January | 4.48 | 7.6 | 6.4 | 56.4 | 22.6 | 3.7 | 26.4 | 1.00 | 63.4 | 0.57 |
| February | 4.83 | 7.2 | 5.8 | 56.1 | 24.1 | 3.5 | 27.6 | 0.90 | 63.6 | 0.63 |
| March | 5.08 | 7.2 | 5.5 | 53.1 | 26.1 | 4.2 | 30.2 | 1.27 | 58.4 | 0.72 |
| April | 4.85 | 7.2 | 5.1 | 51.1 | 27.6 | 5.2 | 32.8 | 1.55 | 53.8 | 0.80 |
| s.e.d.[3] | 0.23 | 0.33 | 0.60 | 1.41 | 1.46 | 0.40 | 1.74 | 0.19 | 2.66 | 0.07 |

[1] Solid fat content calculated from the formulae presented by Mackle *et al*. (1997)
[2] Preformed:*de novo* synthesised ratio. Fatty acids greater than $C_{17:0}$:fatty acids less than $C_{16:1}$
[3] Standard error of difference to compare differences between months

**FIGURE 1:** Monthly variation in stearic ($C_{16:0}$) and oleic ($C_{18:1}$) fatty acids in milk from primiparous and multiparous spring-calving cows grazing pasture.




## DISCUSSION

The seasonal variation in the fatty acid composition of milkfat observed in this study was similar to that reported for milkfat in bulk milk delivered to a Manawatu dairy factory (Gray, 1973). Auldist *et al*. (1998) reported that annual variation in the FAP of milk fat was influenced more by time of year than stage of lactation. Two possible factors influenced this variation – level of feeding and changes in the lipid composition of pasture. Palmquist *et al*. (1993) reported for cows in negative energy balance, a decline in *de novo* synthesis of short- and medium-chain fatty acids, while the mobilisation of long-chain unsaturated fatty acids from the adipose tissue increased. Similar changes in fatty acids were reported by Mackle *et al.* (1999) for cows grazed *ad libitum* and on restricted pasture allowances in spring and summer. This suggests that, at any time during the season, the fatty acid composition of milkfat will change if underfeeding occurs. The effect of underfeeding on milkfat composition was minimised by ensuring that all cows selected from the database had grazed on an adequate pasture allowance (35 kg DM/cow/day or greater). Despite this precaution, primiparous cows in spring produced milkfat that differed in composition from that of multiparous cows (Table 2). The higher oleic acid, total unsaturated fatty acids and P:S ratio suggested that primiparous cows in early lactation were underfed despite being offered a similar pasture allowance and mobilising more body tissue than multiparous cows. Mackle *et al*. (1996) and Rhodes *et al*. (2000) reported, however, low pasture intakes during early lactation for primiparous cows, even when offered an *ad libitum* pasture allowance. The assumption made from this information was that primiparous, in comparison with multiparous cows, were in greater energy deficit in early lactation when grazed at a similar pasture allowance, due to their inability to consume sufficient pasture.

Other seasonal effects observed on milkfat composition possibly result from seasonal changes in the lipid composition of pasture. Hawke (1963) reported that changes in the fatty acid composition of milkfat were associated with changes in the fatty acid composition of pasture. Milkfat from cows grazed on immature ryegrass was more unsaturated than that from cows grazed on mature ryegrass. Gray (1973) concluded, from reviewing past research, that the concentrations of $C_{18}$ acids in milkfat were determined more by amount and type of feed than by stage of lactation. From the analyses of the database, a similar conclusion could be arrived at, especially for multiparous cows, assuming they were meeting nutrient requirements from pasture and effects of stage of lactation were minimal. Also, the greater seasonal effects were noted for the total unsaturated fatty acids and the P:S ratio, which are more influenced by type of diet in fully-fed cows.

The P:S ratio possibly best demonstrates these seasonal changes. This ratio shows a distinct seasonal pattern with preformed fatty acids influencing milkfat composition to a greater extent at the start and end of the season. During mid-lactation, or in summer (Table 2), the lower P:S ratio suggests that *de novo* synthesis was contributing more to the FAP than preformed fatty acids. $SFC_{10}$ varied throughout the season in a similar manner to the P:S ratio, reflecting changes in the physical characteristics of milkfat. In particular, when advancing from spring to summer, $SFC_{10}$ increased, then decreased from summer to autumn. A similar trend in $SFC_{10}$ was observed by Auldist *et al*. (1998). MacGibbon & McLennan (1987) reported a positive correlation between $SFC_{10}$ and the sectility hardness of butter, which reflects spreadability of the product. Butter made in summer would be harder and less spreadable than butter made in spring. The seasonal variation in the calculated $SFC_{10}$ (Tables 1 & 2) was similar to that observed by MacGibbon and McLennan (1987) for the seasonal variation in the hardness of New Zealand butter.

Conjugated linoleic acid (CLA) has in recent years received much attention because of reported anticarcinogenic properties (Parodi, 1999). Concentrations of CLA in milkfat varied throughout the season in a less consistent manner than those observed for the other fatty acids. For example, CLA concentrations increased through spring, declined in summer then increased again in autumn. The highest concentrations for the season were in October and April, which was similar to that reported by Auldist *et al*. (1998).

This study has shown that single fatty acids and fatty acid groups present in milkfat vary seasonally in a predictable manner. The seasonal variation was similar for primiparous and multiparous cows but in early lactation, milkfat from primiparous cows contained higher concentrations of preformed fatty acids than multiparous cows. Possible causes identified for seasonal variations in milkfat composition were: parity, level of feeding and time of year as influenced by stage of maturity of pasture. From an understanding of these seasonal effects and knowledge of critical components in milkfat affecting product functionality (physical properties and nutritive value), then products designed to meet specific purposes could be processed from milkfat at different times of the year.

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