

VARIATION IN MILK FAT CONTENT AND FATTY ACID COMPOSITION OF JERSEY AND FRIESIAN CATTLE

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SUMMARY

The milk fat content and fatty acid composition were determined from Jersey and Friesian cows ranging from mid to late lactation. Jersey milk ($5.7 \pm 0.3\%$) contained significantly more fat than Friesian milk ($4.5 \pm 0.3\%$) and Friesian milk was less saturated. Generally, the higher the milk fat content, the more saturated the fat. The activity of the Δ^9 -desaturase enzyme was not influenced by fat content so at any given fat content, Friesian milk was less saturated than Jersey. Hence the association of low unsaturated fat and high fat content was most likely due to low availability of the precursor of unsaturated fat; C18:0. Thus, in mid-late lactation cows alter rates of *de novo* synthesis of fat in the mammary gland rather than increasing the incorporation of fat from blood into milk.

Keywords: Milk, fatty acids, desaturase activity, Jersey, Friesian

INTRODUCTION

The content and composition of fat in milk are of great interest in human nutrition as they relate to infant growth and disease risk. They are also of interest to food processors due to their effects on the production and flavour of dairy products (Edwards, 1973). Consumers are now demanding low fat products which have a reduced saturated fat content due to reported health benefits of such products. Processors of dairy products could also benefit from altered milk fat composition, however the optimum composition would depend on the production purpose (e.g. cream, butter, yoghurt) (Gibson, 1991). It may be possible to alter milk composition by exploiting the natural variation in milk from cows differing in breed, age and stage of lactation and particularly by altering feed (Baer, 1991). Gibson (1991) suggested that there is sufficient genetic variation within and between breeds to effect significant changes in the fat content and fatty acid composition of milk.

With these facts in mind, it may be desirable to manipulate milk fat at the farm level so as to produce milk specifically for different markets which is more acceptable to consumers and more desirable to dairy processors. The general aim of this project was to investigate opportunities for improving the quality of milk fat. More specifically, the project aimed to elucidate any relationships between milk fatty acid composition and the breed, stage of lactation and age of the cow. The proportion of unsaturated fatty acids and chain length of milk fatty acids was studied to improve the understanding of the desaturation mechanisms in the mammary gland and to examine factors influencing the two major ways in which fat enters milk: *de novo* synthesis and plasma lipid incorporation.

MATERIALS AND METHODS

Milk samples were collected from 24 Jersey and 24 Friesian cows ranging from mid to late lactation (3-9 months) and of various ages (3-12 years). The cows were selected at random across the range of stages of lactation and ages. They were from a large commercial herd comprising many sire lines from both breeds. The samples were frozen (-20°C) and stored until laboratory analysis. The method used to extract fat from milk was adapted from the Roesse-Gottlieb Method in the AOAC Official Method of Analysis (1984). Fatty acids extracted from the milk samples were methylated using the method of Christie (1989) recommended for lipids containing medium chain length fatty acids. The fatty acid methyl esters were separated and quantified using a Hewlett Packard Gas Chromatograph (Model 5890A). The chromatograph was equipped with a flame ionisation detector and a capillary column (BP 20, length 50m, 0.32mm (I.D.), SGE Melbourne, Vic.). The carrier gas used was hydrogen (column head pressure 65kPa). A two stage program was used for milk fat analysis for each run. Stage 1 comprised 40°C (3 mins) initial temperature, 8°C/min increase and 160°C final temperature (3 mins). Stage 2 comprised 3°C/min increase and 208°C final temperature.

Results were analysed using a generalised linear model (Genstat V, 1992). The model for fat content contained breed (Jersey or Friesian) and stage of lactation (3-9 months) as fixed effects and age (3-12 years) and age² as covariables. The model for each of the fatty acids included breed and stage of lactation as fixed effects and age and fat content (2.4-10.5%) as covariables. Significance was defined as P<0.05 based on F-tests using type-1 SS.

To aid interpretation of the results, short and medium chain (C4:0-C16:1) and long chain (C18:0-C18:3) fatty acids were summed for comparison of methods of entry into the milk (*de novo* synthesis versus direct from blood respectively). Total saturated (e.g. C18:0) versus unsaturated (e.g. C18:1) were also evaluated. Lastly, an index of Δ^9 -desaturase activity was calculated as shown below. This index represents the proportion of C18:0 which has been converted by the enzyme Δ^9 -desaturase to C18:1(9).

$$\Delta^9\text{-desaturase index} = \frac{\text{C18:1}_{(9)}}{\text{C18:0} + \text{C18:1}_{(9)}} \times 100$$

RESULTS AND DISCUSSION

Breed effects. The fat content of Jersey milk (5.7±0.3%) was significantly higher than Friesian milk (4.5±0.3%). As shown in Table 1, breed differences were significant for some minor fatty acids (C14:1, C15:0 and C18:2) and one major fatty acid (C18:1(9)). The milk fat of Jerseys contained a smaller proportion of C18:1(9) than that of Friesians. This difference was reflected in total saturates: Jersey 73.1±0.1% versus Friesian 70.5±0.1%. The index of desaturase activity also reflected the difference in C18:1(9) where Friesian cows (60.9±0.9%) had a far higher activity (over 5 standard deviations) than Jersey cows (55.7±0.9%).

Table 1 The fatty acid composition (%) of milk fat from Jersey and Friesian cattle (least squares mean \pm standard error)

Fatty Acid	Jersey	Friesian	Significance
C4:0	1.4 \pm 0.2	1.3 \pm 0.2	.798
C6:0	1.3 \pm 0.1	1.3 \pm 0.1	.528
C8:0	1.0 \pm 0.1	1.1 \pm 0.1	.945
C10:0	2.7 \pm 0.1	2.8 \pm 0.1	.195
C12:0	3.5 \pm 0.1	3.4 \pm 0.1	.056
C14:0	12.4 \pm 0.3	12.3 \pm 0.3	.227
C14:1	0.8 \pm 0.1	1.2 \pm 0.1	<.001**
C15:0	1.46 \pm 0.05	1.52 \pm 0.05	.029*
C16:0	33.7 \pm 0.6	32.9 \pm 0.6	.093
C16:1	1.5 \pm 0.1	1.6 \pm 0.1	.422
C18:0	15.7 \pm 0.5	13.9 \pm 0.5	.055
C18:1 (9)	19.7 \pm 0.5	21.4 \pm 0.5	<.001**
C18:1 (7)	3.9 \pm 0.2	3.9 \pm 0.2	.051
C18:2	0.7 \pm 0.1	1.2 \pm 0.1	.004**
C18:3	0.4 \pm 0.5	0.3 \pm 0.5	.167

* P<0.05, ** P<0.01

Stage of lactation and age effects. Stage of lactation (month) was important for some of the minor fatty acids (C4:0, C10:0, C12:0 and C18:2), although overall, the average chain length and degree of saturation of milk fatty acids did not vary as lactation progressed. However, stage of lactation may have been more important if results from the first 2 months were included. Age effects were generally not important for specific fatty acids, with the exception being C18:1(7) which was lower in older cows. There was a significant quadratic relationship between age and fat content such that young and old cows had lower fat content than cows of intermediate ages.

Fat content effects. Fatty acid composition also varied with fat content. Again this was the case for some minor fatty acids (C8:0, C10:0 and C12:0) and C18:1(9) which decreased with increasing fat content. It is important to note that the index of Δ^9 -desaturase activity did not change with increasing fat content. Therefore the decrease in unsaturated fats with a high fat content was not due to a decrease in Δ^9 -desaturase activity, but was a result of decreased availability of long chain fatty acids (as short and medium chain fatty acids generally remained saturated). Also, at any given fat content, Friesian milk was less saturated than Jersey. This is demonstrated by the following equations.

Both breeds	Long chain fatty acid percentage = $41.1 - 0.20\text{fat}\%$
Jersey	Unsaturated fatty acid percentage = $27.5 - 0.19\text{fat}\%$
Friesian	Unsaturated fatty acid percentage = $28.1 - 0.19\text{fat}\%$

Note that the standard error on all regression coefficients was 0.09.

Thus, the increased fat content was NOT due to increased extraction of long chain fats from the blood. This phenomenon was also noted in a previous study by Bitman et al. (1995). In order to achieve high fat levels at the beginning of lactation however, cows must break down body fat stores and incorporate the mobilised long chain fatty acids into their milk. This was noted in other recent results which were complimentary to those reported here. Thus as expected, in the complimentary study, fat from cows producing milk of high fat content early in lactation was found to be rich in long chain fatty acids.

Overall, the present study suggests that in order to produce milk of high fat content from mid to late lactation, it appears that cows up regulate *de novo* synthesis in the mammary gland. As these fats can generally not be desaturated, the proportion of unsaturated fatty acids in milk decreases with an increase in milk fat content. In addition, the actual proportion of unsaturated fatty acids in milk varies between Jersey and Friesian cattle due to differing level of Δ^9 -desaturase activity between the two breeds.

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