Milk fatty acids in relation to feeding practices on Dutch organic farms

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***Abstract* -. Various recent studies have indicated positive interactions between organic animal production and poly-unsaturated fatty acids, particularly CLA and omega-3. In this paper, we present the monitoring results of 15 organic farms concerning the relationship between feeding practices and fatty acid pattern. The results indicate a strong negative effect of maize and grass silage and concentrate feeding on CLA levels in milk fat. On the other hand, feeding fresh grass has a positive effect. Omega-3 levels in milk fat seem less related to feed characteristics: similar relations to those with CLA seem to exist, but feed composition explains the variation in omega-3 levels only to a limited extent, while there is a large farm influence. This might be related to the energy balance of the cows. A comparison of measured CLA and omega-3 levels in organic milk with common levels in conventional milk shows a small difference during the stable period. Effects of adding oil - as a possibility to improve the level of CLA and omega-3 in a way that is organically acceptable - are explored, but effects remain small.[1]**

Introduction

Various recent studies have indicated possible positive interactions between organic animal production and poly-unsaturated fatty acids (PUFA), particularly conjugated linoleic acid (CLA) and omega-3 fatty acids. Thus, CLA and omega-3 are seen as possible distinguishing quality parameters for organic milk. Variations in CLA and omega-3 levels, however, seem to be high, indicating both the importance of other factors and possibilities for improvement. In this paper, we present the results of participatory research at 17 organic farms concerning the relationship between feeding practices and fatty acid pattern. The research formed part of a product development project in which LBI collaborated with a Dutch cheese factory (Aurora), to produce organic cheese with distinct levels of CLA and omega-3.

Materials and Methods

From June 2004 until August 2005 (with no samples during spring), milk samples were taken at 17 organic dairy farms located in the frontier area of the Netherlands and Germany, mainly on sandy soils. Feed practices in the week before milk sampling were recorded to establish the relation between feeding practices and fatty acid patterns in the milk.

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Feed ration composition was estimated based on farmers' estimations, combined with an assumed dry matter intake of 16 kg per day. General farm characteristics were recorded by questionnaire, but are excluded in the statistical analysis as models proved to be unreliable. The tests were carried out on frozen samples from raw (bulk) cow's milk by the Institute of Grassland and Environmental Research (IGER, UK) using the Kramer bimethylation method. Gas chromatography was used to reveal the full fatty acid pattern. Statistical analysis was performed with GenStat 7.2 on 105 samples of 15 farms of which sufficient, reliable data were available.

Results

Feed ration highly important for CLA, less for omega-3

In table 1, results are clustered according to season. As can be found in other studies, it is clear that CLA and omega-3 levels are higher during the grazing period compared to the winter period. This is likely to be caused mainly by differences in feed composition. However, the comparison between seasons gives little information on the nature and importance of the different feed characteristics as several parameters change simultaneously.

Table 1. Levels of CLA and omega-3 and feed ration composition per season.

	Summer	Autumn	Winter
Total CLA (mg/g milk fat)	10,3	11,0	6,5
Omega3 (mg/g milk fat)	11,2	10,6	9,4
	Percentage in ration		
Fresh grass	67	39	2
Red clover fresh	1	5	0
Concentrate	15	17	18
Grass silage	11	28	59
Maize silage	2	3	6
Whole grain silage	1	0	2
Red clover silage	2	7	10
Others	2	0	2
Added oil (g/day)	50	96	100

Initially, a stepwise multiple linear regression was performed to analyse the available data. In the case of CLA, the multiple regression model was satisfactory considering criteria such as Mallow Cp and R^2, if 8 factors were included. The final model, explaining 81% of the variance, included 'farms' besides 7 feed factors. 'Farms', however, contributed only 16% to

the explained variance, indicating a strong influence of the feed composition even though this could only be roughly estimated and did not include potentially important differences in roughage quality.
In the case of omega-3, the regression model was less satisfying. The final model could only explain 66% of the variation, while including a large 'farm'-effect (of 49%!). This suggests that the omega-3 level in milk fat is less feed-related than the CLA-level. However, the model could not explain some high values, as they seem to relate to factors that had too few observations. For example, one farm, with Jersey cows on a very low concentrate feed ration and young grass with high levels of white clover, attained omega-3 levels between 10.4 and 18.3 mg/g fat, while farms with botanically rich swards also showed higher omega-3 levels.
In tables 2 and 3, results are listed of an analysis of single feed factors combined with a forced 'farm' factor. This gives a first indication of the importance and the type of influence of each feed factor. Further statistical analysis may well refine these conclusions.

Factors influencing CLA
From table 2, it may be concluded that fresh grass has a major positive effect on the CLA-level, particularly as it is interlinked with the percentage of grass silage, which has a similar negative effect. Although the predictions are less reliable, this analysis also shows strong positive and negative effects of feeding red clover, maize silage and concentrate respectively. This is consistent with most literature, although the magnitude is higher than expected.

Table 2. Factor analysis of CLA (with forced inclusion of farm as grouping factor).

	Explained variance (R^2)	Estimated effect per 10% in the ration (mg per g fat)
Fresh grass	61	0.58
Grass silage	49	- 0.61
Maize silage	41	- 2.39
Concentrate	31	- 2.79
Red clover fresh	26	1.70

Factors influencing omega-3
From table 3, it may be concluded that both concentrate and maize silage have a relatively strong negative effect, while fresh grass and red clover have a rather small positive effect. The relatively high influence of concentrate combined with the observation of high omega-3 levels with Jersey cows on a low energy feed ration, however, also indicates that not the feed composition as such but mainly the energy balance of the animals may be an important factor influencing the omega-3 level. This is consistent with the results of Leiber (2005) studying the influence of Alpine roughages (compared to lowland grass and silage). He also found high levels of omega-3 if cows had a negative energy balance.

Table 3. Factor analysis of CLA (with forced inclusion of farm as grouping factor, explaining most of the variance).

	Explained variance (R^2)	Estimated effect per 10% in the ration (mg per g fat)
Fresh grass	62	0.31
Concentrate	53	- 1.65
Maize silage	52	- 0.79
Grass silage	58	- 0.32
Red clover fresh	48	0.49

DISTINGUISHABLE ORGANIC QUALITY

Added oil to improve CLA levels in organic milk
CLA and, to a lesser extent, omega-3 levels in organic milk during the winter period (table 1) are only slightly higher than in conventional milk (with levels usually between 4 and 6 respectively 5 and 8 mg/g). Therefore, possibilities to improve the level of CLA and omega-3 in a way that is organically acceptable were explored. In early 2005, 8 farms added extra sunflower or linseed oil (with levels varying between 80 and 220 g/cow/day) to a feed ration that was as constant as possible. This resulted in an increase of 1 mg CLA per 100 mg added oil (n=31; 82% of the variance being explained if 'farms' was added as a factor), while omega-3 levels only increased at one farm where linseed oil was used. This is a relatively small effect compared to the difference between grazing and stable period. Higher levels of added oil proved to cause severe fat depression.

Holistic quality parameters: an option?
Using PUFA's as a single distinguishing quality parameter for organic milk is a risky strategy: conventional agriculture can ultimately achieve much higher levels of for instance omega-3 - up to >200 mg per g fat by using rumen protected fatty acids (Scollan et al., 2005). Moreover, a single quality parameter like CLA or omega-3 hardly reflects organic intentions to produce quality in a more holistic way, being an inherent reflection of proper agricultural practices. Therefore, we have also started to monitor the development of two alternative analytical methods such as biophotons and bio-crystallisations. Both analytic methods relate to the hypothesis stating that the structure (the 'order') of food is just as important to human health as the material composition. Exploratory research into differences in raw (bulk) cow's milk, comparing milk from organic and conventional farms, has shown that organic milk has systematically more 'order': it has a better 'ordered structure' and better 'integration and coordination' (Adriaanse-Tennekes et al., 2005). A full analysis of current results is still in progress.

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