Feed composition and strategies to improve poly-unsaturated fatty acid levels in organic cow milk

De Wit, J. & de Vries, A.[1]

Key words: omega-3, CLA, grass pellets, roughage quality.

Abstract

Like in various other countries, organic milk in the Netherlands has higher levels of poly-unsaturated fatty acids, particularly CLA and omega-3, than conventional milk. Monitoring results from a total of 25 farms between 2004 till 2007 are presented. Regression analysis indicates a negative effect of maize silage and positive effects of feeding fresh grass, grass pellets, red clover and addition of oil on CLA levels in milk fat. Results with omega-3 are similar, but omega-3 levels in milk fat seem less related to feed characteristics: the model with feed composition, seasonal effects and farm effects as major parameters, explains a smaller part of the variation, while farm influence is much larger with omega-3 compared to CLA.

Farm influence might be caused by genetic differences and constant factors influencing roughage quality. Genetic influences are likely but could not be investigated as milk samples were not taken from individual cows. The influence of grass quality is suggested by the large effect of sampling date found in this study. Moreover, some high residual values and statistical estimates for individual farms seem often related to silage quality, botanically rich pastures and red clover feeding.

Introduction

Poly-unsaturated fatty acids (PUFA), particularly conjugated linoleic acid (CLA) and omega-3 fatty acids are increasingly recognized for their beneficial health impact. Similar to other countries (Butler et al, 2007), there are considerable differences in CLA and Omega-3 levels between organic and conventional milk the Netherlands. On average omega-3 and CLA levels were 60 and 38% respectively, higher in organic milk, with lowest levels during winter (Slaghuis & de Wit, 2007).

Variations in CLA and omega-3 levels, however, are high. Highest levels appear with fresh grass utilization and the addition of rumen protected oil, the latter technology now being used to produce conventional milk with higher levels of omega-3 fatty acids (www.campina.com). This urges for organic dairy producers to improve the levels of beneficial fatty acids in organic milk, particularly during winter. To facilitate this, a participatory research programme concerning the relationship between feeding practices and fatty acid pattern at Dutch organic farms was started in 2004. In this paper, we present the results of this research that started as part of a product development project together with a Dutch cheese factory (Aurora), to produce organic cheese with distinct levels of CLA and omega-3. Later, it became part of the governmental supported research for organic agriculture in the Netherlands (see www.biokennis.nl).

[1] Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, the Netherlands. Email j.dewit@louisbolk.nl. Internet www.louisbolk.nl

Materials and methods

From June 2004 until September 2007, bulk milk samples were taken at variable intervals at a variable number of organic dairy farms, on average 15 farms. In total 415 samples were analysed from 25 farms. Samples were taken both at regular intervals as well as shortly before and two weeks after an interesting change in feeding ration, as un-replicated trials at farm level. Farms were selected to include as much variation as possible in feeding pattern, breeds, soil and farm type. Feed practices in the week before milk sampling were recorded by questionnaire. Feed ration composition was assessed based on farmers' estimations, combined with an assumed dry matter intake of 16 and 15 kg per day during summer and winter respectively, and a replacement rate of 0.5 resp. 0.4 kg DMI per kg concentrate in summer resp. winter. The tests were carried out from raw bulk milk by IGER (UK) on frozen samples till June 2005 and by COKZ (Netherlands) using fresh samples using the Kramer bimethylation method. In the analysis only rumen acid (C18:2 c9, t11) is taken as CLA, while omega-3 includes α-linolenic acid (C18:3 c9,12,15), EPA (C20:5, c5,8,11,14,17) and DHA (C22:6 c7,10,13,16,19). Statistical analysis was performed with GenStat 9.1 (2006), using the stepwise multiple linear regression procedure.

Results and discussion

Results are clustered according to season in table 1. CLA and omega-3 levels in this research are 1 resp. 1.5 - 2 mg per g milk fat higher compared with averages of Dutch organic milk (Slaghuis & de Wit, 2007), as a result of the farm selection process, which also resulted in relatively high levels of added oil (in the form of pure oil or included in oil rich residues). However, a comparison between seasons provides little information on the nature and importance of the different feed characteristic as several parameters change simultaneously.

Tab. 1: Means of CLA and omega-3 samples and ration composition per season

	Summer (n=208)	Autumn (n=78)	Winter (n=129)
CLA (mg/g milk fat)	9.51	8.86	5.60
Omega-3 (mg/g milk fat)	11.06	10.83	10.32
	Percentage in ration		
Concentrates	14	16	18
Grass pellets	1	2	3
Fresh grass	63	35	1
Grass silage	13	33	61
Maize silage	3	3	5
Whole grain silage	0	0	1
Red clover	2	7	10
Other roughages	2	3	2
Added oil (g/day)	38	50	78

Statistical data analysis gave a feasible model including only significant factors ($p<0.05$), explaining 74.5 resp. 62.1% of the variance for CLA and omega-3. The model included a constant factor (estimated at 6.6 resp. 11.48 mg CLA and omega-3 per g fat), feed ration components (see table 2; contributing 12 resp. 15.1% to the explained variance of CLA and omega-3), an effect of sampling date expressed as calendar week number in the year (see figure 1, contributing 48.3 resp. 11.7%), a small effect of year, and a farm effect (contributing 38.2 resp. 68.9%).

Tab. 2: Estimated contributions of feed components to CLA and omega-3 in milk fat (as mg per g milk fat per kg DM)

	CLA (mg/g milk fat)	Omega-3 (mg/g milk fat)
Added oil	9.61	5.71
Grass pellets	0.29	0.74
Fresh grass	0.33	Not incl.
Maize silage	- 0.23	- 0.25
Red clover	0.24	0.21
Whole grain silage	Not incl.	- 0.70

Concerning the influence of feed components, the effects of red clover, maize silage, oil and fresh grass intake are consistent with literature (e.g. Chillard & Ferlay, 2004; Elgersma et al, 2006). The positive effect of red clover seems to be related to specific plants components and/or higher levels of PUFA's in clover. Both aspects of red clover seem highly variable (e.g. Vanhatalo et al, 2007), which is coherent with the variable effects of red clover in this research. The positive effect of feeding grass pellets might be related to increased rumen passage and thereby reduced bio hydrogenation (see e.g. Cabrita et al, 2007) as well as to higher levels of PUFA's in the grass as oxidation between harvesting and conservation is limited. The effects of grass pellets in this research are not constantly high, probably due to differences in original grass quality and time span between mowing and pelleting. The highly negative effect of whole grain silage might be an artefact, due to the low number of values (30) on which this estimate is based, but it might also be due to the high level of NDF inducing slow rumen passage and thus increased bio hydrogenation.

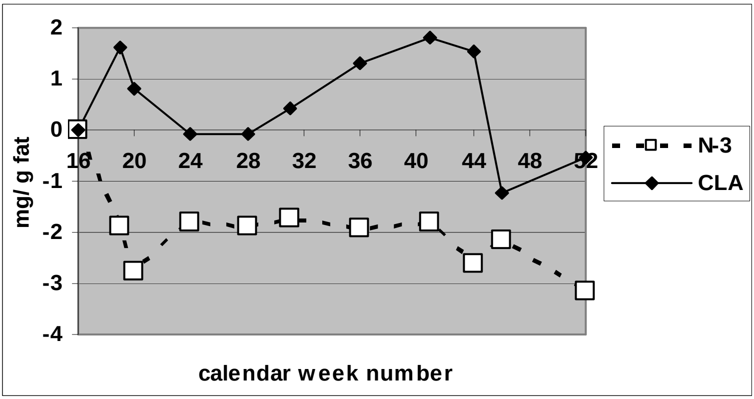

Figure 1: Estimated influence of week on level of omega-3 and CLA

The large effect of sampling date (see figure 1) indicates strong seasonal influences, probably related to grass quality. For omega-3, particularly week 16, when cows are grazing very young grass, is high compared to the other periods, with smaller negative estimates for week 20, when grass is maturing, and winter (week “52” includes all winter values), when silage is fed with lower PUFA levels compared to fresh grass. For CLA, higher levels appear in spring and in autumn, mainly related to young leafy grass in spring and a growth flush of grass in autumn 2006 respectively.

Also, some unexplained high individual values and part of the large farm effect in the model seem related to feed quality factors such as the botanical composition of pastures, red clover feeding and silage conservation strategies (mowing at mature stages or ensiling with high dry matter content). In depth study in 2007, in which additional feed quality information of the grass silage and fresh grass was obtained, did not reveal a clear influence of feed quality on milk fatty acid composition. This disappointing result might be caused by the limited number of samples (n=37), as well as differences between sampling and ingested feed (due to selection or deterioration of the silage during feeding).

The large farm effect might also be caused by genetic influences. Important breed effects appear unlikely in this research, but differences between individual cows of the same breed haven proven to be large (Elgersma et al, 2006) and seem genetically based (van Arendonk, unpublished). This could not be proven in this research as no individual milk samples were analysed.

Conclusions

Feed has a large influence on beneficial fatty acids levels in milk, even though feed components could explain only part of the variance in the bulk milk samples analysed in this research. Part of the large seasonal and farm effect, as well as some high individual residual values seem related to silage quality, red clover feeding and grazing botanically rich pastures. If organic dairy farms want to strengthen their distinguishable position, also vis-à-vis conventional milk with enhanced levels of beneficial fatty acids, they can best opt for using grass pellets as concentrate, red clover, maximum use of fresh grass and/or some oil supplements. The influence of other measures influencing roughage quality could not be convincingly proven.

References

Butler, G., Stergiades, S., Eyre, M., Leifert, C., Borsari, A., Canaver A., Slots, S., Nielsen, J.H. (2007): Effect of production system and geographic location on milk quality parameters. In Niggli, U., Leifert, C., Alföldi, T., Lück, L., Willer, H. (eds.): Improving sustainability in organic and low input food production systems, FiBl, Frick, Switzerland, p.100-103.

Cabrita, A.R.J., Bessa, R.J.B., Alves, S.P., Dewhurst, R.J., Fonseca, A.J.M. (2007): Effects of dietary protein and starch on intake, milk production and milk fatty acid profiles of dairy cows fed corn silage-based diets. J. of Dairy Science 90: 1429-1439.

Chillard, Y., Ferlay, A. (2004): Dietary lipids and forage interactions on cow and goat milk fatty acid composition and sensory properties. Reprod. Nutr. Dev. 44: 467-492.

Elgersma, A., Tamminga, S., Ellen, G. (2006): Modifying milk composition through forage. Animal Feed Science and Technology 131: 207–225

GenStat© (2006). Lawes Agricultural Trust, Rothamsted Experimental Station, UK.

Vanhatalo, A., Kuoppala, K., Toivonen, V., Shingfield, K.J. (2007): Effects of forage species and stage of maturity on bovine milk fatty acid composition. Eur. J. of Lipid Sc. and Techn. 109: 856-867.

Slaghuis, B., de Wit, J., 2007. Productkwaliteit zuivel: verschil tussen biologisch en gangbaar. ASG-report 23, WUR/LBI, Lelystad, Netherlands, 14p.