Effect of feeding system on cow milk fatty acids composition in a panel of Galician dairy farms

Resch-Zafra C.[1], Pereira-Crespo S.[2], Flores-Calvete G.[1], Dagnac T.[1], Gónzalez L.[1], Agruña M.J.[2], Fernández-Lorenzo B.[1] and Veiga M.[1]

[1]Centro de Investigacións Agrarias de Mabegondo, P.O. Box 10, 15080 A Coruña, Spain; [2]Laboratorio Interprofesional Galego de Análise do Leite, Mabegondo, 15318 Abegondo, A Coruña, Spain

Abstract

Sixty farms located in the Galicia region (NW Spain) were sampled four times during 2012 and samples of ration ingredients and bulk-tank milk were taken with the objective of studying the relationships between dairy cow ration and the fatty acid (FA) composition of the milk. Diets were grouped into five clusters based on ration ingredients and significant differences among clusters were observed for saturated, polyunsaturated, omega-3 and conjugated linoleic fatty acids, as well as for the omega6-omega3 ratio. In general, milk from grazing extensive systems and from intensive systems based on silage and concentrates supplemented with extruded linseed showed the highest contents of human-health FA. The ability of FA-based discriminant functions for assigning farm tank milk samples to a particular diet was deemed as not satisfactory.

Keywords: authentication, pasture, silage, linseed supplement, milk, fatty acids

Introduction

There is currently an increased consumer demand for information related to consumption of functional foods that may exhibit health benefits beyond their nutritional value. Actual studies focus their efforts on feeding strategies to obtain dairy milk low in saturated fatty acids (SFA), high in polyunsaturated FA (PUFA), low omega6/omega3 ratio and increased levels of certain functional molecules like conjugated linoleic acid (CLA) that matches the actual human-health requirements and which also has a higher market value. The objective of this work was to define ‘typical diets’ fed on Galician dairy farms and to explore the relationship between diet and fatty acid (FA) composition of the milk, as well as to evaluate the capacity of FA profile for tracing the feeding origin of milk.

Materials and methods

This work was performed on a panel of sixty dairy farms in Galicia (NW Spain) with different levels of intensification. The farms were visited four times (once every three months) during the year 2012. At each visit, an alimentary survey was made that recorded the composition of the diet being consumed by the lactating dairy cows and samples of feed ingredients and bulk tank milk were taken. Diet composition was expressed in terms of percentage of each component of the ration in the total dry matter intake (DMI) by the cows. In the case of grazing animals, pasture intake was estimated as the difference of the DMI and the total dry matter of the ration consumed indoors. DMI (kg d^{-1}) was estimated following the expression DMI = 5.5 + 0.33Y + 0.01LW, where Y is milk yield (l d^{-1}) and liveweight (LW) was fixed as 650 kg. FA composition of milk-tank samples was determined by gas chromatography.

Finally, a data set of 158 observations with diet composition and FA profile was obtained. A cluster analysis of diet data was performed (Proc Cluster of SAS) followed by stepwise discriminant analysis (Proc Stepdisc of SAS) to identify which individual FA showed a better discriminant power for the different clusters, after which discriminant functions for the diet types were constructed (Proc Discrim of SAS) using the selected FA as independent variables. The ability of these functions to correctly assign the diet origin of a given milk sample was checked and ANOVA analysis was performed on clusters diet composition and representative FA profile, after the transformation of the percentage data by means of the arcsine function.

Results and discussion

Five typical diets were identified by cluster analysis based on the composition of dominant forage source in the ration (grazed pasture, grass silage, maize silage, dry forages, by-products, concentrate) and the use or not of linseed as a concentrate supplement (Table 1). Clusters were identified as: pasture (P) where approximately 50% of DMI was fresh pasture; maize and grass silage (MS+GS), where maize and grass silages accounted by 34 and 22% DMI, respectively; GS, where this forage represented 51% DMI; linseed supplemented maize and grass silages (MS+GS+L), where extruded linseed was almost 3% DMI, and grass silage with by-products (GS+B), where dominant forage was grass silage as in cluster 3 with 9% DMI as by-products (sugar beet pulp). Significant differences among clusters were detected ($P<0.0001$) for the main ingredients of the rations.

SFA percentage was significantly lower ($P<0.0001$) in linseed diets and the highest values were found in the GS+B diets. Linseed and pasture diets showed the highest percentage values for PUFA, omega-3 FA and CLA, whilst unsupplemented maize silage-dominant diets (MS+GS) showed the highest omega-6/omega-3 ratio ($P<0.0001$). The better performance of pasture diets, compared with silage and dry forage diets has been observed by other authors, for example Rouillé and Montourcy (2010) in French dairy farms. In general, milk from extensive systems which include fresh pasture in the diet and from intensive systems based on silage and concentrates supplemented with extruded linseed showed the least-saturated and highest-unsaturated FA profile, which is in accordance with the observations of other authors (Dhiman *et al.,* 1999; Palmquist *et al.*, 1993).

Alpha-linolenic acid ($P<0.0001$), palmitic acid ($P<0.0001$), conjugated linolenic acid ($P<0.0001$), SFA ($P=0.0021$) and myristic acid ($P=0.0068$) were the FA showing the highest discriminant capacity for the five types of diet. Discriminant functions for assigning milk samples to one of the diet types are shown in Table 2. The cross-validation process showed that the percentage of success obtained in the

Table 1. Diet composition and milk fatty acids (FA) composition by cluster.

	Cluster of diet[1,2]					*P*-value
	P (n=48)	MS+GS (n=38)	GS (n=22)	MS+GS+L (n=38)	GS+B (n=12)	
Diet composition (% of each ingredient in total dry matter intake)						
Pasture	45.7[a]	0.94[c]	13.6[b]	2.2[c]	11.4[b]	<0.0001
Grass silage	8.0[d]	21.9[c]	50.5[a]	23.2[c]	35.0[b]	<0.0001
Maize silage	13.9[b]	33.7[a]	1.4[c]	33.0[a]	8.5[b]	<0.0001
Dry forages	9.6[a]	3.6[b]	6.3[ab]	4.7[ab]	8.9[a]	0.0117
By-products	0.3[b]	0.0[b]	0.2[b]	0.0[b]	9.3[a]	<0.0001
Concentrate	22.1[c]	39.6[a]	27.5[b]	33.8[a]	26.9[b]	<0.0001
Extruded linseed	0.1[b]	0.0[b]	0.1[b]	2.9[a]	0.0[b]	<0.0001
Milk fatty acids composition (% total FA unless stated otherwise)[2,3]						
Saturated FA	67.4[bc]	68.0[b]	68.3[ab]	65.8[c]	69.9[a]	<0.0001
PUFA	4.55[a]	4.07[b]	4.03[b]	4.69[a]	4.07[b]	<0.0001
Omega-3 FA	0.88[b]	0.61[d]	0.79[bc]	0.97[a]	0.75[c]	<0.0001
CLA	0.87[a]	0.55[c]	0.68[bc]	0.78[ab]	0.62[c]	<0.0001
Omega-6/-3 ratio	3.3[b]	5.0[a]	3.4[b]	3.0[b]	3.6[b]	<0.0001

[1] P = pasture, MS = Maize silage; GS = Grass silage; L = Linseed supplement; B = by-products.

[2] Means within the same row which are followed by the same letter are not significantly different by Duncan's multiple-range test.

[3] PUFA = polyunsaturated fatty acids; CLA = conjugated linoleic acid.

Table 2. Discriminant functions for each type of diet (top) and percentage of observations assigned to the correct diet (bottom) based on their fatty acid (FA) composition.

Discriminant functions	Cluster of diet[1]				
	P	MS+GS	GS	MS+GS+L	GS+B
Intercept	-820.5	-798.2	-835.0	-786.0	-832.7
α-linolenic acid	4.7	-2.3	3.4	8.1	3.5
Palmitic acid	-17.9	-18.1	-18.3	-18.1	-17.8
Conjugated linolenic acid	126.6	122.6	125.6	120.1	125.1
Total saturated fatty acids	-59.6	-59.5	-61.7	-57.7	-60.4
Myristic acid	42.0	41.8	42.8	41.3	42.3
Initial group	**Assigned group**				
	P	MS+GS	GS	MS+GS+L	GS+B
P	58	7	19	6	10
MS+GS	5	63	11	8	13
GS	10	10	65	0	15
MS+GS+L	5	0	5	84	5
GS+B	16	0	29	0	55

[1] P = pasture, MS = Maize silage; GS = Grass silage; L = Linseed supplement; B = by-products.

assignation of a given milk sample to the correct diet, when applying the discriminant equations, was low. As can be seen, only 58% of milk samples from the pasture group were correctly assigned to that group. Similarly, only 63, 65, 84 and 55% of the samples initially in MS+GS, GS, MS+GS+L and GS+B groups, respectively, was correctly assigned. This shows that using milk FA composition as the only tool for tracing the dietary origin of tank milk samples from dairy farms is not good enough to be used in practice, which is in concordance with the findings of Capuano *et al.* (2014).

Conclusions

It was possible to define five 'typical diets' in Galician dairy farms based mainly on the predominant forage in the ration. A clear relationship between diet and FA profile of dairy milk was observed. 'Pasture' and 'linseed supplemented' diets type showed a more healthy FA profile. The potential of FA for tracing the dietary origin of tank milk samples from dairy farms seems to be not sufficiently reliable.

References

Capuano E., Van der Veer G., Boerrigter-Eenling R., Elgersma A., Rademaker J., Sterian A. and Van Ruth S.M. (2014) Verification of fresh grass feeding, pasture grazing and organic farming by cows farm milk fatty acid profile. *Food Chemistry* 164, 234-241.

Dhiman T.R., Anand G.R., Satter L.D. and Pariza, M.W. (1999) Conjugated linoleic acid content of milk from cows fed different diets. *Journal Dairy Science* 82, 2146-2156.

Palmquist D.L., Beaulieu A.D. and Barbano D.M. (1993) Feed and animal factors influencing milk fat composition. *Journal Dairy Science* 76, 1753-1771.

Rouillé B. and Montourcy M. (2010) Influence of French dairy feeding systems on cow milk fatty acid composition. *Grassland Science in Europe* 15, 619-621.