Session 39 – Abstract n° 7387

Fatty acid composition of conventional milk related to the diet in seventeen farms in France

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Abstract

The aim of this study was to identify different fatty acid (FA) composition of dairy cow milk in some French feeding systems. Seventeen farms from six regions were selected. Milk samples and a description of the diet were collected at five periods between May 2008 and February 2009 (May, July, September, January and February). Five milk classes were identified regarding milk FA profile ($P<0.001$). Diets associated to milk classes were described and analysed through percentages of all the forages and the concentrates.
Fatty acid composition of milks produced by the grazed grass diets are statistically different (*P<0.001*) from milks from other diets [milk richer in polyunsaturated fatty acids (PUFA). in *trans* fatty acids (*trans* FA). and with a lower omega-6/omega-3 ratio]. Increasing the percentage of grass in the diet induces variations on (i) PUFA, monounsaturated fatty acids (MUFA) (increase), (ii) saturated fatty acids (SFA), omega-6/omega-3 ratio (decrease). According to their FA composition, the results show a strong link between the fatty acid profile and the diet. Milks obtained with hay based diets have a low ω6/ω3 ratio but a high SFA share. Grass-based diets produce milks with better nutritional profile. It is particularly obvious for pasture-based diets. The results are totally different when the diet is based on maize silage.

Introduction

The diversity of milk fatty acids (FA) induces a high interest of milk fat for human nutritional issues. However, milk fat does not have a good reputation in human nutrition due to its relative richness in satured FA (SFA). However, increasing mono-unsatured FA (MUFA), poly-unsatured FA (PUFA) and decreasing omega-6/omega-3 ratio under five are goals to improve milk quality according to nutritionists. Dairy cows diet is an efficient. fast and reversible way to modify milk composition. Nutritional and sensorial qualities of milk depend on this composition. Effects of different forages and concentrates are now well-known. As actions to improve milk fatty acid composition are well established. the main issues are to identify different milk composition and to develop diets that lead to an adapted milk composition regarding consumer's needs. The goal of this study is to characterise different milk fatty acid composition in relation with different diets in some French feeding systems.

Materials and methods

From May 2008 to February 2009, five samples of milk (0.15 L per sample) were made in

seventeen farms. leading to a pool of eighty five samples. The farms were chosen to be different according to the feeding system and to be representative but non-exhaustive of the French systems diversity. They were located in mountains areas (6). in plains with grass dominance (5) and in plains with maize dominance (6). Each sample was coupled with a description of the diet. Frozen samples were analysed in a professional laboratory using a gas-chromatography method leading to the separation of fifty eight fatty acids.
Data from diet surveys were verified and corrected if necessary using herds. forages and concentrates characteristics. The pasture intake was estimated from the information given by the farmers. the intake of forages and concentrates.
The analysis on milk fatty acids composition was made with a principal component analysis (PCA) method using SPAD software. Differences between milk quality classes were tested by a variance analysis. as well as differences between diets associated to milk classes.

Results and discussion

The eighty-five milk samples were statistically separated into five classes. The most significant parameters were SFA, MUFA, PUFA, *trans* FA, omega-3 and omega-6 percentages and omega-6/omega-3 ratio (P<0.001).

Class	***C1***	***C2***	***C3***	***C4***	***C5***	***SD***	***P***
n	9	17	12	32	15		
Milk FA composition (% of total FA)							
SFA	62.50^{c}	66.25^{b}	67.11^{b}	71.71^{a}	71.84^{a}	3.54	P<0.001
MUFA	31.16^{a}	28.80^{b}	28.77^{b}	24.57^{c}	23.90^{c}	2.93	P<0.001
PUFA	4.96^{a}	3.86^{b}	3.24^{c}	2.92^{d}	3.29^{c}	0.72	P<0.001
Trans FA	7.87^{a}	4.81^{b}	3.77^{c}	2.76^{d}	2.76^{d}	1.72	P<0.001
ω3	1.03^{a}	1.00^{a}	0.58^{c}	0.39^{d}	0.83^{b}	0.30	P<0.001
ω6	2.20^{b}	2.51^{a}	2.49^{a}	2.66^{a}	2.20^{b}	0.40	P<0.001
ω6/ω3	2.21^{c}	2.57^{c}	4.45^{b}	7.22^{a}	2.75^{c}	2.43	P<0.001
Short FA	9.71	10.37	10.20	10.37	11.04	1.79	NS
Medium FA	45.26	47.40	49.90	51.29	54.98	8.85	NS
Long FA	43.65^{a}	41.13^{b}	39.01^{c}	31.32^{d}	33.01^{d}	7.16	P<0.001
Diet composition (%)							
Concentrates	18.84^{b}	19.55^{b}	22.00^{b}	27.48^{a}	24.05^{ab}	6.40	P<0.001
By-products	0.00^{b}	0.00^{b}	4.42^{a}	4.43^{a}	1.67^{ab}	5.16	P<0.05
Maize silage	3.48^{c}	20.87^{b}	30.63^{b}	50.48^{a}	6.92^{c}	24.13	P<0.001
Hay	5.70^{cd}	13.13^{b}	3.09^{d}	7.35^{c}	48.47^{a}	22.92	P<0.001
Grass silage	0.00	8.00	10.97	7.15	16.30	16.84	NS
Grazed grass	71.98^{a}	38.45^{b}	27.89^{b}	3.11^{c}	2.60^{c}	27.70	P<0.001
Total grass	77.68^{a}	59.57^{a}	41.95^{b}	17.60^{c}	67.37^{a}	28.73	P<0.001

Table 1 : composition of milk fatty acid classes and associated diets

- Milk class #1 (n=9) is characterised by a low percentage of SFA (62.5%) and high percentages of MUFA (31.2%), PUFA (4.96%), *trans* FA (7.87%) and omega-3 (1.03%). The low percentage of omega-6 (2.20) leads to a low omega-6/omega-3 ratio (2.21). This class is considered as the most interesting milk concerning nutritional issues.
- Milk class #4 (n=32) has an opposite composition compared to milk class #1. This class presents a high percentage of SFA (71.7%) and low percentages of MUFA (24.6%), PUFA (2.92%), *trans* FA (2.76%) and omega-3 (0.39%). The omega-6/omega-3 ratio is high (7.22) due to a high percentage of omega-6 (2.66%).

- Milk classes #2 (n=17) and #3 (n=12) are between class #1 and class #4 concerning milk fatty acid profiles. They contain respectively 66.3% and 67.1% of SFA, 28.8% of MUFA for both classes, 3.86% and 3.24% of PUFA, 4.81% and 3.77% of *trans* FA, 1.00% and 0.58% of omega-3. Omega-6/omega-3 ratio is 2.57 for class #2 and 4.45 for class #3.
- Milk class #5 (n=15) is particular as it contains a high percentage of SFA (71.8%) but also a low omega-6/omega-3 ratio (2.75). This is due to a relatively high percentage of omega-3 (0.83%) and a low percentage of omega-6 (2.20%). MUFA and trans FA percentages are low (23.0% and 2.76% respectively). PUFA percentage is 3.29%. which is a medium value.

Although the selected farms do not represent the whole French diversity, the results clearly show that different milk qualities exist regarding fatty acid composition. Improvement of this issue is possible using diet changes in order to go towards class #1 fatty acid profile.

Diets associated to the five milk classes were described and analysed. Each component of the diet represents a percentage of the global intake. Six factors were used to classify the diets: percentages of grazed grass (GG), grass silage (GS), hay (H), maize silage (MS). by-products (BP) and concentrates (CC). Diets parameters are also statistically different ($P<0.001$). except for the percentages of BP ($P<0.05$) and GS (ns).

- Diet #1 (milk class #1) is composed of 72.0% of GG, 5.7% of H, 3.5% of MS and 18.8% of CC in average. This class clearly regroups pasture diets.
- Diets #2 (milk class #2) and #3 (milk class #3) are respectively composed of 38.5 and 27.9% of GG, 8.0 and 11.0% of GS, 13.1 and 3.1% of H, 20.9 and 30.6% of MS, 0.0 and 4.4% of BP, 19.1 and 22.0% of CC. The two diet classes represent transition diets from winter to spring period and from autumn to winter period in the French feeding systems. Diets #2 and #3 are also used during winter period as they associate MS and different forms of grass.
- Diet #4 (milk class #4) is a typical diet based on MS. It contains in average 3.1% of GG, 7.2% of GS, 7.4% of H, 50.5% of MS, 4.4% of BP and 27.5% of CC.
- Diet #5 (milk class #5) contains 2.6% of GG, 16.3% of GS, 48.5% of H, 6.9% of MS, 1.7% of BP and 24.1% of CC. This diet is much utilized in mountain grass-based system during winter time.

Milk classes and diets associated to them establish strong relations between the use of GG and a good fatty acid profile regarding milk FA composition. Improvement of a MS dominant diet is possible by increasing the percentage of GG. GS and/or H during the winter period when it is possible. H diets (#5) are very specific as they contain a high percentage of SFA but also a low omega-6/omega-3 ration. These results clearly establish that milk produced from grass-based diets and especially from pasture-based diets contained higher amounts of health promoting FA than milk from maize silage-based diets. Variations in fatty acid composition over the year exist because of the succession of different diets at different periods.

Conclusion

This study shows the large diversity of milk fatty acid composition existing in France. It also underlines efficient. fast and reversible diet solutions to improve milk regarding health promoting FA. This leads to possible technical advices on feeding systems and strategies during a whole year if the main goal is to improve milk quality (at least FA).