Milk Fatty Acids Predicted by Mid-infrared Spectroscopy in Mixed Dairy Herds

Paolo GOTTARDO (✉)
Francesco TIEZZI
Mauro PENASA
Valentina TOFFANIN
Martino CASSANDRO
Massimo DE MARCHI

Summary

Over the last years, healthy food has gained interest among consumers, especially with regard to the fat content of livestock products which has been associated to the risk of cardiovascular diseases. Individual milk samples (n = 12,624) of 2,977 Holstein-Friesian (HF), Brown Swiss (BS) and Simmental (SI) cows from 39 multibreed herds were analyzed for fat content, protein content, casein content and somatic cell count using mid-infrared spectroscopy (MIRS). Daily milk yield was also recorded. Groups of fatty acids (FA), expressed as percentage of milk fat, were predicted by MIRS: they were saturated (SFA), unsaturated (UFA), monounsaturated (MUFA) and polyunsaturated (PUFA) FA. Data were analyzed with a linear mixed model including the fixed effects of month of sampling, parity, days in milk (DIM), herd, breed, and interactions between parity and breed, and DIM and breed. The random effects were cow nested within breed and residual. Milk of HF cows exhibited the lowest percentage of SFA (70.45%) and the highest of UFA (31.20%), and milk of SI cows was intermediate between that of HF and BS breeds for all groups of FA. The values of groups of FA across DIM were similar for the different breeds. Results from this study indicate that, under similar environmental and management conditions, milk of HF exhibits better FA profile than milk of BS and SI.

Key words

milk fatty acid, multibreed dairy herd, mid-infrared spectroscopy

[1] Department of Agronomy, Food, Natural resources, Animals and Environment (DAFNAE), University of Padova, Viale dell'Università 16, 35020 Legnaro (PD), Italy
✉ e-mail: paolo.gottardo.1@studenti.unipd.it

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Aim

The aim of this study was to estimate the breed effect on milk fatty acids (FA) predicted by mid-infrared spectroscopy (MIRS) in multibreed dairy herds of Holstein Friesian (HF), Brown Swiss (BS) and Simmental (SI) cows.

Material and methods

Since January 2011 the laboratory of the Breeders Association of Veneto Region (Padova, Italy) has been analyzing FA composition of milk samples collected during the official monthly test-day milk recording scheme. Thirty-nine multibreed herds of HF, BS and SI cows were selected. Herds were required to rear at least two of the aforementioned breeds. Moreover, the breed contribution within each herd was calculated and the most represented breed was required to account for at most 90% of total heads within the herd. At the same time, the less represented breed was imposed to have at least 5 cows controlled within each herd. A total of 12,624 milk samples belonging to 2,977 cows were selected between January and December 2012. Samples were analyzed using Milko-Scan FT6000 (Foss Electric A/S, Hillerød, Denmark) for fat, protein and casein contents, somatic cell count (SCC) and saturated (SFA), unsaturated (UFA), monounsaturated (MUFA) and polyunsaturated (PUFA) FA. Somatic cell score (SCS) was obtained via log-transformation of SCC as SCS = [3 + $\log_2$(SCC/100,000)]. Information on daily milk yield was also recorded. Days in milk (DIM) were restricted to be between 5 and 600 days, and parities between 1 and 6. Data were analyzed through a generalized linear model using the MIXED procedure of SAS (SAS, 2008). The model included fixed effects of month of sampling (12 levels), parity (3 classes, the last class including parities ≥3), DIM (12 monthly classes, the first class including DIM between 5 and 30 days, and the last between 360 and 600 days), herd, breed, interaction between parity and breed, and interaction between DIM and breed, and the random effects of cow nested within breed and residual.

Table 1. Descriptive statistics of milk yield, quality, and groups of fatty acids

Trait[1]	Mean	SD	Minimum	Maximum
Milk yield, kg/d	28.25	9.15	4.30	65.30
Fat, %	3.85	0.72	1.38	6.87
Protein, %	3.50	0.42	2.37	5.16
Casein, %	2.71	0.35	1.77	4.08
SCS	2.96	1.94	-1.32	9.71
SFA, % of milk fat	70.70	3.54	54.31	81.06
UFA, % of milk fat	29.30	4.29	18.63	48.63
MUFA, % of milk fat	24.51	3.59	14.67	41.51
PUFA, % of milk fat	2.12	0.61	0.22	5.09

[1]SCS = somatic cell score; SFA = saturated fatty acids; UFA = unsaturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Table 2. Least squares means (SE) of milk yield and composition for fatty acids for Brown Swiss (BS), Holstein Friesian (HF) and Simmental (SI) cattle breeds

Trait[1]	BS	HF	SI
Milk yield, kg/d	24.34 (0.22)[a]	27.93(0.15)[b]	24.77 (0.32)[a]
Fat, %	4.11 (0.02)[a]	3.72 (0.014)[b]	3.90 (0.03)[c]
Protein, %	3.67 (0.01)[a]	3.38 (0.01)[b]	3.56 (0.015)[c]
Casein, %	2.87 (0.01)[a]	2.63 (0.01)[b]	2.77 (0.01)[c]
SCS	2.92 (0.06)[a]	3.19 (0.04)[b]	2.78 (0.09)[a]
SFA, % of milk fat	71.65 (0.09)[a]	70.45 (0.06)[b]	70.93 (0.13)[c]
UFA, % of milk fat	29.71 (0.10)[a]	31.20 (0.07)[b]	30.68 (0.15)[c]
MUFA, % of milk fat	23.69 (0.09)[a]	24.95 (0.06)[b]	24.67 (0.13)[b]
PUFA, % of milk fat	2.08 (0.01)[a]	2.09 (0.01)[a]	2.03 (0.02)[a]

[1]SCS = somatic cell score; SFA = saturated fatty acids; UFA = unsaturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; [a-c]Least squares means with different letters are significantly different according to Bonferroni's test ($P < 0.05$).

Results and discussion

Descriptive statistics of the studied traits are shown in Table 1. Mean of milk yield, fat content, protein content, casein content and SCS were 28.25 kg/d, 3.85%, 3.50%, 2.71% and 2.96, respectively. Mean values of SFA, UFA, MUFA and PUFA were 70.70%, 29.30%, 24.51% and 2.12% of milk fat, respectively. As previously reported by Bobe et al. (2008), SFA was the most important group of FA followed by MUFA and PUFA. Values of SFA and UFA were similar to those reported by Mele et al. (2009) and De Marchi et al. (2011) for HF and BS cows, respectively.

Least squares means of the studied traits are reported in Table 2. As expected, HF breed exhibited the highest milk yield (27.93 kg/d) and the worst quality of milk, whereas BS breed showed the best milk composition with 4.11%, 3.67% and 2.87% of fat, protein and casein contents, respectively. Brown Swiss and SI produced less milk (24.34 and 24.77 kg/d, respectively) than HF cows. Simmental was intermediate between HF and BS for all traits, except for SCS, which was lower for SI. These findings are supported by previous studies which reported the superiority of HF for milk yield compared with other breeds (Tyrisevä et al., 2004; Cecchinato et al., 2011) and its inferiority for fat and protein contents, and for milk coagulation properties (De Marchi et al., 2007). Milk of BS showed the highest percentage of SFA (71.65%) and the lowest of UFA (29.71%) and MUFA (23.69%), whereas HF showed the opposite, with the lowest percentage of SFA (70.45%) and the highest of UFA (31.20%). Monounsaturated FA were comparable among dairy breeds (Table 2). Differences between FA profile across cattle breeds have been reported in the literature (DePeters et al., 1995; Kelsey et al., 2003; Auldist et al., 2004; Soyeurt et al., 2006).

To our knowledge no studies have investigated the variation of milk FA composition of major Italian dairy cattle breeds in mixed herds and only a few researches have been conducted on Italian single-breed herds. Mele et al. (2009) analyzed FA composition of milk from HF cows reared in 34 commercial farms of north-eastern part of Italy and they reported lower percentage of MUFA (19.97%) than that found in the present study. De Marchi et al. (2011) investigated the potential of MIRS to predict FA using BS data; however, the comparison with our results is difficult due to the different way of expression of FA concentration in milk adopted by De Marchi et al. (2011): in fact, the au-

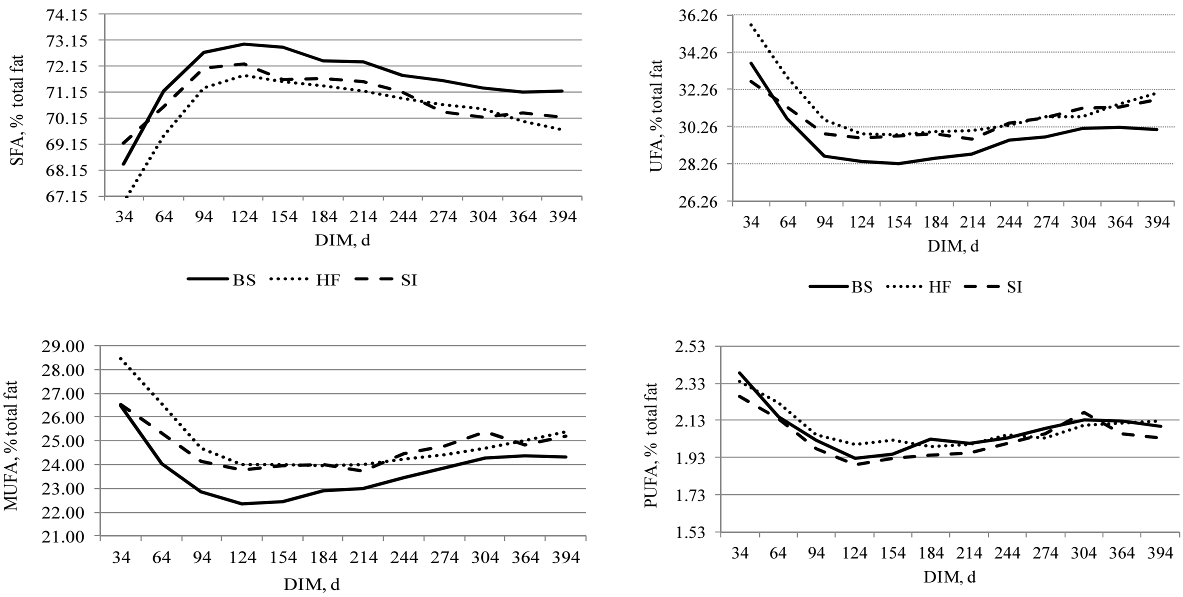

Figure 1. Least squares means of saturated fatty acids (SFA), unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) for Brown Swiss (BS), Holstein Friesian (HF) and Simmental (SI) cattle breeds across days in milk (DIM)

thors expressed FA as g of FA/kg of milk and not as % on milk fat as we did.

Results of variation of groups of FA across DIM are shown in Figure 1. Similar trends have been found for all breeds, with SI being intermediate between BS and HF. An increased content of SFA until the fourth month of lactation was shown, whereas UFA, MUFA and PUFA exhibited an opposite trend, with the lowest values at 120 days of lactation. Similar variation of MUFA across lactation was reported by Mele et al. (2009) who reported a reduction of MUFA from 21.32% (DIM<100 days) to 19.36% (DIM from 100 to 200 days), followed by a slight increase (20.52%) from 200 DIM onward. The variation across lactation of FA profile is related to the variation of animal energy balance (Chillard et al., 2001, Henning et al., 2006); in early stages preformed FA (SFA derived from body fat) generally contribute a larger portion of the total FA, whereas the contribution from de novo FA increases as lactation progresses (Bauchart, 1993; Palmquist et al., 1993; DePeters et al. 1995). This biological explanation was confirmed also by Bastin et al. (2011), Kay et al. (2005) and Henk et al. (2009).

Conclusions

Dairy cattle breeds reared under the same herd conditions differed in terms of milk composition and groups of FA. The HF breed showed the highest milk production and better FA composition than SI and BS cows. The SI breed was intermediate between HF and BS for studied traits, except for SCS. No statistically significant differences were found in studied breeds for PUFA. The variation of FA during lactation was very different between SFA and other groups of FA; the SFA followed the lactation curve, suggesting a close relation with body energy status of the cow.

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