Prediction of cow diet composition from bulk milk spectra by Medium Infrared Reflectance Spectroscopy (MIRS)

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Abstract

The aim of this work was to develop equations using Medium Infrared Reflectance Spectroscopy (MIRS) spectra of bulk milk from commercial farms to predict dairy cow diet composition. A total of 429 bulk cow milk samples were collected from 176 commercial farms located in Northwest Italy from 2011 to 2017, and analysed by MIRS. Data on the production conditions were recorded on-farm at each sampling by compiling a detailed questionnaire. Calibrations for the predictions of cow diet composition were calculated with modified partial least square regression. Dairy cow feeding varied to a great extent.

The total forages calculated including the 60% of DM of maize silage and the total concentrates including the 40% of DM of maize silage were successfully predicted by MIRS ($R^2CV > 0.80$). The predictions for total concentrates (without part of DM of maize silage), the total forages (including the 100% of DM of maize silage), and the fresh herbage proposition in cow diet were found to be promising ($R^2CV > 0.75$). These results can have a great interest in the authentication milk, especially for those dairy products having feeding restriction in their specification protocols.

Keywords: milk, authentication, cow feeding, MIRS

Introduction

In Europe, dairy product labelling or certification strategies, such as protected designation of origin (PDO) or protected geographical indication (PGI) consist in a useful tool to support local producers, especially in marginal areas, giving an added value (and higher prices) to dairy products. These labels imply a specific protocol, which often include restriction in dairy cow feeding (i.e. interdiction of silage, limit to concentrate amount, minimum supply of fresh herbage, etc.), that result in dairy products with specific traits of composition or sensory profile (Martin et al., 2005; Giaccone et al., 2016). To guarantee the authenticity of such dairy products for consumers, reliable, rapid and cheap methods of authentication are required. Medium infrared reflectance spectroscopy (MIRS) is non-invasive, rapid and inexpensive and can be an alternative technique to reference analysis for a routine use in the collection of information on animal diet and milk authentication (Coppa et al., 2102).

The aim of this work was to develop equations using MIRS spectra of bulk milk from commercial farms to predict dairy cow diet composition.

Material and methods

A total of 429 bulk cow milk samples were collected from 176 commercial farms located in Northwest Italy from 2011 to 2017. To explore the maximum variability of milk composition, samples were collected in different seasons in farms ranging from the intensive systems of the plain to the extensive systems of the Alps. Milk samples were collected on each farm, transported at 4°C, without any added preservative, and analysed by MIRS (MilkoScan FT6000, Foss System, Hillerød, Denmark). Data on the production conditions were recorded on-farm at each sampling by compiling a detailed questionnaire drawn up by Borreani et al.

(2013). The total concentrate and forages were calculated both considering corn silage as forage and partially as a concentrate (40% of DM) and partially as a forage (60% of DM), as proposed by Mertens (2009). Calibrations for the predictions of cow diet composition were performed using WinISI II Project Manager, version 1.50 (Infrasoft International, South Atherton St. State College, PA, USA) and calculated with modified partial least square (MPLS) regression. The statistics used to develop and evaluate the calibration models included the standard error of calibration (SEC), the coefficient of determination for calibration (R^2C), standard error of cross-validation (SECV), the coefficient of determination for cross-validation (R2CV), and the ratio of the standard deviation of reference data to the SECV (RPD).

Results and discussion

The composition of the diet of dairy herds from which the milk was sampled are given in Table 1. Dairy cow feeding varied to a great extent and included full fresh herbage (pasture- or indoor-fed) or hay diets, corn silage- or grass or legume silage-based diets and diets in with more than 50% of the DM of concentrates. Feeding systems in northwest Italy are highly diversified because of the proximity of the Alps, whose pastures are grazed by dairy herds, and to the presence of the Po plain, which hosts intensive maize silage-based farming systems (Borreani et al., 2013).

Table 1: Descriptive statistics of cow diet composition in the calibration dataset

Feedstuffs (% diet DM)	Average	Min	Max	SD
Total forages (including 60% maize silage)	52	27	100	19.2
Total concentrates (including 40% maize silage)	48	0	73	19.2
Total forages (including 100% maize silage)	62	35	100	16.2
Total concentrates (exluding maize silage)	38	0	65	16.2
Hay	15	0	89	18.0
Total grass-derived forages	25	0	89	16.2
Maize silage	26	0	63	14.4
Fresh herbage	10	0	100	27.4

Table 2: MIRS prediction results for cow diet composition

Feedstuffs (% diet DM)	Calibration					
	N	SEC	R^2C	SECV	R^2CV	RPD
Forages (including 60% maize silage)	411	7.1	0.84	7.7	0.82	2.53
Concentrates (including 40% maize silage)	411	7.1	0.84	7.7	0.82	2.53
Forages (including 100% maize silage)	415	6.9	0.80	7.5	0.77	2.26
Concentrates (excluding maize silage)	415	6.9	0.80	7.5	0.77	2.26
Hay	397	8.8	0.49	9.6	0.41	1.40
Grass-derived forages	392	9.0	0.35	9.7	0.25	1.24
Maize silage	412	10.0	0.47	10.3	0.44	1.38
Fresh herbage	399	9.7	0.79	10.2	0.77	2.17

The MIRS calibration statistics obtained for the various feedstuffs are shown in Table 2. The total DM of forages calculated including 60% of maize silage (plant) and the total amount of concentrates including 40% of maize silage (grain) were successfully predicted by MIRS ($R^2CV > 0.80$). The predictions for total concentrates (without maize silage), the total forages

(including 100% of maize silage), and the fresh herbage proportion in cow diet were found to be promising ($R^2CV > 0.75$). The hay and the maize silage proportions in cow diet were poorly predicted and grass derived forages (hay and grass or legume silages) did not allow to obtain reliable models. The SECV were reasonably low, especially considering the method of estimation of reference data through in farm surveys that could imply a lower detail in information compared with controlled experiments (Coppa et al., 2013). This is the case for fresh herbage proportion in the cow diet that, however, showed a SECV similar or slightly higher than those of the other feedstuffs.

Conclusions

The presented model appear reliable for the estimation total forages, total concentrates and the fresh herbage proportions in cow diets. These results can have a great interest in the authentication of milk, especially for those dairy products having feeding restriction in their specification protocols (i.e. Protected Denomination of Origin). Further studies would be required to improve the equations and to individuate strategies for a careful use of those equations which have shown low performances.

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