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The use of mid-infrared spectrometry to estimate the ration composition of lactating dairy cows

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ABSTRACT

The composition of cow milk is strongly affected by the feeding regimen. Because milk components are routinely determined using mid-infrared (MIR) spectrometry, MIR spectra could also be used to estimate an animal's ration composition. The objective of this study was to determine whether and how well amounts of dry matter intake and the proportions of concentrates, hay, grass silage, maize silage, and pasture in the total ration can be estimated using MIR spectra at an individual animal level. A total of 10,200 milk samples and sets of feed intake data were collected from 90 dairy cows at 2 experimental farms of the Agricultural Research and Education Centre in Raumberg-Gumpenstein, Austria. For each run of analysis, the data set was split into a calibration and a validation data set in a 40:60 ratio. Estimated ration compositions were calculated using a partial least squares regression and then compared with the respective observed ration compositions. In separate analyses, the factors milk yield and concentrate intake were included as additional predictors. To evaluate accuracy, the coefficient of determination (R^2) and ratio to performance deviation were used. The highest R^2 values (for kg of dry matter intake/for % of ration) for the individual feedstuffs were as follows: pasture, 0.63/0.66; grass silage, 0.32/0.43; concentrate intake, 0.39/0.34; maize silage, 0.32/0.33; and hay, 0.15/0.16. Estimation of groups of feedstuffs (forages, energy-dense feedstuffs) mostly resulted in R^2 values >0.50. Including the parameters milk yield or concentrate intake improved R^2 values by up to 0.21, with an average improvement of 0.04. The results of this study indicate that not all ration components may be estimated equally accurately. Even if some estimates are good on average, there may be strong deviations between estimated and observed values in individual data sets, and therefore individual estimates should not be overemphasized. Further research including pooled samples (e.g., bulk milk, farm samples) or variations in ration composition is called for.
Key words: dairy cow, feed ration, mid-infrared spectrometry, estimation

INTRODUCTION

Mid-infrared (**MIR**) spectrometry is currently the method of choice for measuring milk lactose, fat, and protein contents for standard milk recording systems all around the world. In past decades, the MIR spectra of milk samples have been associated with a variety of additional milk- and cow-related parameters, such as the fatty acid profile (Soyeurt et al., 2006; Maurice-Van Eijndhoven et al., 2013; Ferrand-Calmels et al., 2014), major mineral contents (Soyeurt et al., 2009), genetic variability of immune-relevant substances in milk (Soyeurt et al., 2007), methane emissions (Dehareng et al., 2012; Vanlierde et al., 2016), ketone bodies and subclinical ketosis (de Roos et al., 2007; van Knegsel et al., 2010; van Gastelen and Dijkstra, 2016) energy intake (McParland et al., 2015), and body energy balance (McParland et al., 2011). As shown by De Marchi et al. (2014) and Gottardo et al. (2015), MIR spectrometry is an economically viable method for large-scale screening of phenotypes of dairy animals.

The feed ration leaves a "fingerprint" (i.e., patterns in composition) in milk (Sutton, 1989; White et al., 2001; Slots et al., 2009; Larsen et al., 2016), and milk traits such as fatty acid composition have been successfully used to predict ration composition (Coppa et al., 2015). Other milk components that have been explored as potential predictors of diet are carotenoids (Nozière et al., 2006) and UV-absorbing compounds in milk that are related to polyphenols in the feed ration, which are again very specific to the feedstuff (Besle et al., 2010). The MIR spectra of bulk milk samples have also proven useful in distinguishing between feeding systems with

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