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Short communication: Field study to investigate the associations between herd level risk factors for milk fat depression and bulk tank milk fat percent in dairy herds feeding monensin

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ABSTRACT

Fat is the most variable milk component, and maintaining milk fat continues to be a challenge on commercial dairy farms. Our objectives were to establish associations between herd-level risk factors for milk fat depression and bulk tank milk fat content in commercial dairy herds feeding monensin. Seventy-nine Holstein commercial dairy herds in the northeast and upper Midwestern United States were enrolled in an observational study. Data were collected on herd characteristics, total mixed ration (TMR) samples, all component silage samples, and bulk tank milk samples. The unconditional univariable association of each explanatory variable and bulk tank milk fat percentage was evaluated using simple linear regression and multivariable regression models. Milk fat content of *trans*-10 C18:1 had an exponentially negative relationship to herd milk fat percentage. In general, milk fat content of fatty acids synthesized de novo in the mammary gland were positively related to herd milk fat, and the content of several *trans*-C18:1 fatty acids, which would be products of alternate pathways of ruminal biohydrogenation, were negatively related to herd milk fat. Variables related to TMR composition did not have univariable relationships with herd milk fat percentage. Herds that had >49.8% of the TMR particles on the middle screen of the Penn State particle separator had higher milk fat percentage than those with ≤49.8%, and herds with >54.0% of TMR particles in the bottom pan had lower milk fat percentage than herds with ≤54.0%. Dietary content of monounsaturated fatty acids (C16:1 and C18:1) had negative relationships with herd milk fat percentage; however, no single diet component accounted for more than 11% of the variation in herd-level milk fat percentage. Univariable monensin dose was not associated with herd milk fat percentage. The relative lack of significant univariate relationships with herd-level milk fat suggests many factors contribute to milk fat content, and herds experiencing low milk fat will need to examine many potential risk factors when working to troubleshoot this challenge.
Key words: milk fat depression, monensin, unsaturated fatty acids

Short Communication

Classically, milk fat depression (**MFD**) is represented by a reduction in milk fat content and yield attributed to a shift in the biohydrogenation of C18 UFA and increased production of unique biohydrogenation intermediates (Bauman and Griinari, 2001; Bauman et al., 2011). In controlled experiments, the concentration of *trans*-10 C18:1 in milk fat has been shown to be a good marker for the shift in biohydrogenation (Lock et al., 2007; Rico and Harvatine, 2013). Previous work has demonstrated that *trans*-10,*cis*-12 CLA has an important role in modulating milk fat synthesis (Baumgard et al., 2000); however, only a portion of MFD is accounted for by this isomer, suggesting that other isomers and additional factors must also influence milk fat synthesis (Palmquist et al., 1993; Bauman et al., 2006).

It is well accepted that the presence of PUFA is a prerequisite for MFD (Bauman and Griinari, 2003), although many dietary factors may interact to induce this effect, including feed particle size (Grant et al., 1990a, b), NDF level (Griinari et al., 1998; Duffield et al., 2003; Rico and Harvatine, 2013), and the rate or extent of starch degradation (Oba and Allen, 2003; Lascano et al., 2016). Cows fed diets high in corn silage tend to have lower milk fat content than those fed diets containing other forage sources (Onetti et al., 2004; Wattiaux and Karg, 2004), but forage type is not always a predisposing factor for MFD (Dhiman and Satter, 1997; Groff

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and Wu, 2005). Further, supplementing lactating cattle with the ionophore monensin (Rumensin, Elanco Animal Health, Greenfield, IN) has been associated with decreases in milk fat percentage (Duffield et al., 2008) and changes in ruminal VFA production (Ramanzin et al., 1997) or production of biohydrogenation intermediates (Bell et al., 2006) consistent with classical MFD. A recent study observed that up to 90% of herds in the northeastern United States fed monensin (Lawton et al., 2016). In our experience, when herds are having challenges with MFD, monensin is often removed from the diet, albeit with varying results on correcting the MFD. We are often asked if any preeminent factors contribute to MFD when troubleshooting challenges on commercial dairy herds. Based upon this, it was of interest to conduct a comprehensive field study of the factors that affect milk fat percentage. The objectives of our study were to investigate putative risk factors, with a specific interest in univariable factors that might be major contributors to herd-level milk fat variations in commercial dairy herds feeding monensin and to evaluate the fatty acid (**FA**) profile of bulk tank milk samples for the presence of FA intermediates consistent with the biohydrogenation theory of MFD.

Seventy-nine Holstein herds from the northeast and upper Midwestern United States were enrolled in a cross-sectional observational study to investigate herd-level factors that affect milk fat percentage in herds feeding monensin. Herds were identified and enrolled by working in collaboration with allied industry herd service providers. The final data set consisted of 79 Holstein herds contributed by 48 different allied industry professionals from 28 organizations. The 48 individuals could be further categorized into feed company-based nutritionists (n = 35), consulting group nutritionists (n = 8), and veterinarians (n = 5). Herds from 10 states were included in the final data set. These included New York (n = 43), Michigan (n = 14), Pennsylvania (n = 9), Ohio (n = 6), Maryland (n = 2), New Hampshire (n = 1), Wisconsin (n = 1), Maine (n = 1), Minnesota (n = 1), and Virginia (n = 1). When enrolling herds, we sought to include a diverse sampling of herds, including some that were experiencing MFD during study sample collection. Data were collected during 1 visit to the herd by Cornell research staff and herd service providers, and consisted of a survey on herd and facility/group characteristics, 3 duplicate samples of the high-milk production lactating cow group TMR, samples of all the component silages, and duplicate bulk tank milk samples (samples taken from 1 morning milking, tank agitated for 10 min before sample collections). We chose to sample the high-producing lactating cow group because these cows are at the highest risk of MFD on the dairy, and we hypothesized that their group characteristics would have the greatest relationship to herd-level milk fat. In addition to the survey and sample collection, copies of diet formulations that corresponded to the TMR samples were collected for all herds.

Milk samples were sent to a commercial laboratory for analysis of milk fat content (Dairy One, Ithaca, NY) using midinfrared analysis (AOAC International, 2000; method 972.160). The TMR samples were dried (55°C) and ground (2-mm sieve) by Cumberland Valley Analytical Services (Maugansville, MD) for analysis of DM (Goering and Van Soest, 1970; AOAC International, 2000, method 930.15), CP (AOAC International, 2000, method 990.03), soluble CP (Krishnamoorthy et al., 1982), ADF (AOAC International, 2000, method 973.18), NDF (Van Soest et al., 1991), crude fat by ether extract (AOAC International, 2000, method 2003.05) and acid hydrolysis (AOAC International, 2000, method 954.02), ash (AOAC International, 2000, method 942.05), starch (Hall, 2009), and sugar (Dubois et al., 1956) using wet chemistry methods. The particle size of the TMR was assessed by Cumberland Valley Analytical Services using the Penn State particle separator (**PSPS**; Nasco, Fort Atkinson, WI) according to Lammers et al. (1996). A representative portion of the dried and ground sample was sent to Clemson University for analysis of FA composition by GLC (Sukhija and Palmquist, 1988; T. C. Jenkins Laboratory, Clemson University). Milk FAME were extracted from the bulk tank milk samples and methylated according to the procedure described by Bernal-Santos et al. (2003) and quantified by GLC and conditions reported by Perfield et al. (2002; D. E. Bauman Laboratory, Cornell University).

All statistical analyses were performed using SAS software (version 9.2; SAS Institute Inc., Cary, NC). The unconditional univariable association of each continuous explanatory variable and milk fat percentage was evaluated using simple linear regression with PROC Reg. The unconditional univariable association of each categorical explanatory variable and milk fat percentage was evaluated using a 2-sample *t*-test with PROC Ttest. Similarly, each of the explanatory variables were offered to a multivariable general linear model with PROC GLM and PROC Mixed, where herd was a random effect among the fixed effects of interest in a mixed model. An ANOVA was used to study the relationship between bulk tank milk fat percentage and conditional relationships of the putative risk factors. Plausible 2-way interactions were evaluated. Backward, step-wise, and manual elimination of variables was used to select the most parsimonious model that explained the most variation in bulk tank milk fat percent, had all individual terms with a type 1 error risk of less than 5%, and had the best model fit. All potential

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