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# An appraisal of the concept of Rumen Unsaturated Fatty Acid Load and its relation to milk fat concentration using data from commercial dairy farms

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## ABSTRACT

*The concept of Rumen Unsaturated Fatty Acid Load (RUFAL) has been proposed to reflect the supply of dietary unsaturated fatty acids in relation with their potential to disturb ruminal fermentation and trigger milk fat depression in lactating dairy cows. The objective of this study was to assess this concept, and its relationship with milk fat concentration, using data available in a DHI database. Data from Holstein cows recorded over 3 yr by Valacta (Sainte-Anne-de-Bellevue, QC, Canada) were used for the analysis. The fatty acid concentrations in feed were obtained from CNCPS V6.1, INRA-AFZ Tables of Feed Composition, and peer-reviewed articles. Multiple regression analyses were performed at 2 stages of lactation (early: 1–100 DIM; and established: 101–350 DIM) using the MIXED procedure of SAS. Estimated breeding value was also included to account for the effect of genetics on milk fat concentration. Results show that RUFAL has a negative and significant relationship with milk fat concentration at each stage of lactation ($P < 0.01$), which confirms the validity of this concept under commercial conditions. The negative effect of RUFAL was continuous and progressive, and data did not allow defining a threshold value above which the supply of dietary unsaturated fatty acids should be limited to avoid milk fat depression. Dietary 16:0 has also been retained in prediction models with positive coefficients and was therefore associated with greater milk fat concentration ($P < 0.01$). As the complete fatty acid profile of feedstuffs could be determined in a single laboratory analysis using GLC, we conclude that the RUFAL concept could be improved by considering an adjustment factor taking into account the concentration of dietary 16:0.*

**Key words:** dairy cow, dietary fatty acid, milk fat, dairy herd improvement, database

## INTRODUCTION

Diets fed to lactating cows usually contain low levels of fatty acids (**FA**; Palmquist and Jenkins, 1980). Among the unsaturated lipids found in common feed ingredients of dairy rations, 18:3 is the predominant FA in most grass and legume forage species, followed by 18:2 (Boufaïed et al., 2003). In both corn grain and corn silage, FA are composed mainly of 18:2, followed by *cis* 18:1 (Morand-Fehr and Tran, 2001). Other cereal grains, such as barley and wheat, are also rich in 18:2 and contain appreciable amounts of 16:0. Fat supplements could be used in the rations of dairy herds to increase their energy density. Among the lipid sources available, 16:0 and *cis* 18:1 are abundant in animal fats and palm oil. Finally, canola is rich in *cis* 18:1, whereas 18:2 is predominant in soybeans (Morand-Fehr and Tran, 2001).

Dietary additions of fat supplements rich in unsaturated FA have been shown to decrease milk fat concentration (**MFC**) in dairy cows (Stoffel et al., 2015). Lower MFC is explained under these conditions by a disturbance in ruminal fermentation causing a shift from the *trans*-11 to the *trans*-10 pathway of PUFA biohydrogenation, leading to the production of *trans*-10, *cis*-12 18:2. This conjugated linoleic acid isomer has been shown

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to decrease the expression of lipogenic enzymes and reduce milk fat synthesis in the mammary gland (Bauman and Griinari, 2003).

Based on this knowledge, Jenkins et al. (2009) and Lock (2010) proposed the concept of Rumen Unsaturated Fatty Acid Load (**RUFAL**) to reflect the total amount of dietary unprotected unsaturated FA entering the rumen on a daily basis and their potential to trigger milk fat depression. As suggested by these authors, RUFAL can be calculated as the sum of the 3 primary unsaturated FA consumed by dairy cows, namely *cis* 18:1, 18:2, and 18:3. Therefore, RUFAL accounts for the supply of unprotected unsaturated FA from all feed ingredients, rather than FA intake coming only from fat supplements as it is often evaluated in the literature.

These relationships have been established under experimental conditions, mostly within controlled environments. There is a need to verify their validity under more practical situations. The objective of this study was therefore to assess the RUFAL concept, and its relationship with MFC, using data available in a DHI database, and by employing the method of multiple regression analyses (**MRA**).

## MATERIALS AND METHODS

### *Data*

The database from Valacta (Dairy Production Centre of Expertise, Québec and Atlantic Provinces, Sainte-Anne-de-Bellevue, QC, Canada) for the years 2009 to 2011 was used. Cow data included parity, DIM, as well as milk yield and composition. The estimated breeding value (**EBV**) for MFC was also available as a measure of cow genetic potential (Goddard and Hayes, 2009). Feeding data include the quantities and DM concentration of forages and concentrates offered to an individual cow at a specific test-day (**TD**). When data for ingredients composing the diet were not available for a TD, the ingredient composition of the diet from the closest TD was used, as done previously by Caccamo et al. (2012).

The FA profile of feed ingredients was not originally available in the database. Total fat and FA as well as individual FA concentration (12:0, 14:0, 16:0, 16:1, 18:0, *cis* 18:1, *trans* 18:1, 18:2, and 18:3) of forages and concentrates were then obtained from the feed library of the Cornell Net Carbohydrate and Protein System (V6.1, Cornell University, Ithaca, NY), the INRA-AFZ (2002) tables of feed composition, and scientific literature (Hutchinson et al., 2012; Lock et al., 2013). Feed ingredients for which the FA profile was not available were removed from the database, as well as the associated dietary and lactation records. Because the fat composition of perennial forages varies with species and maturity, FA profile was adjusted according to the forage families (grasses and legumes) and growth stages at harvest (immature, mid mature, and mature) listed in the database. These categories did not allow identifying the plant species. Knowing that the majority of forages grown in Québec and Atlantic Provinces are mixtures of timothy and alfalfa (Statistics Canada, 2010), the FA profiles of these 2 plant species were used in different proportions according to their respective category ratio (timothy:alfalfa) as follows: grasses (75:25), predominantly grasses (66:33), mixed grasses and legumes (50:50), predominantly legumes (33:66), and legumes (25:75). A validation was finally carried out on fat concentration of feed ingredients between the actual values recorded in the database and those from the feed libraries.

Based on the information in the database, the FA composition of diet (% of DM) for each cow at each TD was calculated according to the quantities offered and the lipid profile of feedstuffs using the SQL procedure of SAS (SAS Institute Inc., Cary, NC). The RUFAL was calculated as the sum of *cis* 18:1, 18:2, and 18:3. To exclude outliers of production and feeding records, data were restricted to those within 3 standard deviations of the mean, as done previously by de Vries and Veerkamp (2000). Lactation length was restricted to 350 DIM and was divided into early (1 to 100 DIM) and established lactation (101 to 350 DIM).

Milk composition is known to be affected by several factors over the year, such as heat stress during summer (Bertocchi et al., 2014). Diet composition is also known to be more variable in autumn when newly harvested forages and grains are gradually introduced in the rations. For these reasons, only records from December to April were used for the analysis. Finally, the analysis was restricted to records from Holstein cows, and only data from farms each with a total of at least 10 TD records per year were retained for analysis. After these restrictions, 4,205 TD records (2,075 cows in 111 herds) and 5,454 feedstuffs were available for the analyses.

### *Statistical Analysis*

A descriptive data analysis was first completed with the GPLOT procedure of SAS (SAS Institute Inc.) using the smoothing lines method. This operation included total fat, as well as total and individual FA concentrations. Correlations between these variables were then calculated following the CORR procedure of SAS (SAS Institute Inc.), and variables were tested for collinearity with the variance inflation factor using the REG procedure of SAS (SAS Institute Inc.). Thereafter, only variables with the greatest correlations and without collinearity were kept for the MRA that were carried out with the MIXED procedure of SAS. Finally, a principal component analysis of dietary FA was performed with PRINCOMP procedure of SAS (SAS Institute Inc.). This procedure allows bringing together the different FA according to their origin from various feedstuffs and assists in their selection in the regression model.

After completing these procedures, the effects of individual FA and