Relationship between milk fatty acids and body energy status in Holstein dairy cows

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Introduction

Energy balance is the differential between energy intake and expenditure. Negative energy balance is associated with mobilisation of body reserves to make up the short fall of energy required for milk production. The ratio of milk fat to protein is often used as an indicator of energy status (Friggens *et al.*, 2007). Milk, however, contains hundreds of fatty acids (FA) which differ in their origin and can be classified into two broad groups: saturated fats (SAT) and unsaturated fats (UNSAT). These groups can be further divided according to their number of structural carbons (C). The objective of this study was to determine the association between groups of milk FA and the body energy status of Holstein cows.

Materials and Methods

Performance data from 1990 to 2010 from a research herd of Holstein cows stationed at Crichton Royal Farm, Scotland were obtained. Cows were split in two groups and fed either a high concentrate or a low concentrate diet. Random regressions were fit through the records of milk, fat and protein yield, individually recorded dry matter intake, live weight and body condition score to create daily solutions and ultimately compute body energy status (EB; MJ) for each day in milk according to the methodology of Banos and Coffey (2010).

Monthly between September 2008 and May 2010 milk samples from the morning (AM), midday (MD) and evening (PM) milkings of all research cows were analysed using a MIR spectrometer. From the resulting spectrum, the level of milk FA in each milk sample was predicted using the equations developed by Soyeurt *et al*. (2010). Groups of FA predicted included: 1) SAT, 2) UNSAT, 3) short chain FA (SCFA; FA between 4 and 10 C), 4) medium chain FA (MCFA; FA between 12 and 16 C) and 5) long chain FA (LCFA; FA between 17 and 22 C). Accuracy of predicting the groups of fats ranged from 0.91 for the SCFA to 0.98 for SAT (Soyeurt *et al*., 2010). The weighted average FA content of the AM, MD and PM milk samples was obtained for each day with an associated MIR spectrum.

Product moment correlations between each group of FA and EB were undertaken. The correlations between each group of milk FA and EB were also investigated separately within each feeding treatment.

Results and Discussion

The mean proportion of SAT and UNSAT in the milk fat of the cows in the study was 700 mg/g fat and 300 mg/g fat, respectively. Mean proportion of SCFA, MCFA, and LCFA in milk fat were 90 mg/g fat, 530 mg/g fat and 380 mg/g fat, respectively. Weak to moderate correlations existed between FA groups and EB. The correlation between the milk fat to protein ratio and EB was -0.11. Across both experimental feeding systems, cows in positive EB had a higher proportion of SAT in the milk fat (r = 0.30) and lower levels of UNSAT in the milk fat (r = -0.19). The negative association between UNSAT and EB may be driven by oleic acid, the most abundant UNSAT in milk, as it is released during body fat mobilisation (Rukkwamsuk *et al*. 2000) and was also negatively associated with EB in the present study (r = -0.21). In addition, the preformed milk fat precursors originating from body fat mobilisation (i.e. negative energy balance) reduce the requirement for *de novo* synthesis, and thus reduce the proportion of SAT in the milk. Positive correlations between both SCFA and MCFA and EB existed (r = 0.18 and 0.35, respectively), yet there was a negative correlation between LCFA and EB (r = -0.24). This negative association between LCFA and EB may be explained by the LCFA stearic acid (r= -0.14), also released during lipolysis (Rukkwamsuk *et al*. 2000).

Table 1 summarises the differences between the high and low concentrate feeding groups in their relationship between milk FA and EB. The proportion of FA in the milk were similar between the two groups, yet the association between the FA and EB of the group of cows fed low concentrate were stronger than the same associations in the cows fed high concentrates.

Table 1. Mean (standard deviation) of EB(MJ) and proportion of FA group (mg/g fat) and its correlation (r) with EB for the high and low concentrate diet groups

	High Concentrate		Low Concentrate	
	Mean (sd)	r	Mean (sd)	r
EB	-1.1(23.2)	-	-8.0(34.2)	-
SAT	70.2(8.5)	0.15	69.1(8.5)	0.39
UNSAT	29.7(4.8)	-0.13	30.9(4.9)	-0.23
SCFA	9.2(1.4)	-0.04	8.9(1.3)	0.32
MCFA	55.0(7.0)	0.27	52.5(7.2)	0.51
LCFA	36.5(6.1)	-0.20	39.5(6.3)	-0.24

Conclusions

Weak to moderate correlations between milk FA groups and EB were observed. Although no correlation was strong enough to be used exclusively to predict EB, these findings indicate that milk FA are more useful as indicators of EB than the milk fat to protein ratio.

Acknowledgements

The RobustMilk project is financially supported by the European Commission under the 7th Research Framework Programme, Grant Agreement KBBE-211708

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