J. Dairy Sci. 98:1–12
http://dx.doi.org/10.3168/jds.2014-9207

Postruminal synthesis modifies the odd- and branched-chain fatty acid profile from the duodenum to milk

B. Vlaeminck,* R. Gervais,† M. M. Rahman,* F. Gadeyne,* M. Gorniak,‡ M. Doreau,§ and V. Fievez*[1]
*Laboratory for Animal Nutrition and Animal Product Quality, Faculty of Bioscience Engineering, Ghent University, Proefhoevestraat 10, 9090 Melle, Belgium
†Département des Sciences Animales, Université Laval, 2425 rue de l'Agriculture, Québec, Québec G1V 0A6, Canada
‡Institute of Animal Nutrition, Friedrich-Loeffler Institute, Federal Research Institute for Animal Health, Bundesallee 50, 38116 Brunswick, Germany
§INRA/Vet Agro Sup, UMR1213 Herbivore Research Unit, 63122 Saint-Genès Champanelle, France

ABSTRACT

Milk odd- and branched-chain fatty acids (OBCFA) have been suggested as potential biomarkers for rumen function. The potential of milk OBCFA as a biomarker depends on whether their profile reflects the profile observed in the duodenum. The objective of this study was to evaluate whether the OBCFA profile in duodenum samples is reflected in plasma and milk. For this, 2 dairy cattle experiments were used. In experiment 1, 4 Holstein cows fitted with rumen and proximal duodenum cannulas were used in a 4 × 4 Latin square design. The treatments consisted of 2 nitrogen levels (143 vs. 110 g of crude protein/kg of dry matter for high and low N, respectively) combined with either 1 of the 2 energy sources (i.e., starch from barley, corn, and wheat or fiber from soybean hulls and dehydrated beet pulp). In experiment 2, 4 Holstein cows fitted with rumen and proximal duodenum cannulas were used in a 3 × 3 Latin square design, with the treatments consisting of 3 diets: (1) RNB−, a diet with a crude protein content of 122 g/kg of dry matter, predicted to provide protein digested in the small intestine according to the requirement of the animals, but with a shortage of rumen degradable protein; (2) RNB− to which 6 g/d of niacin was added through inclusion in the mineral and vitamin premix, and (3) RNB− to which urea was added to balance rumen degradable N supply resulting in a CP content of 156 g/kg of dry matter. In both experiments, samples of duodenal digesta, plasma, and milk were collected and analyzed for fatty acids. Additionally, lipids in plasma samples were separated in lipid classes and analyzed for fatty acids. The OBCFA profile in milk was enriched in 15:0, *iso*-17:0, *anteiso*-17:0, and *cis*-9–17:1 as compared with duodenal samples, and milk secretions even exceeded duodenal flows, which suggests occurrence of postruminal synthesis, such as de novo synthesis, desaturation, and elongation. The postruminal modification of the OBCFA profile might hamper the application of OBCFA as diagnostic tools of rumen function.

Key words: bovine, endogenous fatty acid synthesis, microbial fatty acids, elongation, blood lipids

INTRODUCTION

Milk odd- and branched-chain fatty acids (**OBCFA**) have been suggested as potential biomarkers of duodenal flow of microbial biomass (Cabrita et al., 2003; Vlaeminck et al., 2005) and molar proportions of VFA in the rumen (Fievez et al., 2012). Nevertheless, from other studies, the potential of these milk FA as biomarkers was questioned given the weak relationship between their duodenal flow and milk secretion (Dewhurst et al., 2007). The apparent recovery of duodenal FA in milk fat depends on various factors, including digestibility, FA metabolism (both synthesis and oxidation) in the cow's tissues, the cow's physiological status (positive vs. negative energy balance), blood lipid classes [NEFA, triacylglycerols (**TAG**), phospholipids (**PL**), or cholesterolesters (**CE**)] in which FA are transported, and the duodenal FA flow, with higher transfer efficiencies at lower intestinal flows (Chilliard et al., 2000). Milk FA either are de novo synthesized or arise from plasma NEFA (mobilized from adipose tissue) or from TAG-rich lipoproteins (chylomicrons and very low density lipoproteins). Fatty acids concentrated in CE and PL fractions of plasma are poorly transferred to milk fat because the mammary gland lipoprotein-lipase has a low affinity for these fractions (Annison et al., 1967; Shennan and Peaker, 2000). As a result, the profile of OBCFA in plasma and milk might be altered as compared with the duodenal profile. As adipose tissue is enriched in OBCFA of longer chain length (Craninx et al., 2008), differences in mobilization of body fat reserves also could contribute to the weak relationship

Received December 8, 2014.
Accepted March 27, 2015.
[1]Corresponding author: Veerle.Fievez@UGent.be

between their duodenal flow and milk secretion. Furthermore, de novo synthesis in the mammary gland has been shown for 15:0 and 17:0 (Vlaeminck et al., 2006) as well as desaturation of 17:0 to *cis*-9–17:1 through the action of delta-9 desaturase (Fievez et al., 2003).

The aim of the present study was to gain additional insight in factors affecting the duodenum-milk relationship for OBCFA. Consequently, samples for the current study were obtained from 2 dairy cattle experiments initially designed to evaluate the effect of diet composition on efficiency of N utilization, and where large variation in duodenal flow of microbial protein (Fanchone et al., 2013; Aschemann et al., 2012), rumen proportions of VFA (Fanchone et al., 2013; Aschemann et al., 2012), and the rumen microbial population (Belanche et al., 2012) were measured. The dietary effect on both DMI, milk production and composition, and duodenal flow of microbial N were reported previously (Aschemann et al., 2012; Fanchone et al., 2013).

MATERIALS AND METHODS

The 2 experiments from which samples were obtained were explained in detail by (Fanchone et al., 2013) and (Aschemann et al., 2012). Brief descriptions of those experiments are given below. The proportions of ingredients used in the different treatments of both experiments and their nutritive value are presented in Table 1.

Experiment 1 (Fanchone et al., 2013)

Four Holstein cows fitted with rumen, proximal duodenum, and terminal ileum cannulas were used in a 4 × 4 Latin square design. At the beginning of the experiment the cows weighed on average 662 ± 62 kg at 71 ± 10 DIM. The treatments consisted of 2 nitrogen levels (low and high) combined with either 1 of the 2 energy sources (high starch or high fiber). The high

Table 1. Dietary ingredients, chemical composition, and FA intake in experiment 1 and experiment 2[1]

	Experiment 1[2]				Experiment 2[3]		
	Starch		Fiber				
Item	High N	Low N	High N	Low N	RNB−	RNB-NA	RNB0
Ingredient, g/kg of DM							
Corn silage	405	405	405	405	593	593	593
Hay	100	100	100	100	—	—	—
Dehydrated alfalfa	90	90	90	90	—	—	—
Molassed wheat straw	52	63	—	—	—	—	—
Soybean hulls	—	—	224	310	—	—	—
Dehydrated beet pulp	—	—	90	90	61	61	58
Soybean meal	108	36	86	—	82	82	82
Barley grain	95	119	—	—	93	93	90
Wheat grain	112	141	—	—	93	93	90
Corn grain	36	46	—	—	77	77	74
Urea	2	—	5	5	—	—	12
Chemical composition, g/kg of DM							
OM	938	943	930	933	958	958	959
NDF	361	362	471	507	343	343	342
ADF	184	188	274	307	167	167	167
CP	142	110	144	111	122	122	156
Rumen degradable protein	98	74	97	76	98	97	134
Starch	29	32	15	15	ND[4]	ND	ND
FA, g/d							
16:0	66.9	70.4	56.5	52.8	71.2	70.0	70.1
18:0	12.2	11.9	12.8	12.3	11.1	11.3	10.9
18:1	83.9	89.0	82.0	77.7	110	109	110
18:2n-6	189	198	154	140	247	245	242
18:3n-3	29.9	29.7	30.1	29.6	19.1	19.3	18.9

[1]In experiments 1 and 2, 200 and 70 g, respectively, of a vitamin-mineral supplement was fed daily per dairy cow with the concentrate.

[2]The high level of N met 110% of protein requirements of cows expressed in the French protein digestible in the intestine system, whereas the low level covered 80% of these requirements with a shortage in rumen-degradable N (Fanchone et al., 2013).

[3]RNB = ruminal nitrogen balance, with RNB− = balanced diet in terms of ME and utilizable CP at the duodenum according to the average requirements of the dairy cows in experiment 2, but with a shortage of rumen degradable protein (RNB = −0.41 g of N/MJ of ME); RNB-NA = diet with the same composition as RNB− but to which 6 g/d of niacin was added; RNB0 = diet with the same composition as RNB− but to which urea was added to balance rumen degradable N supply (RNB = 0.08 g of N/MJ of ME; Aschemann et al., 2012).

[4]ND = not determined.