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Fatty acid intake and milk fatty acid composition of Holstein dairy cows under different grazing strategies: Herbage mass and daily herbage allowance

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ABSTRACT

The objective of this study was to investigate the effect of level of 1) pregrazing herbage mass (HM) and 2) level of daily herbage allowance (DHA) on the performance and fatty acid (FA) composition of milk from grazing dairy cows. Sixty-eight Holstein-Friesian dairy cows were allocated to either a high or low pregrazing HM (1,700 vs. 2,400 kg of DM/ha; >40 mm), and within HM treatment, cows were further allocated to either a high or low DHA (16 vs. 20 kg of DM/d per cow; >40 mm) in a 2 × 2 factorial design. Pregrazing HM did not affect dry matter intake (17.5 ± 0.75 kg/d), milk production (22.1 ± 0.99 kg/d), milk composition (milk fat, 3.88 ± 0.114%; milk protein, 3.28 ± 0.051%), body weight (525 ± 16 kg), or body condition score (2.65 ± 0.064). Increasing DHA increased dry matter intake (+1.5 kg/d) but did not affect any other variable measured. Cows grazing the low HM or high DHA had a higher daily intake of total FA (+0.12 and +0.09 kg/d, respectively, for the low HM and high DHA), α-linolenic acid (LNA; +0.08 and +0.05 kg/d, respectively, for the low HM and high DHA), and linoleic acid (+0.01 for both the low HM and high DHA) compared with either the high HM or low DHA. Milk conjugated linoleic acid (*cis*-9, *trans*-11 isomer) was not affected by treatment (13.0 ± 0.77 g/kg of total FA); however, large variation was recorded between individual animals (range from 5.9 to 20.6 g/kg of total FA). Milk concentrations of LNA were higher for animals offered the low HM (5.3 g/kg of total FA), but across treatments, milk concentrations of LNA were low (4.9 ± 0.33 g/kg of total FA). The present study indicates that changes in HM and DHA do not have a great effect on the milk FA composition of grazing dairy cows. Further enhancement of the beneficial FA content in milk purely from changes in grazing strategy may be difficult when pasture quality is already high.

Key words: conjugated linoleic acid, linolenic acid, herbage mass, daily herbage allowance

INTRODUCTION

There is increasing interest in enhancing the polyunsaturated fatty acid (**PUFA**) composition of the human diet, particularly the n-3 fatty acid (**FA**) and conjugated linoleic acid (**CLA**) content. Indeed, both these groups of PUFA are thought to confer positive effects on human health (Parodi, 1999; Hamazaki et al., 2003; Lock and Bauman, 2004). For humans, milk fat from dairy cows is one of the principal dietary sources of CLA (Khanal and Olson, 2004; Schroeder et al., 2004), a collective term for geometric and positional isomers of the essential dietary PUFA linoleic acid (**LA**), of which the *cis*-9, *trans*-11 isomer is the most predominant in ruminant tissues. Furthermore, concentrations of the essential n-3 PUFA α-linolenic acid (**LNA**; C18:3n-3) and its longer chain derivatives are present in ruminant tissue and milk (Lock and Bauman, 2004).

Many studies have shown that increased pasture intake leads to elevations in the CLA and n-3 FA concentrations of milk (Kelly et al., 1998; Dhiman et al., 1999; Kraft et al., 2003), potentially because of higher concentrations of LNA in particular in fresh herbage compared with either conserved forages or cereal-based concentrate feeds (Schroeder et al., 2004; Dewhurst et al., 2006). Conjugated linoleic acid is synthesized by ruminal microorganisms during the ruminal biohydrogenation of LNA and LA. The majority of tissue and milk CLA is formed through de novo mammary tissue synthesis from the desaturation of another product of this ruminal biohydrogenation process, vaccenic acid (**VA**; *trans*-11 C18:1), to *cis*-9, *trans*-11 CLA. This latter reaction is catalyzed by the actions of the enzyme stearoyl coenzyme A, otherwise known as Δ^9-desaturase (Lock and Garnsworthy, 2003), and is responsible for up to 90% of the *cis*-9, *trans*-11 CLA found in milk fat (Piperova et al., 2002; Lock and Garnsworthy, 2003). Furthermore, there is evidence of a synergistic relationship between dietary LA and n-3 PUFA intake

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on the synthesis of *cis*-9, *trans*-11 CLA in dairy cows (AbuGhazaleh et al., 2007).

Because the PUFA content in fresh forage is highly variable (Palladino et al., 2009), the milk PUFA content in grazing cows can be influenced by many factors, including the species and cultivars grazed as well as the quantity and quality of the herbage available. For example, seasonal effects on milk PUFA concentration have been identified, in which CLA was at a higher concentration in milk during spring and early summer compared with autumn, coincident with seasonal variation in the herbage PUFA content (Chilliard et al., 2001; Lock and Garnsworthy, 2003; Dewhurst et al., 2006). Furthermore, reducing the daily herbage allowance (**DHA**) from 20 to 16 kg of DM per cow reduced the concentration of CLA in milk (Stanton et al., 1997; Dewhurst et al., 2003). Additionally, Elgersma et al. (2004) recorded lower concentrations of milk CLA and VA when herbage allowance was reduced by 50%. Despite this, other authors have failed to observe any effect of modifying the pasture allowance on milk PUFA content (Dewhurst et al., 2006).

The equivocation between studies has resulted in a lack of clear information for producers on grazing management practices to optimize the concentration of health-promoting PUFA in milk across the season. Additionally, to the authors' knowledge, there is little or no published information on the effect of variation in pregrazing herbage mass (**HM**) on milk FA composition. Indeed, an understanding of how HM and DHA interact to affect sward structure, and thus milk yield and composition, is essential to successfully manipulate the concentration of beneficial FA in milk from grazing cows.

The objective of this study was therefore to examine the effect of contrasting levels of pregrazing HM (kg of DM/ha) and DHA (kg of DM/d per cow) on the milk FA composition of grazing dairy cows during 4 different stages of lactation (**SL**).

MATERIALS AND METHODS

The experiment was carried out at Moorepark Dairy Production Research Center, Fermoy, Co. Cork, Ireland (52°09′ N; 8°16′ W), during 2007. The soil type is a free-draining acid brown earth of sandy loam to loam texture. A predominantly perennial ryegrass (*Lolium perenne* L.) pasture was used during the experimental period. The swards were on average 5 yr old.

Animals and Experimental Design

The objective of this study was to investigate the effect of 2 levels of pregrazing HM (1,700 vs. 2,400 kg of DM/ha; >40 mm), and within this, 2 levels of DHA (16 vs. 20 kg of DM/d per cow; >40 mm) on the milk FA composition of grazing dairy cows. Sixty-eight Holstein-Friesian dairy cows (20 primiparous and 48 multiparous) were selected from the Moorepark spring-calving dairy herd and balanced by calving date (February 7; SD 15.6), lactation number (2.8; SD 1.84), and the following data, which were collected during wk 2 and 3 of lactation: milk yield (28.1; SD 4.26), BW (513; SD 64.2), and BCS (2.8; SD 0.41). Animals were then randomly allocated within block to 1 of 4 treatments in a 2 × 2 factorial design replicated over 4 time points (April, May, July, and August) representing different SL, although these time points also represented differences in the stage of grass growth. Cows commenced the study at 74 DIM (SD 14.7). The 4 treatments were **HH** (high HM, high DHA), **HL** (high HM, low DHA), **LH** (low HM, high DHA), and **LL** (low HM, low DHA). Fresh herbage was allocated to each treatment group on a daily basis after the morning milking. A small quantity of concentrate (0.4 kg/cow per day) was offered in the milking parlor in 2 equal feedings at both the morning and evening milking (concentrate composition, on a fresh weight basis, was ground citrus pulp, 0.305 kg/kg of concentrate; barley, 0.237 kg/kg of concentrate; corn (*Zea mays*) gluten, 0.249 kg/kg of concentrate; soybean meal, 0.14 kg/kg of concentrate; vitamin-mineral mix, 0.043 kg/kg of concentrate; and fat, 0.026 kg/kg of concentrate. Chemical analyses are shown in Table 1).

Sampling, Measurements, and Analyses

HM Determination. Herbage mass (grass cut at >40 mm above ground level) was calculated by cutting 4 strips (1.2 × 10 m) for each herbage allowance area twice weekly with an Agria machine (Etesia UK Ltd., Warwick, UK) to determine sward density and HM. Ten grass height measurements were also recorded before and after harvesting by using an electronic plate meter (Urban and Caudal, 1990) with a plastic plate (30 × 30 cm and 4.5 kg/m; Agrosistèmes, Choiselle, France). The herbage harvested was weighed, and subsamples were collected (approximately 0.1 kg) for DM determination at 95°C over 16 h. Additional subsamples were collected for chemical composition (including FA analysis) and stored at −20°C before being freeze-dried. To calculate the sward density, the following equation was used:

$$\text{Sward density} = \{\text{HM (kg of DM/ha)} \div [\text{precutting height} - \text{postcutting height (kg of DM/cm per ha)}]\}.$$

Pre- and Postgrazing Sward Heights. Pregrazing sward height was measured daily throughout the ex-