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Feeding fat from distillers dried grains with solubles to dairy heifers: II. Effects on metabolic profile

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ABSTRACT

The objective of this study was to determine if increased dietary fat from dried distillers grains with solubles (DDGS) in diets of growing heifers affected metabolic profile, plasma fatty acid profile, and reproductive maturation. Thirty-three Holstein heifers (133 ± 18 d of age) were used in a 24-wk randomized complete block design with 3 treatment diets. Treatment diets were (1) control (CON) containing ground corn (15.9% of DM) and soybean products (17.9%), (2) low-fat (LFDG) containing low-fat DDGS (21.9%) and ground corn (11.9%), or (3) high-fat (HFDG) with traditional DDGS (33.8%). Diets were isonitrogenous and isocaloric, but the HFDG diet was formulated to contain 4.8% fat compared with 2.8% in the CON and LFDG diets. All 3 diets were limit-fed to 2.45% of body weight on a dry matter basis, and resulted in a mean average daily gain of 0.96 kg/d across treatments. Every 4 wk, jugular blood was collected for analysis of metabolites and metabolic hormones. During wk 20 of the feeding period, blood samples were collected for analysis of plasma fatty acid profiles. When heifers weighed between 200 and 300 kg of body weight, coccygeal blood samples were taken twice weekly for analysis of progesterone to determine if puberty had been reached. Plasma concentrations of nonesterified fatty acids were similar among treatments and consistent over the duration of the study. Plasma concentrations of β-hydroxybutyrate, insulin, insulin-like growth factor-1, and leptin were similar among heifers fed each treatment diet, but increased over the duration of the feeding period. Serum concentrations of glucose tended to be less in heifers fed HFDG compared with heifers fed the CON diet. Glucose concentrations fluctuated throughout the feeding period, but no treatment by time interactions were noted. Plasma urea N concentrations were less in heifers fed LFDG compared with heifers fed HFDG and CON diets. The concentrations of plasma urea N increased over the duration of the feeding period, with no treatment by week interaction. Total plasma cholesterol was greater in heifers fed HFDG compared with the CON and LFDG diets, and a significant week effect and a week by treatment interaction were observed. Fatty acid profiles also differed among treatments based on the supply of fatty acids from the diet. Progesterone analysis indicated that heifers fed HFDG tended to be pubertal at a younger age than heifers on CON. These results demonstrate that dietary fat from DDGS can be used in high-plane of nutrition rations for growing heifers and maintain metabolic energy status compared with starch from corn, but alters the concentrations of different blood lipids.

Key words: dairy heifer, distillers grains, metabolic profile

INTRODUCTION

Previous research on feeding distillers grains to dairy heifers has demonstrated that growth performance can be maintained compared with feeding other common feedstuffs (Anderson et al., 2009; Schroer et al., 2014). It has been established in previous research (Anderson et al., 2006, 2009; Schingoethe et al., 2009) that feeding conventional distillers grains at increasing inclusion rates also increases dietary fat concentrations. Because of these changes in dietary nutrient profile compared with traditional corn- and soybean-based diets, metabolites, metabolic hormones, and body composition may be affected. It was speculated that metabolic changes may be occurring despite similar ADG or skeletal growth, even when all heifers are fed on a high plane of nutrition. Changes in metabolic profile are of particular interest in dairy heifers for several reasons. First,

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metabolic status and body composition are linked to the onset of puberty (Funston et al., 2012; Perry, 2012). Second, timing of puberty and rate of gain have been found, in turn, to influence mammary development and subsequent milk production (Tucker, 1981; Van Amburgh et al., 1998; Zanton and Heinrichs, 2005). In light of these findings, determining if increased dietary fat from feeding distillers dried grains with solubles (**DDGS**) results in changes in metabolic profile, in particular, metabolites and hormone related to energy metabolism, or onset of puberty is an important endeavor because differences could influence long-term performance.

Research regarding effects of feeding specific FA profiles to growing dairy calves and heifer diets is lacking. It is speculated that certain FA may be more beneficial than others, although results were conflicting in calf study by Hill et al. (2009) and a calf-to-heifer (0–6 mo of age) feeding study by Thibault et al. (2003). Polyunsaturated fat was reported to increase pubertal mammary growth in sheep (McFadden et al., 1990), but Thibault et al. (2003) fed dairy heifers a high-soybean oil diet that was high in linoleic acid and found no differences in growth or mammary development. Ambrose et al. (2006) demonstrated that dietary supplementation of PUFA, in particular α-linolenic acid, improved reproduction in lactating cows, and Thomas et al. (1997) demonstrated that isolipidic diets affected reproduction differently depending on degree of saturation in beef heifers.

Leptin is of interest because it may be a link between metabolic status and reproductive status (Zieba et al., 2005). When growing animals reach a certain metabolic status or body fat composition, leptin is thought to have a permissive action on release of gonadotropin releasing hormone (Zieba et al., 2004, 2005). In beef heifers it has been demonstrated that serum concentrations of leptin increased in a linear fashion from 16 wk before puberty until the week of ovulation (Maciel et al., 2004).

Distillers dried grains with solubles have a relatively high fat value at 10 to 15% ether extract. Typically 50% of the fat in DDGS is linoleic acid (C18:2; Leonardi et al., 2005; Anderson et al., 2006, 2009). Linoleic acid is thought to be one of the essential FA because it can be elongated to arachidonic acid and cholesterol, which are used for hormone synthesis and cellular membranes (Simopoulos, 1991). In beef heifers, research revealed that feeding DDGS did not affect age or BW at puberty, but did improve AI conception rates and pregnancy rates compared with a control supplement of equal energy (Martin et al., 2007).

The major objective of our study was to characterize how increased dietary fat from feeding a high inclusion rate of DDGS affected the blood metabolic profile, including key metabolic hormones and metabolites related to energy metabolism, in growing dairy heifers fed on a high plane of nutrition. Because FA composition has been shown to differentially affect reproduction, it was also a goal to characterize the plasma FA profiles. A secondary objective was to determine if changes in metabolism were enough to change age at onset of puberty. However, because of the scope of this research we were only able to use low numbers of heifers, thus the secondary objective was preliminary in nature and focused more on determining if future research is warranted rather than making definitive conclusions. The main hypothesis was that metabolic and FA profiles would be different between the HFDG diet compared with the CON and LFDG diets because of the replacement of starch with fat as an energy source in diets that provided for high rates of ADG. It was also hypothesized that changes in metabolic profiles may influence the age at onset of puberty among treatments.

MATERIALS AND METHODS

Experimental Design

Samples for this research were taken during the feeding study described in the companion paper (Anderson et al., 2015); for more details on diets, feeding protocols, and heifer growth characteristics, refer to that paper. Briefly, 33 heifers were used in randomized complete block design with 3 dietary treatments. The study lasted for 24 wk during the prepubertal growth period. The 3 treatment diets (Table 1) were a control diet containing corn and soybean products (**CON**), a diet utilizing low-fat distillers dried grains that was similar to the control in starch and fat content (**LFDG**), and a diet containing traditional DDGS that was lesser in starch and higher in fat (**HFDG**) compared with the CON and LFDG diets. All diets contained approximately 40% grass hay and 25% corn silage on a DM basis. The diets were formulated to be isonitrogenous and isocaloric. Diets were limit-fed to 2.45% of BW on a DM basis. Diets provided for a high plane of nutrition, as ADG averaged 0.96 kg/d for the 3 treatments (Anderson et al., 2015). Throughout the feeding period, collection of blood samples was performed for assessment of metabolic and reproductive status of the growing heifers via analysis of hormones and metabolites.

Sample Collection and Analysis

For analysis of glucose, NEFA, BHBA, cholesterol, plasma urea nitrogen (**PUN**), insulin, IGF-1, and