J. Dairy Sci. 101:1–14
https://doi.org/10.3168/jds.2018-14843

Highly fermentable starch at different diet starch concentrations decreased feed intake and milk yield of cows in the early postpartum period

Rodrigo I. Albornoz and Michael S. Allen[1]
Department of Animal Science, Michigan State University, East Lansing 48824

ABSTRACT

The objective of this study was to evaluate the effects of diet starch concentration and fermentability (SF) fed during the early postpartum (PP) period on dry matter intake (DMI), yields of milk and milk components, body reserves, and metabolism. Fifty-two multiparous Holstein cows were used in a randomized block design with a 2 × 2 factorial arrangement of treatments. Treatment diets were formulated to 22% (LS) or 28% (HS) starch with dry ground corn (DGC) or high-moisture corn (HMC) as the primary starch source. Treatments were fed from 1 to 23 d PP and cows were switched to a common diet until 72 d PP to measure carryover (CO) effects. Treatment period (TP) diets were formulated for 22% forage neutral detergent fiber and 17% crude protein, and starch concentration was adjusted by substitution of corn grain for soyhulls. Throughout the experiment DMI and milk yield were measured daily, and milk components, body condition score (BCS), and body weight were measured weekly. Blood was collected weekly during the TP and every second week during the CO period. During the TP, HMC decreased DMI more when included in the HS (3.9 kg/d) than in the LS (0.9 kg/d) diets and HMC decreased yields of milk, fat, and FCM by 4.3, 0.19, and 4.8 kg/d, respectively. Treatments also interacted over time to decrease DMI and yields of milk and milk components more for HMC compared with DGC as time progressed during the TP. Loss of BCS was increased when HMC was fed in a HS diet (−0.38 vs. −0.17) and decreased when included in a LS diet (−0.21 vs. −0.29) with no effects on body weight change during the TP. Treatments interacted with time to affect plasma concentrations of glucose and insulin with HS increasing concentrations early in the TP compared with LS but with similar effects by the end of the TP. During the CO period, treatment effects on DMI diminished over time with no main effects of treatment for the entire period. Starch concentration and SF interacted to affect yields of milk, fat, and FCM during the CO period, which were greater for HS-DGC and LS-HMC (54.8 and 52.8, 1.76 and 1.81, and 51.3 and 52.2 kg/d, respectively) than for LS-DGC and HS-HMC (51.2 and 51.0, 1.68 and 1.64, and 48.4 and 48.6 kg/d, respectively). Treatments did not affect BCS change during the CO period but HS lost body weight compared with LS (−5.7 vs. 7.0 kg). Blood glucose and insulin concentrations were not affected by treatments during the CO period. Feeding a highly fermentable starch source during the early PP period decreased DMI and yields of milk and milk components compared with a less fermentable starch source and the depression in DMI was greater when fed in the higher starch diet. However, diet starch concentration had no effects on yield of milk or milk components.
Key words: starch concentration, starch fermentability, hepatic oxidation theory

INTRODUCTION

Feed intake during the early postpartum (**PP**) period is often inadequate to support the rapid increase in energy required for milk production resulting in negative energy balance affecting health, production, and reproductive performance (Herdt, 2000; Butler, 2003; Ospina et al., 2010). Inadequate nutrition during early lactation resulted in a negative carryover effect on milk yield of 22 to 63% during the following 3 to 12 wk for several studies reviewed by Jørgensen et al. (2016). Energy intake during the early PP period can be increased by substituting high-starch feeds for fiber sources with lower digestibility to a point beyond which rumen function is compromised or feed intake is depressed. Starch is an important source of fermentable energy for rumen microorganisms (Koenig et al., 2003) and supplies glucose and glucose precursors to the cow. However, few studies have investigated the effects of diet starch concentration during the early PP period, and these studies have yielded inconclusive results. Increasing diet starch concentration increased DMI in studies reported by Rabelo et al. (2003) and Andersen et al. (2003) but had no effect on DMI in studies reported by

Received March 28, 2018.
Accepted June 3, 2018.
[1]Corresponding author: allenm@msu.edu

Nelson et al. (2011) and McCarthy et al. (2015a). In addition, ruminal fermentability of starch varies greatly with grain type, processing, and conservation method (Allen, 2000), but increased starch fermentability decreased DMI in one study (Sadri et al., 2009) and had no effect in another (Rockwell and Allen, 2016).

Conflicting results of previous studies reported in the literature evaluating effects of diet starch concentration and fermentability are likely from interactions among diet starch concentration and fermentability, diet forage NDF (**fNDF**) concentration and duration of treatments. Propionate from ruminal fermentation of starch is a primary glucose precursor needed to restore euglycemia, but propionate can also suppress feed intake (Oba and Allen, 2003a; Bradford and Allen, 2007), especially for cows in the PP period that are in a lipolytic state (Oba and Allen, 2003a; Piantoni et al., 2015a). This suppression of feed intake has been linked to the stimulation of fuel oxidation in the liver by propionate, with hypophagic effects likely aggravated during the early PP period when cows increase mobilization of body reserves and acetyl CoA available for hepatic oxidation is increased (Oba and Allen, 2003b; Stocks and Allen, 2012, 2013; Piantoni et al., 2015a).

Our objective was to evaluate the combined effects of diet starch concentration and fermentability for cows in the early PP period and their potential carryover effects on DMI, yields of milk and milk components, body reserves, and metabolism. The starch treatments were corn grain harvested as high-moisture (high ruminal fermentability) or dry (moderate ruminal fermentability). Starch concentration of diets were adjusted by substituting corn grain for soyhulls, keeping fNDF and the filling effect of diets constant. We hypothesized that rations with highly fermentable starch will decrease DMI and yields of milk and milk components by cows during the early PP period compared with rations with moderate starch fermentability, and effects will be greater for diets with greater starch concentration. We also hypothesized that treatment effects during the PP period will carryover once they receive a common diet but the effects will diminish over time.

MATERIALS AND METHODS

Animal Care

This study was conducted from February 1 to November 15, 2015, at the Dairy Cattle Research and Teaching Center at Michigan State University with all experimental procedures approved by the Michigan State University Institutional Animal Care and Use Committee (East Lansing, MI; AUF 11/13–254–00). Cows were housed individually in tiestalls, allowing for daily records of feed offered and refused, and fed once a day (0800 h) at 115% of expected intake and milked at the parlor twice a day (0400 h and 1430 h). All cows were in apparent good health at the beginning of the experiment, and standard farm health and reproductive protocols were maintained during this study. Signs for ketosis (e.g., depressed feed intake and milk yield and change in normal behavior) were monitored daily and diagnosis was aided with the use of a urine ketone test (Ketostix, Bayern Corp., Elkhart, IN). Confirmed cases were administered 300 mL of propylene glycol for 3 to 5 d.

Experimental Design and Treatments

Fifty-two multiparous Holstein cows were used in a completely randomized block design experiment with 2 × 2 factorial arrangement of treatments with 13 cows per treatment. Blocking criteria consisted of BCS observed within 1 wk before expected calving date (up to 1 unit difference using a 5-point scale, where 1 = thin and 5 = fat; Wildman et al., 1982), previous lactation 305-d mature equivalent milk production (within 5,000 kg) and date of parturition (within 60 d). A common close-up diet was fed from 21 d before expected parturition date until calving. This diet contained corn silage, mature grass hay, dry ground corn, soybean meal, Soy-Chlor (West Central Soy, Ralston, IA), and a mineral and vitamin mix, and was formulated to contain 42.5% NDF, 38.3% fNDF, 21.5% starch, and 13.5% CP.

Treatments included diet starch concentration (**SC**; low starch = 22%, **LS**, or high starch = 28%, **HS**) and diet starch fermentability (**SF**; dry ground corn, **DGC**, or high-moisture corn, **HMC**). At calving, cows were randomly assigned to 1 of the 4 diet treatment combinations (LS-DGC, LS-HMC, HS-DGC, HS-HMC). Dry ground corn grain was stored in a covered gravity wagon and HMC was ground and ensiled in a bag (Ag-Bag Plastic, Cottage Grove, MN) for at least 4 mo after harvest before utilization. Differences in SF were confirmed by 7-h in vitro starch digestibility analysis before and throughout the experiment (Table 1) according to Goering and Van Soest (1970). Starch concentration of treatment diets was adjusted by partially replacing the main starch source with soyhulls to maintain the same fNDF concentration across treatment diets. Treatment diets contained alfalfa silage, grass hay, corn grain treatments, soyhulls, soybean meal, minerals, and vitamins and were formulated to 17% CP and 22% fNDF (Table 2). Cows received their respective diets beginning at the day of calving if they calved before feeding time (0800 h) or at the following morning's feeding until 23 d