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Effects of Feeding Prepubertal Heifers a High-Energy Diet for Three, Six, or Twelve Weeks on Feed Intake, Body Growth, and Fat Deposition

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ABSTRACT

The objective was to determine the effects of feeding prepubertal dairy heifers a high-energy diet for a duration of 0, 3, 6, or 12 wk on feed intake, growth, and fat deposition. We also used feed composition, daily intake, and body growth data to evaluate the nutritional model of the 2001 National Research Council (NRC) Nutrient Requirements of Dairy Cattle. Holstein heifers (age = 11 wk; body weight = 107 ± 1 kg) were assigned to 1 of 4 treatments (n = 16/treatment) designated H0, H3, H6, and H12 and fed a low-energy diet for 12, 9, 6, or 0 wk, followed by a high-energy diet for 0, 3, 6, or 12 wk, respectively. Four heifers were killed initially (11 wk of age) and 64 heifers were killed at the end of the treatment period (23 wk of age). The low-energy diet was formulated to achieve 0.6 kg of average daily gain and contained 16% crude protein, and 45% neutral detergent fiber. The high-energy diet was formulated to achieve an average daily gain of 1.2 kg and contained 18% crude protein and 23% neutral detergent fiber. Actual daily gains averaged over the 12-wk treatment period were 0.64, 0.65, 0.83, and 1.09 kg for the H0, H3, H6, and H12 groups, respectively. Body weight, withers height, hip width, carcass weight, liver weight, and perirenal fat increased in heifers fed a high-energy diet for a longer duration. In addition, percentage of fat increased and percentage of protein decreased in rib sections with a longer duration on the high-energy diet. Uterine and ovarian weights adjusted for body weight decreased when heifers were fed the high-energy diet for a longer duration. The 2001 NRC underestimated dry matter intake of the high-energy diet and overestimated dry matter intake of the low-energy diet. On the basis of actual intakes of each diet, the NRC slightly underestimated gain for the low-energy diet and overestimated gain by 40% for the high-energy diet. The likely explanation for this is that the NRC underestimated the proportion of gain that was fat in the heifers fed the high-energy diet and therefore predicted more body gain per unit of energy intake. We concluded that feeding a high-energy diet for a short duration altered body growth and fat deposition in a time-dependent, linear manner consistent with feeding a high-energy diet for a long duration.
Key words: heifer, nutrition, growth, carcass

INTRODUCTION

Raising replacement dairy heifers accounts for approximately 20% of total dairy herd expenses, with actual costs until calving ranging from $1,000 to $1,300 per heifer (Cady and Smith, 1996). The optimal BW of heifers before calving ranges from 590 to 640 kg (Hoffman, 1997); typically, calving occurs at 24 to 26 mo of age. Feeding a high-energy diet to allow for rapid growth enables heifers to be bred and calve earlier, potentially reducing the costs associated with raising replacement heifers while still achieving the optimal BW. However, mammary growth relative to body growth and milk yield potential are reduced when heifers that are approximately 3 to 10 mo of age are fed high-energy diets that promote gains of >1 kg/d for periods of 12 wk or longer (Sejrsen et al., 1982; Petitclerc et al., 1999; Radcliff et al., 2000). Feeding heifers for gains of >1 kg/d also increases the amount of fat deposition (Radcliff et al., 1997). Thus, a major goal in raising replacement heifers is to manage them for rapid structural growth along with optimal development of the mammary gland. Although some fat deposition is necessary, fat gain contributes little to structural growth, decreases the efficiency of feed use, and may compromise mammary development.

If prepubertal heifers are fed high-energy diets to promote rapid BW gains for >3 mo, their body tissue gain has a greater proportion of fat (Radcliff et al., 1997; Waldo et al., 1997). However, steers fed a high-energy diet following a period of a low-energy diet deposited more protein and less fat than control steers during the first weeks of the new diet (Fox et al., 1972). Therefore, we hypothesized that feeding heifers high-energy diets for a short duration also might increase gains, with

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little increase in body fatness and no inhibition of mammary development. Such an effect would be consistent with our previous finding that high-energy intake before weaning increases structural growth without increased fatness and mammary impairment (Brown et al., 2005a,b). Such an effect also would be consistent with the reported benefits of a stairstep feeding program for dairy heifers (Park et al., 1987; Choi et al., 1997). Short periods of high-energy feeding in young heifers might be one cost-effective way to decrease age at first calving and improve the efficiency of growth without causing a detrimental effect on mammary development or an increase in body fatness.

The major objective of this study was to determine whether feeding prepubertal dairy heifers a high-energy diet for a short duration altered body growth, organ weights, and body fatness differently from what would be expected based on feeding a high-energy diet for a long duration. Prior studies with prepubertal heifers that involved treatment periods of 12 wk or longer indicated that high-energy intake caused excessive fat deposition and hampered mammary growth relative to body growth. Thus, 12 wk was selected as a long duration time point, 6 and 3 wk as shorter duration time points, and 0 wk of feeding a high-energy diet as a baseline control treatment. Treatment effects on mammary growth are reported in a companion paper (Davis Rincker et al., 2008).

The Nutrient Requirements of Dairy Cattle (NRC, 2001) is commonly used as a reference for nutrient analysis, nutrient utilization, and diet formulation. Few studies have been published that have evaluated the 2001 NRC (Gabler and Heinrichs, 2003). Van Amburgh (2005) suggested that actual gains of heifers are typically higher than those predicted by the model. However, despite data showing that increased daily gain increases the proportion of gain that is fat in 5- to 10-mo-old heifers (Radcliff et al., 1997; Waldo et al., 1997), the composition of gain in the 2001 NRC is relatively insensitive to changes in the rate of gain. Thus, a second objective of this study was to evaluate the nutritional model of the 2001 NRC for heifers between 3 and 6 mo.

MATERIALS AND METHODS

Animals and Dietary Treatments

Animals. For the study, we used Holstein heifers from 11 to 23 wk of age. This age was selected because we were confident that almost all the animals would not reach puberty before slaughter. Furthermore, recent evidence from our laboratory showed that feeding for rapid growth before 14 wk of age increases mammary parenchymal gain as much as or more than the increase in body growth (Brown et al., 2005a,b). Sixty-eight heifers (approximate age = 8 wk) were purchased from a supplier during 4 consecutive weeks in the fall (17 heifers/wk), with each week classified as a separate purchase group. Heifers were housed at the Michigan State University Beef Cattle Research Center and were exposed to ambient temperatures and lighting during the adaptation and treatment periods, which occurred during late fall and winter. Heifers were housed with 4 animals per pen in an open-sided barn with enough space per pen (50 m^2/pen) to allow for exercise. All procedures were approved by the Michigan State University Animal Care and Use Committee.

Each purchase group was allowed a 3-wk adaptation period for adjustment to facilities and diet. At the beginning of the adaptation period, heifers were fed a texturized complete feed (21% CP; ADM, Quincy, IL) and alfalfa hay; this was similar to how they were fed before arrival on campus. Alfalfa silage, corn silage, oatlage, and straw were slowly introduced into the diet during the first 2 wk of the adaptation period. For the last week of the adaptation period, heifers were consuming a TMR that was a 1:1 mixture of the high- and low-energy treatment diets. One heifer within each purchase group was randomly selected and slaughtered at 11 wk of age for baseline measurements used for calculation of accretion rate data (see Davis Rincker et al., 2008).

Body temperatures was measured daily during the first week of the adaptation period, and thereafter only if heifers appeared ill; heifers were treated if body temperatures were greater than 39.7°C, appeared ill, or were lame. During the second week of the adaptation period, heifers were vaccinated against bovine rhinotracheitis, bovine viral diarrhea, parainfluenza type 3, and leptospirosis (BoviShield4, Pfizer, New York, NY); pasteurella (Pfizer); and *Clostridium perfringens* (Ultrabac7/Somubac, Pfizer). No animals died during the adaptation or treatment periods. A total of 6 heifers appeared ill and were medicated during the treatment period. One heifer (treatment H3) had chronic bloat, and the other 5 heifers were treated once for respiratory-type symptoms (H0 = 1; H3 = 2; H6 = 2; H12 = 0). All heifers given medication were being fed the low-energy diet at the time of the apparent illness.

Treatments. At 11 wk of age, 16 heifers within each purchase group were blocked by BW and randomly assigned within block to 1 of 4 treatments (BW = 107 ± 1 kg). All heifers within a given treatment in the same purchase group were housed in the same pen. Thus, 4 pens of 4 heifers (1 pen per purchase group) were used in each of the 4 treatments. The timeline for the experiment is depicted in Figure 1. In our study, we used 2 basic diets (high energy or low energy), but the treatments were the number of weeks that heifers were fed