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Effect of limit feeding high- and low-concentrate diets with *Saccharomyces cerevisiae* on digestibility and on dairy heifer growth and first-lactation performance[1]

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ABSTRACT

Growth and digestibility were examined for heifers limit fed high- (HC; 60%) and low-concentrate (LC; 20%) diets with or without yeast culture (YC) addition in 2 experiments. A third experiment was undertaken to monitor first-lactation production of heifers limit fed HC or LC diets. In experiment 1, 32 Holstein heifers were individually fed at controlled intakes for 133 d to maintain a targeted average daily gain of 0.80 kg/d for all 4 treatments [HC; LC with and without *Saccharomyces cerevisiae*; Yea-Sacc[1026] (Alltech Inc., Nicholasville, KY), 1 g/kg as fed]. Targeted average daily gain was achieved for all treatments during the individual feeding period (0.80 ± 0.01 kg/d). Average dry matter intake needed to maintain constant gain was slightly reduced for HC and YC treatments. Reduced dry matter intake and similar targeted average daily gain resulted in a tendency for improved feed efficiency of HC-fed heifers. Skeletal measurements and targeted average daily gain were not affected by concentrate level or YC. The objective of experiment 2 was to elucidate effects of concentrate level and YC on nutrient digestibility. Four young (284.35 ± 4.51 d) and 4 older (410.28 ± 2.14 d) heifers were allocated to the 4 treatments used in experiment 1. Heifers fed the HC diet had increased dry matter digestibility (75.67 vs.72.96 ± 0.72%), and YC addition increased dry matter digestibility (74.97 vs. 73.65 ± 0.71%). Intake of N and apparent N digestibility were similar for all treatments. High-concentrate diets and YC addition decreased wet and dry matter output of feces. Urine excretion was not different; therefore, total manure output was lower for HC-fed heifers as compared with LC-fed heifers. Results suggest that HC diets can improve feed efficiency without affecting growth when limit fed to dairy heifers. Yeast culture increased dry matter digestibility in HC- and LC-fed heifers; HC diets were more digestible and reduced fecal output, with YC enhancing this effect. In experiment 3, heifers from experiment 1 were group fed the same diets (HC or LC) without YC until parturition, and milk production was measured through 154 d of lactation. Group-fed average daily gain was not different between treatments (HC = 1.11 vs. LC = 1.04 kg/d, SE = ±0.06 kg/d). Heifers fed the HC and LC diets calved at 23.50 and 23.79 ± 0.50 mo, respectively. Peak milk was lower and there was a tendency for reduced daily milk and protein yield for primiparous cows fed HC diets from 8 mo of age to the dry/prefresh period (long term), but predicted yields of milk and components were similar in the first 154 d of lactation.
Key words: growth, first lactation, digestibility, forage-to-concentrate ratio, yeast culture

INTRODUCTION

Finding strategies to raise dairy replacement heifers economically and efficiently is important in order to increase dairy industry profitability. Although heifers contribute no revenue until the onset of lactation, costs from birth to calving represent the second or third largest expense on a dairy farm (Heinrichs, 1993). Several cost-containment strategies have been explored (e.g., accelerated growth, reduced age at first calving, bST injections), but these have been inapplicable or have reduced milk production in first lactation (Van Amburgh et al., 1998; Lammers et al., 1999; Radcliff et al., 2000).

Dairy heifers are typically fed high-fiber diets, but there is inherent energy and protein inefficiency in these diets (Moody et al., 2007; Zanton and Heinrichs, 2007). This has attracted growing attention to the use of high-concentrate diets to improve feed utilization by ruminants. Reynolds et al. (1991a,b) observed that growing beef heifers retained more tissue energy when animals were fed a constant level of ME from high-concentrate (**HC**; 75% concentrate) versus low-concentrate (**LC**; 25% concentrate) diets, with the HC-fed heifers exhibiting less heat energy production. These findings appear to suggest that maintenance requirements for

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the purposes of digestion could be reduced, allowing a greater proportion of nutrients to be used for productive purposes (Zanton and Heinrichs, 2007). Thus, use of HC diets permits a reduction of the DMI needed to satisfy the nutrient requirement of the animal.

An important consideration when using this type of diet is to restrict intake to avoid problems related to increased ADG and reduction in first-lactation performance (Van Amburgh et al., 1998; Lammers et al., 1999). Research to date suggests that a prepubertal ADG of approximately 0.80 kg/d is appropriate for large-breed dairy heifers to maximize first-lactation milk yield (Sejrsen et al., 2000; Zanton and Heinrichs, 2005). Recently, the use of HC diets fed restrictively has reduced manure output (Moody et al., 2007), resulted in similar milk yields (Hoffman et al., 2007; Zanton and Heinrinchs, 2007), and had no negative effects on rumen fermentation (Lascano and Heinrichs, 2009). However, there is a gap in the literature concerning the prolonged effect of HC or LC diets when fed from 8 mo of age to the dry/prefresh period (long term; **LT**) for a constant growth rate.

In addition, when limit feeding high-energy forages and diets, growth and performance of the growing dairy heifer might be challenged. Research shows that when yeast culture (**YC**) is added to ruminant diets, an increase in total number of rumen bacteria is often observed, including cellulolytic and lactate-using species. Although in many studies the increased number of bacteria did not reach statistical significance, most research demonstrated that feeding yeast stimulated total bacteria numbers (Lascano and Heinrichs, 2007). This stimulation of bacteria numbers can affect DM digestibility (**DMD**) because bacteria are required for rumen fiber degradation. Also, increased microbial protein flow to the small intestine and a lower risk of lactic acidosis (Erasmus et al., 1992; Martin and Nisbet, 1992; Wallace, 1994) could be beneficial for animal performance. It has been noted that when feeding traditional high-forage diets, the response of lactating cows and heifers to YC addition is variable and might have a more stable response when used in HC diets (Wallace, 1994).

Our project focused on reducing the costs to raise dairy heifers by feeding more concentrates relative to forages at a targeted ADG (**T-ADG**). In the United States, feed costs per unit of energy or protein are often cheaper for concentrates than for forages, and the use of YC in this type of diet could improve animal performance. Therefore, the objectives of these experiments were to evaluate 1) growth–feed efficiency (**FE**; kg of ADG/kg of DMI), 2) diet digestibility and N utilization of heifers limit fed HC or LC diets with or without supplemental YC, and 3) first-lactation milk production for primiparous cows fed HC or LC diets LT for a constant ADG.

MATERIALS AND METHODS

Experiment Layout

Three experiments were conducted according to guidelines from The Pennsylvania State University Institutional Animal Care and Use Committee. Experiment 1 was a heifer growth trial that lasted for 133 d with 4 treatments using a completely randomized block design. Experiment 2 was a digestibility trial undertaken concurrently, utilizing the same diets and treatments as experiment 1. A split-plot, Latin square design with heifer age as the whole plot and treatment as subplot was used. Experiment 3 utilized heifers from experiment 1; heifers were group fed the same diets (HC or LC) without YC until parturition, and milk production was measured through 154 d of lactation.

Diets

Total mixed rations consisted of corn silage (sole forage source) with primary concentrate feeds (Table 1). Heifers were fed once a day at 0800 and 1000 h for experiments 1 and 2, respectively. Rations were mixed in a Calan Super Data Ranger (American Calan, Northwood, NH) for approximately 5 min, with refusal amounts recorded before feeding. Refusal amounts were negligible, and the amounts were recorded but not sampled. The forage-to-concentrate ratios (**F:C**) for HC and LC diets were 40:60 and 80:20, respectively. Forage and TMR samples were collected daily and composited every 15 d and monthly, respectively; concentrate samples were collected once per month. Immediately after collection, samples were dried in a forced-air oven (55°C) for 3 consecutive days and then stored for further analyses. Feedstuffs and TMR were ground through a 1-mm screen using a Wiley mill (Arthur H. Thomas, Philadelphia, PA) and analyzed for DM, OM, ash (AOAC, 1990), and ADF and NDF (Van Soest et al., 1991) using an Ankom^{200} Fiber Analyzer (Ankom Technology Corporation, Fairport, NY) with heat-stable α-amylase and sodium sulfite for the NDF procedure. Crude protein was analyzed using the Kjeldahl method (AOAC, 1990). Rations were formulated and fed restrictedly to provide 0.80 kg/d T-ADG and 0.22 Mcal of ME intake/kg of empty BW$^{0.75}$, with a fixed level of 13% CP. For experiment 3, heifers that finished experiment 1 were assigned to the same HC or LC diets but without YC addition. They were fed once daily at 0800 h, as in experiment 1, and then moved to dry-cow/prefreshening pens with uniform diets. After