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Performance strategies affect mammary gland development in prepubertal heifers

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ABSTRACT

In Brazil, the majority of dairy cattle are Holstein × Gyr (H×G). It is unknown whether excessive energy intake negatively affects their mammary development to the same extent as in purebred Holsteins. We hypothesized that mammary development of H×G heifers can be affected by dietary energy supply. We evaluated the effect of different average daily gains (ADG) achieved by feeding different amounts of a standard diet during the growing period on biometric measurements, development of mammary parenchyma (PAR) and mammary fat pad (MFP), and blood hormones. At the outset of this 84-d experiment, H×G heifers (n = 18) weighed 102.2 ± 3.4 kg and were 3 to 4 mo of age. Heifers were randomly assigned to 1 of 3 ADG programs using a completely randomized design. Treatments were high gain (HG; n = 6), where heifers were fed to gain 1 kg/d; low gain (LG; n = 6), where heifers were fed to gain 0.5 kg/d; and maintenance (MA; n = 6), where heifers were fed to gain a minimal amount of weight per day. Heifers were fed varying amounts of a single TMR to support desired BW gains. Over the 84 d, periodic biometric and blood hormone measurements were obtained. On d 84, all heifers were slaughtered and carcass and mammary samples were collected. At the end, HG heifers weighed the most (181 ± 7.5 kg), followed by LG (146 ± 7.5 kg) and MA (107 ± 7.5 kg) heifers. The ADG were near expected values and averaged 0.907, 0.500, and 0.105 ± 0.03 kg/d for HG, LG, and MA, respectively. In addition, body lengths, heart girths, and withers heights were affected by dietary treatment, with MA heifers generally being the smallest and HG heifers generally being the largest. Body condition scores differed by treatment and were highest in HG and lowest in MA heifers; in vivo subcutaneous fat thickness measurement and direct analysis of carcass composition supported this. The HG heifers had the heaviest MFP, followed by LG and then MA heifers. Amount of PAR was highest in LG heifers and was the same for HG and MA heifers. The percentage of udder mass occupied by PAR was lowest in HG heifers, differing from LG and MA heifers. Composition of MFP was not evaluated. Regarding PAR composition, no differences in ash or DM were found. On the other hand, CP concentration of PAR for HG heifers was lower than that for LG heifers, which was lower than that for MA heifers. Regarding the fat content, HG treatment was higher than LG and MA treatment, which did not differ from each other. In PAR, differences in relative abundance of genes related to both stimulation and inhibition of mammary growth were observed to depend on dietary treatment, sampling day, or both. The same can be said for most of the blood hormones that were measured in this experiment. In this experiment, high ADG achieved by feeding different amounts of a standard diet during the growing period negatively affected mammary development.
Key words: heifer, mammary gland, diet

INTRODUCTION

Fat accumulation in mammary glands due to excessive energy intake is well documented in Holsteins (Meyer et al., 2006; Davis Rincker et al., 2008), and energy intake is a major regulator of weight gain (Owens et al., 1995). A meta-analysis of 15 studies published between 1990 and 2005 concluded that, in Holsteins, BW gains in excess of 800 g/d have potential to reduce milk production (Zanton and Heinrichs, 2005). In Brazil, the majority of dairy cattle are Holstein × Gyr (**H×G**). It is unknown whether excessive energy intake negatively affects their mammary development to the same extent as in purebred Holsteins. Regardless of breed, there remains uncertainty on the main mediator of negative mammary composition effects in heifers: diet composition, BW gained per day (which we call performance), or both. This highlights the need

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to isolate such effects and study their direct effects on mammary gland development.

In cattle, mammary development is typically quantified after slaughter by measurement of tissue mass, composition, and relative abundance of genes associated with tissue growth (Brown et al., 2005; Meyer et al., 2006; Daniels et al., 2009). These approaches have obvious drawbacks, the main one being inability to measure eventual milk production. Recent studies (Esselburn et al., 2015), including our companion paper (Albino et al., 2017), have explored noninvasive means for measuring mammary development through ultrasonography.

In addition to affecting mammary growth and composition, heifer nutrition programs for Holsteins can affect concentrations of circulating blood metabolites such as IGF-1 (Whitlock et al., 2002; Radcliff et al., 2004; Daniels et al., 2009). As with mammary development, the effect of dietary energy on concentrations of blood IGF-1 is not well characterized in H×G. Knowledge of how blood IGF-1 is affected by nutrition in H×G is valuable.

Similar to previous work conducted with Holsteins, our hypothesis was that mammary development of H×G heifers can be affected by dietary energy supply. Therefore, our aim was to evaluate the effect of different ADG achieved by feeding different amounts of a common diet during the growing period on (1) development of mammary parenchyma (**PAR**) and mammary fat pad (**MFP**), (2) blood IGF-1, and (3) biometric measurements.

MATERIALS AND METHODS

Experimental Design

The 84-d experiment was conducted in the Animal Science Department of the Universidade Federal de Viçosa (Viçosa, Minas Gerais, Brazil). The institutional ethics committee approved the experiment (protocol no. 20/2015). Before treatment assignments and the experimental period, all heifers had ad libitum access to an adaptation diet consisting of corn silage, corn-based concentrate, soybean meal, and minerals with a roughage:concentrate ratio of 60:40. Additionally, all heifers were treated for endo- and ectoparasites with 1 mL of Dectomax (doramectin 1%; Pfizer, New York, NY)/50 kg of BW.

At the end of the adaptation period, H×G heifers (n = 18) weighed 102.2 ± 3.4 kg and were 3 to 4 mo of age. At this time, heifers were randomly assigned to 1 of 3 ADG programs using a completely randomized design. Treatments were high gain (**HG**; n = 6), where heifers were fed to gain 1 kg/d; low gain (**LG**; n = 6), where heifers were fed to gain 0.5 kg/d; and maintenance (**MA**; n = 6), where heifers were fed to gain a minimal amount of weight per day. The dairy NRC (2001) was used to formulate a diet with a standard composition that met CP, RDP, RUP, TDN, and macro- and microminerals of HG heifers (Table 1). Heifers on LG and MA treatments were fed lower daily amounts of the standard diet. The MA heifers were fed sufficient feed to meet maintenance needs and allow for a marginal ADG of 100 g/d. The HG heifers were fed for 5% refusals (as fed). Daily intake of LG and MA heifers was controlled such that no refusals remained; this facilitated desired daily BW gains. All heifers were weighed every 14 d, and diet amount was adjusted accordingly.

Table 1. Ingredients and chemical composition of concentrate and diet

Item	Concentrate	Diet
Ingredient, % DM		
Corn silage	—	59.2
Corn	54.6	22.3
Soybean meal	23.0	9.4
Bypass soybean meal	18.8	7.7
Urea	0.7	0.3
Minerals[1]	2.8	1.2
Composition, g/kg of DM unless noted		
DM, g/kg of fresh matter	889.8	331.7
Minerals	48.7	60.3
CP	270.0	171.2
RDP	144.6	109.1
RUP	126.4	62.1
NDF	145.2	361.8
Ether extract	28.1	21.3
NFC	511.9	390.1
TDN	806.1	711.2

[1]Limestone, 40 g/kg; dicalcium phosphate, 15 g/kg; sulfur flower, 0.5 g/kg; potassium iodate, 4 mg/kg; sodium selenite, 1 mg/kg; cobalt sulfate, 1.5 mg/kg; copper sulfate, 60 mg/kg; manganese sulfate, 5 mg/kg; zinc sulfate, 0.2 mg/kg.

Feed Analysis

Corn silage samples were collected weekly and partially dried in a forced-air oven at 55°C for 72 h to determine DM content. Weekly DM measurements were used to adjust roughage:concentrate ratio of the diet.

Samples of soybean meal, corn, and bypass soybean meal that composed the concentrate were collected twice during the 84-d experiment. All feed samples were ground, passed through a 1-mm sieve, and subsequently analyzed for DM (AOAC, 1990; method 920.87), ash (AOAC International, 2005; method 942.05), CP (AOAC International, 2005; method 990.13), and insoluble NDF (Mertens, 2002) with correction for ash,