Effects of L-Glutamine Supplementation on Growth, Starter Intake and Health of Early-Weaned Dairy Heifer Calves

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Summary and Implications

The present study was conducted to examine the effects of L-glutamine supplementation (2.0% of total DM intake) during weaning on starter intake, growth performance, and health status of Holstein heifer calves fed a high volume of milk (9 qt/d). Thirty-six calves of 4 wk of age were assigned to three treatments, 1) a later weaning age of 49 d, 2) an early weaning age of 35 d, and 3) the early weaning age supplemented with L-glutamine. Weaning was commenced by reducing the daily milk allowance from 9.0 to 3.0 qt. Calves were completely weaned once they achieved a 1.0 kg/d starter intake over two consecutive days. The results revealed that early-weaned calves receiving glutamine had a greater average daily gain (ADG) as opposed to early-weaned calves not receiving glutamine during weaning. Moreover, early-weaned calves receiving L-glutamine took fewer number of days to achieve a starter intake of 1.0 kg/d (15 vs. 17 d), and thus weaned completely at a younger age (50 vs. 52 d). Calves receiving L-glutamine had numerically lower (1.04 vs. 1.78 g/L) serum haptoglobin concentrations than those not receiving L-glutamine during weaning. Moreover, calves supplemented with L-glutamine had greater hip width and body length post-weaning (9 to 10 wk of age). Calves weaned partially at 49 d of age were weaned completely at 59 d of age. Body weight, starter intake, and ADG of the late-weaned calves were similar to that of early-weaned calves regardless of L-glutamine supplementation. The present study demonstrated a possibility of weaning dairy calves as early as 5 wk of age without compromising growth performance and feed intake post-weaning in systems where calves are fed a high volume of milk. The results further highlighted that supplementation of L-glutamine could help those calves face weaning stress successfully as indicated by improved ADG and faster increments in starter intake during weaning.

Introduction

Pre-weaned heifer calves represent the most expensive group of animals in dairy replacement herd. An average dairy farmer spends nearly $6.50/d to raise a pre-weaned heifer calf. An ability to wean calves early would significantly reduce the overall production cost of a dairy farm. Even though several controlled-research trials have shown a potential to wean calves as early as 4 to 5 weeks of age, according to a USDA survey in 2014, dairy producers usually wait until 8 to 10 weeks of age. Nonetheless, weaning is a stressful event to young animals primarily due to diet changing from highly palatable and digestible milk to less palatable and moderately digestible starter feed. Changing housing type from individual cages to group cages could further increase the stress. These tresses are usually reflected in reduced ADG and slower rate of achieving a desired starter intake (e.g., 1.0 kg/d). The restriction of liquid feed intake could negatively affect the rate of gut development and the integrity of gut epithelium acting as a barrier for pathogens and their toxins. Some recent research has shown that those effects could be more severe in calves fed high milk volumes than low milk volumes as indicated by elevated serum haptoglobin concentrations. Elevated haptoglobin concentrations in blood is often related to an activation of the immune system. When activated, immune system uses a significant amount of energy that could be used otherwise for productive functions including growth. Blunted growth rates are typical during weaning and could affect negatively the growth performance post-weaning. Therefore, helping animals handle weaning stress appears to have a positive effect on their performance not only during weaning but also after weaning.

Optimizing immune function and nutritional status can help young animals handle weaning stress successfully. In this regard, L-glutamine, a dispensable amino acid, has shown promising results in mice, pigs, and humans. Glutamine supplementation has been found to enhance gut development, help maintain the integrity of gut epithelium, and favorably modulate metabolism of carbohydrates and proteins in weaned piglets. No previous study has examined the effects of L-glutamine in dairy calves undergoing weaning. In the present study, we hypothesized that supplementation of L-glutamine would minimize the detrimental effects of weaning and thus improve growth rates, starter intake and health status of calves during weaning process. The study objectives were 1) to examine the impact of early weaning on starter intake and growth performance in calves receiving a high daily milk allowance, and 2) to examine the impact of supplementation of L-glutamine on feed intake, growth performance, and serum haptoglobin concentrations in those early-weaned calves.

Materials and Methods

All animal procedures were approved by Animal Care and Use Committee at Iowa State University. The trail was conducted from August to December of 2018 at the Dairy Research and Teaching Farm at Iowa State University (ISU-Dairy). Thirty-six Holstein heifer calves born from July 24 to October 4 in 2018 were enrolled in the study, when they were 28 d of age. Calves were matched for parity of the dam and assigned to three treatments (12 calves per treatment) as listed below.

1) Late weaning (**CW**): weaning began at 49 d of age
2) Early weaning (**EW**): weaning began at 35 d of age
3) EW with a L-glutamine supplementation (**EW+Gln**)

All the calves were housed in individual pens bedded with straw (floor area = 1.2 m × 1.8 m) throughout the trial period. Each individual calf had free access to an ad libitum amount of clean drinking water and a starter ration (corn grain plus pellets) in two separate plastic buckets throughout the study. Starter and drinking water intake of individual calves were recorded daily throughout the study period. Calves were fed a high volume (9.0 qt) of pasteurized liquid milk three times per day (3.0 qt per feeding at 6:00, 14:00, and 22:00 h). In each treatment, weaning was initiated by cutting down the milk volume by 67% (only 3.0 qt/d at 22:00 h). Calves were completely weaned once they consumed 1.0 kg of starter feed over two consecutive days as recommended by USDA. Calves in EW+Gln were supplemented with glutamine at 2.0% of daily dry matter intake over one week before and after weaning had been initiated (from day 28 to 42). The DMI was determined considering dry matter in milk and dry matter in pelleted starter ration. The 2.0% supplementation rate was chosen based on improved gain: feed ratios and immune responses observed in a previous study using weaned piglets. The glutamine dose was fed by dissolving in the 3.0 qt milk allowance at 22:00 h. Blood were drawn from the jugular vein after 22:00 h feeding for the analysis of haptoglobin on d 35, 38 and 42 d of age.

Body weight, hip height, hip width, heart girth, and body length of individual calves were measured weekly until they were 70 d old. After recording 70 d body measurements, calves in all three treatments were returned to the general herd. Average daily gain was calculated taking the difference between two consecutively body weight measurements divided by 7. Ambient temperature in the calf barn was measured daily using six temperature data loggers placed across the barn leaving an equal distance among them. Blood were analyzed for serum haptoglobin concentrations using commercially available ELISA assay kit.

Statistical significance of the treatments (CW, EW, EW+Gln) on water and starter intake, serum haptoglobin concentrations and growth performance were analyzed using SAS 9.4. The MIXED and GLM procedures were applied respectively, when multiple or single observation were used for each calf. Growth performance were analyze using the baseline measurements as covariates. Starter and water intake were analyzed using ambient temperature as a covariate. Orthogonal contrasts were applied to test differences between CW and early weaning regardless of glutamine supplementation, and EW and EW+Gln.

Results and Discussion

The baseline body weights of calves at 28 d of age were similar across the treatments (Figure 1A and Table 1). As mentioned before, EW and EW+Gln calves were weaned partially by cutting down the milk volume from 9.0 qt/d to 3.0 qt/d at 35 d, whereas CW calves were weaned in similar manner at 49 d of age. All three groups were weaned completely, once they reached a starter intake of 1.0 kg/d. The EW+Gln calves reached 1.0 kg/d starter intake about two days earlier (14.9 vs. 17.3 d, $P < 0.001$, Table 1) than EW calves. On the other hand, CW calves achieved a 1.0 kg/d starter intake earlier (within 9.6 d) than the both EW and EW+Gln calves ($P < 0.001$). Calves in all treatment groups had similar starter intake post-weaning (9 to 10 wk of age, Table 1). Once weaned at 35 d of age, both EW and EW+Gln calves experienced a depression in ADG during the first week of weaning (Figure 1A). The growth depression was however more severe in EW than EW+Gln. The EW calves had a zero ADG (-0.13±0.08 kg/d), whereas calves receiving glutamine gained a significant weight (ADG = 0.20±0.08 kg/d) during this period (Table 1).

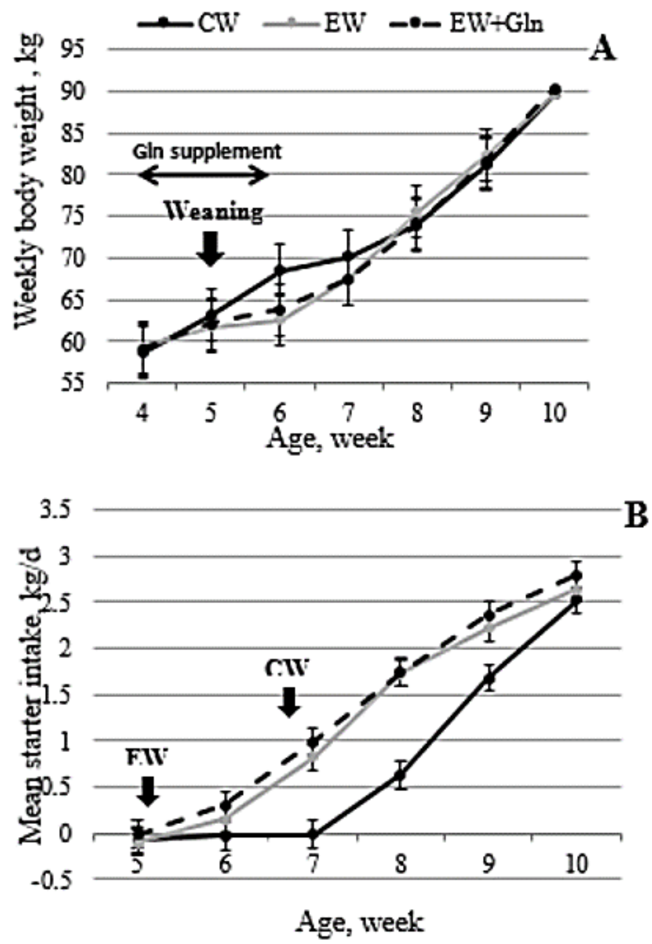

Figure 1. Body weight measured in the end of each week (A) and mean starter intake during each week (B) for calves weaned at a later age of 49 d (CW), and at an earlier age of 35 d, with (EW+Gln) and without (EW) a L-glutamine supplementation (2.0% of total dry matter intake) around weaning (from d 28 to 42).

One possible way that glutamine would support weight gain is enhancing availability of nutrients for growth. In a study published recently, L-glutamine was shown to reduce utilization of essential amino acids by commensal bacteria in the gut. In line with the improved growth performance during weaning, EW+Gln calves had greater hip width (*P*=0.014) and a tendency towards a greater body length (*P*=0.054) than EW calves post-weaning (Table 1). On the other hand, those body measurements were similar between CW and both EW and Ew+Gln calves. A research group at University of Illinois has showed a positive association between hip width and first lactation milk yield in heifers. In another study, heifers with longer body lengths calved earlier than those with shorter body lengths. Overall, early weaning at 5 wk of age did not appear to compromise future growth and milk production potential of heifers.

Since EW and EW+Gln calves had similar starter intake (Table 1 and Figure 1B) and similar milk intake (data not shown), the improved ADG of EW+Gln also suggests an improved feed conversion efficiency. In a study using piglets, L-glutamine improved feed conversion efficiency during the first three weeks after weaning. Some studies have also shown significant improvements in plasma glucose concentrations in calves supplemented with a mixture of Glutamine and Glutamate compared to control calves around weaning. Given the fact that activated immune system can utilize a significant amount of glucose, a glutamine supplementation could increase availability of glucose for growth by minimizing the likelihood that immune system is overly activated. The numerically lower serum haptoglobin concentrations (1.04 vs. 1.78 g/L, *P*=0.255) in EW+Gln compared to EW during the first week of weaning supports this idea.

Conclusions

Supplementation of L-glutamine mitigated the potential negative effects of weaning on growth and starter intake during weaning. Moreover, weaning calves at 5 wk of age performed as same as those weaned two weeks later in terms of growth and starter intake post-weaning.

Acknowledgements

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Table 1. Starter and water intake, growth performance, serum haptoglobin, and feed conversion efficiency (FCE) of calves weaned at a later age of 49 d (CW), and those weaned at an early age of 35 d with (EW+Gln) or without (EW) a glutamine supplementation around weaning (from d 28 to 42).

	LSM				*P*-values for orthogonal contrasts	
	CW	EW	EW+Gln	SEM	CW vs EW & EW+Gln	EW vs EW+Gln
Baseline BW, kg	58.6	59.3	59.1	1.4	0.751	0.922
36 to 42 d of age (during weaning of EW and EW+Gln)						
Starter intake, kg/d	-0.03	0.37	0.44	0.08	<0.001	0.469
Water intake, kg/d	0.37	1.00	1.35	0.28	0.004	0.262
ADG, kg/d	0.56	-0.13	0.20	0.08	<0.001	0.011
Serum haptoglobin, g/L	nd*	1.78	1.04	0.45	nd	0.255
d to reach a 1.0 kg starter intake	9.6	17.3	14.9	0.40	<0.001	<0.001
Age, completely weaned, d	58.6	52.3	49.9	0.45	<0.001	<0.001
56 to 70 d of age (post weaning period of all three groups)						
BW, kg	83.2	82.5	85.4	2.1	0.710	0.281
Hip height, cm	92.7	91.7	92.7	0.8	0.458	0.225
Hip width, cm	23.8	23.2	24.1	0.3	0.621	0.014
Body length, cm	87.1	86.9	88.5	0.6	0.316	0.054
ADG, kg/d	0.98	0.87	1.10	0.13	0.997	0.149
Starter intake, kg/d	1.34	1.43	1.42	0.13	0.486	0.967
Water intake, kg/d	4.16	4.32	3.78	0.75	0.877	0.577

*Not determined