# Additional Nutritional Considerations for Preconditioning Beef Calves[1]

Philipe Moriel[2]

## Introduction

As discussed in EDIS document AN260, *Preconditioning Calves Using Co-Products*, preconditioning beef calves is a management option that can add value to calf crop production. This process of preconditioning cattle involves weaning, vaccinating, and acclimating cattle to eating from feed bunks using a wide variety of feed ingredients. However, feed ingredient selection is not the only factor to consider during a preconditioning process. Recent studies demonstrated that diet composition and frequency of supplementation can have positive or negative effects on calf performance during preconditioning (Artioli et al. 2015; Moriel et al. 2015; Moriel et al. 2016). This fact sheet will focus on the ways beef cattle producers can modify the nutritional composition of diets and frequency of concentrate supplementation to optimize growth and immunity of preconditioning beef calves or prevent detrimental effects.

## Diet Nutritional Composition: Protein Supply

Weaning, vaccination, and feedlot entry are the major sources of stress in cattle. Each of these practices causes an inflammatory response in calves (Arthington et al. 2013; Moriel and Arthington 2013). This inflammatory response is a natural biological process, but it also increases the nutrient demand to support the immune system (Reeds and Jahoor 2001). Survival and immunity have greater priority for nutrients than growth, so it is understandable that animals will grow less when facing a disease or any immunological challenge. In order to support the immune response, muscle protein tissue is mobilized and broken to provide amino acids. The amino acids absorbed from the diet will be used for multiple physiological responses, such as synthesis of acute phase proteins, new immune cells, and glucose, and not for growth. Stressed calves have greater nutrient demand, fewer nutrients being used for growth, and consequently, lower average daily gain. In addition, multiple exposures to stress will decrease the immune system of calves, leading to a greater risk of developing respiratory diseases. However, beef cattle producers can modify the nutrient composition of the diet and increase protein intake to provide the necessary amino acids to support the immune system and alleviate muscle protein mobilization (Moriel and Arthington 2013). We designed a study to evaluate the growth performance and immune response of vaccinated beef steers that received increasing amounts of protein supplementation during a 42-day preconditioning period.

Angus crossbred steers (approximately 500 lb and 184 days of age) were weaned and immediately transferred into feedlot pens. Treatments consisted of one of three corn silage-based diets formulated to provide 85%, 100%, or 115% of the daily metabolizable protein requirements of a beef steer gaining 2.2 lb of body weight daily. Diets contained 79%, 76%, and 74% of dry matter as total digestible nutrients (TDN), and 11%, 15%, and 19% of

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2. Philipe Moriel, assistant professor, Department of Animal Sciences; UF/IFAS Range Cattle Research and Education Center, Ona, FL 33865.

dry matter as crude protein (CP), respectively. Diets were offered in amounts to provide the same daily energy intake, but increasing levels of crude protein intake. Calves were vaccinated against respiratory pathogens on days 14 and 28 after feedlot entry.

In this study, average daily gain from day 0 to day 42 increased as protein supply was increased (Table 1). Steers that received a diet deficient in protein (85% of their protein requirements) were 27 lb lighter than steers that were provided 100% of their protein requirements. Steers that received a diet containing protein levels above their daily protein requirements were 15 lb heavier than steers that were provided 100% of their protein requirements (Table 1). One of the reasons for the better growth performance as dietary protein was increased was the difference observed for dry matter intake. As dietary protein supply was increased, weekly dry matter intake also increased. However, steers fed 100% and 115% of their protein requirements were 17% and 21%, respectively, more feed efficient compared to steers that were provided 85% of their protein requirements (Table 2).

The amount of antibody produced after vaccination can be used as an indicator of both the level of immune protection (Bolin and Ridpath 1995) and the percentage of calves responding to the vaccination (Richeson et al. 2008). The ability of an animal to respond to vaccination varies from animal to animal and depends on environmental and genetic factors. In our study, steers provided with 115% of their protein requirements had greater serum titers against Bovine Viral Diarrhea Virus-1b (BVDV-1b) on day 42 compared to steers that met 85% and 100% of their protein requirements (Figure 1). Most bovine respiratory disease cases occur within 30 days after weaning or 14 days after feedlot entry (Kirkpatrick et al. 2008). Therefore, steers that receive 115% of their protein requirements might have greater immune protection and fewer chances of developing a respiratory disease following feedlot entry.

Increasing the metabolizable protein supply to physiologically stressed, preconditioning beef steers provided the additional amino acid supply required by the immune system, alleviated muscle protein mobilization, and led to greater growth performance during a 42-day preconditioning period. The greater dietary protein supply provided during a preconditioning vaccination protocol also increased calf response to vaccination.

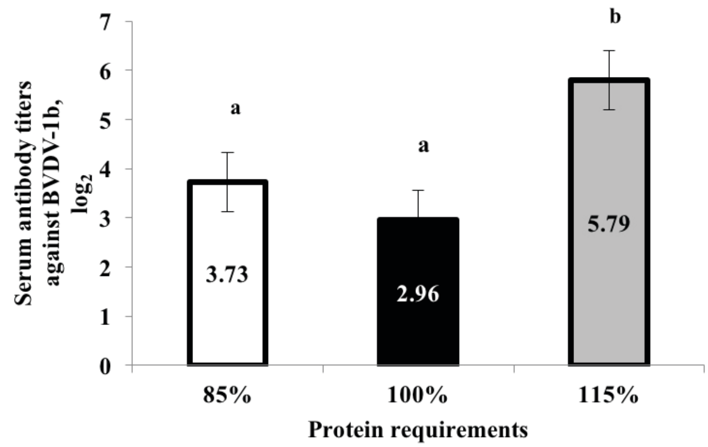


Figure 1. Serum antibody titers against Bovine Viral Diarrhea Virus-1b (BVDV-1b) of steers provided with 85%, 100%, or 115% of their protein requirements during a 42-day preconditioning period (Moriel et al. 2015). [a-b] Within a row, bars without a common superscript differ ($P \le 0.05$).

## Frequency of Supplementation

Decreasing the frequency of supplementation consists of providing the same weekly supplement in fewer feeding events in order to reduce costs associated with labor, equipment, and fuel. For instance, if the supplement intake of an animal is 3 lb/day, then the same animal will have consumed 21 lb of supplement over a week (3 lb/day x 7 days = 21 lb). If a producer decides to decrease the frequency of supplementation to three times weekly, then the weekly supplement amount needs to be divided by the number of feeding events (in this case, 3 days). Thus, each animal will be provided 7 lb of supplement three times weekly (7 lb on Monday, Wednesday, and Friday for a weekly supplement consumption of 21 lb). Numerous studies have evaluated the effects of providing supplements infrequently instead of every day to beef cattle fed forage-based diets. However, results reported in the literature are not consistent.

The effect of reducing the supplementation frequency on growth performance depends on several factors, particularly the type of nutrient provided (for example, protein or energy). In the case of protein-based supplements, it was shown that supplementing beef cattle as infrequently as once a week instead of daily did not affect growth performance, forage intake, and digestibility (Kunkle et al. 2000).

In contrast, decreasing the frequency of energy supplementation can be detrimental to beef cattle performance, depending on forage quality and type of energy supplement provided. When cattle consumed low-quality forages, decreasing the frequency of supplementation (low- or high-starch supplements) had negative effects on forage intake and growth performance (Kunkle et al. 2000). For instance, beef heifers consuming low-quality bahiagrass (54% TDN;

9% CP) and receiving daily supplementation of a mixture of fibrous byproducts (wheat middlings, soybean hulls, cottonseed meal, and molasses) had greater average daily gain (0.90 lb/day versus 0.73 lb/day, respectively) and achieved puberty sooner than heifers offered the same supplement three times per week (Cooke et al. 2008). However, decreasing the supplementation frequency of low-starch supplements when beef cattle were consuming medium- to high-quality forages did not impair growth performance of beef heifers (Moriel et al. 2012). For example, daily supplementation of a soybean hull-based concentrate to Brangus crossbred heifers consuming low-quality stargrass hay (50% TDN; 8% CP) or medium-quality bermudagrass hay (52% TDN; 12% CP) did not affect the average daily gain, but it increased the percentage of heifers cycling at the beginning of the breeding season (40% versus 20%) (Moriel et al. 2012).

The period immediately following weaning is one of the most stressful events in a calf's life. Decreasing the frequency of supplementation, regardless of forage quality and supplement type, might increase the stress response to weaning and decrease the growth performance and immunity of recently weaned, stressed beef calves. We designed a study to evaluate the effects of reducing the frequency of energy supplementation (three times weekly versus daily) during preconditioning on growth performance and immune response of beef calves (Artioli et al. 2016).

Angus crossbred steers (480 lb and 210 days of age) were weaned, provided free-choice access to ground tall fescue hay (17% CP; 58% TDN), and supplemented with a pellet-mix of 50% soybean hulls and 50% corn gluten feed for 42 days. Supplements were offered three times weekly (11.7 lb of supplement every Monday, Wednesday, and Friday; **S3**) or daily (5 lb of the same supplement every day; **S7**), resulting in the same amount of supplement being fed weekly. Calves were vaccinated against respiratory pathogens on days 14 and 28 after weaning.

In this study, steers supplemented three times weekly (S3) had a 0.60 lb/day lower average daily gain compared to steers supplemented daily (S7; Table 2). Feed efficiency was numerically lower when the frequency of supplementation was reduced. Also, steers supplemented three times weekly (S3) had a total dry matter intake that was 54 lb less than that of steers supplemented daily (S7), which is a result of the lower hay dry matter intake, since both treatments received the same weekly supplement offer (35 lb of supplement/steer weekly). The lower hay intake of steers that were supplemented three times weekly led to lower total energy and protein intake, which partially explains the reduced average daily gain.

We also analyzed one of several acute-phase proteins called haptoglobin, which is an indicator of the magnitude of the inflammatory response after stress or immunological challenge. We observed that steers supplemented three times weekly had greater overall plasma concentrations of haptoglobin (0.78 mg/mL versus 0.55 mg/mL) than steers supplemented daily. This response indicates that reducing the frequency of supplementation enhanced the stress response of weaned calves.

Steers offered daily energy supplementation (S7) also had greater antibody titers against BVDV-1b than steers supplemented three times weekly (S3; Figure 2). Further studies need to be conducted to evaluate if this greater antibody titer production can increase the immune protection of those calves. It is important to note that the immune response to vaccination of weaned steers that received daily energy supplementation was enhanced, which might result in greater immune competency against a pathogen invasion.

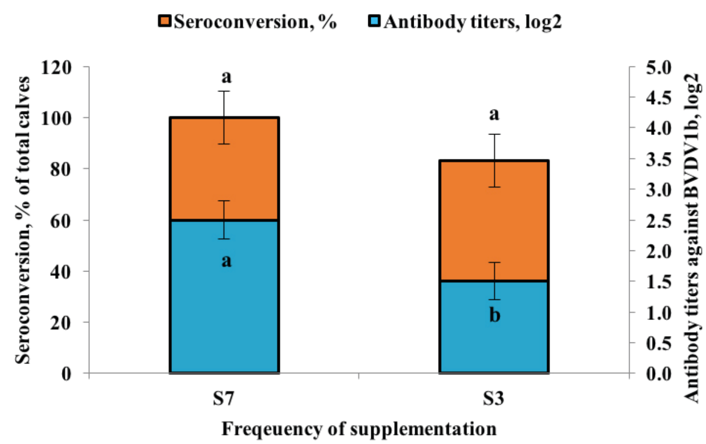

Figure 2. Percentage of calves responding to vaccination and antibody titers against Bovine Viral Diarrhea Virus-1b (BVDV-1b) of beef steers offered energy supplementation daily (S7) or three times weekly (S3) (Artioli et al. 2015). [a-b] Bars without common superscript differ ($P \leq 0.05$).

The data discussed above indicated that producers should not reduce the frequency of energy supplementation to beef steers during the entire period of preconditioning. We designed a second study to investigate if a gradual reduction of frequency of energy supplementation following vaccination could prevent the previously mentioned detrimental effects on growth and immunity of beef steers (Silva et al. 2017). Animals offered concentrate supplementation daily were less stressed at the time of vaccination and after vaccination than animals offered concentrate supplementation three times weekly. Thus, our hypothesis was that offering concentrate daily until the last round of vaccination, and then decreasing the frequency of supplementation to three times weekly until the end of preconditioning would reduce feeding costs and prevent a greater stress response, leading to growth performance and immunity similar to those of calves supplemented daily during the entire study. This strategy would allow producers to reduce feeding costs while maintaining optimal calf growth performance.

Angus steers (440 lb and 175 days of age) were weaned and assigned to one of 14 feedlot pens (three steers per pen). Steers were provided free choice access to ground tall fescue hay (57% TDN, 13% CP of dry matter) and supplemented with concentrate at 1% of body weight (50:50 soybean hulls and corn gluten feed; 71% TDN, 15% CP of DM; dry matter basis). Treatments consisted of similar weekly concentrate offer that was divided and offered daily from day 0 to day 42 (**7X**)**,** three times weekly from day 0 to day 42 (**3X**; Monday, Wednesday, and Friday), or daily for the first 14 days and then three times weekly from day 15 to day 42 (**7-3X**). Steers were vaccinated against Infectious Bovine Rhinotracheitis (IBR), BVDV, parainfluenza-3, *Mannheimia haemolytica*, and *Clostridium* on day 0 and day 15.

Final body weight of steers that were supplemented daily from day 0 to day 14 and then three times weekly from day 15 to day 42 was similar to that of calves supplemented daily during the entire study (Table 3). This indicates that producers will be able to save on labor and feeding costs by gradually reducing the frequency of supplementation without negatively affecting calf growth performance.

As in our previous study, we found that steers supplemented three times weekly for the entire study had greater plasma concentrations of haptoglobin (indicator of inflammatory response) than steers that were supplemented daily for the entire study (Table 4). However, the steers that had the supplementation frequency gradually reduced during the study had plasma concentrations of haptoglobin similar to those of calves supplemented daily for the entire study. Thus, abruptly reduced frequency of supplementation during the vaccination process increases the stress response of calves. However, a gradual reduction of frequency of supplementation prevented those negative effects. In addition, calves supplemented three times weekly during the entire study had lower antibody production against IBR. Fewer calves in this category responded to vaccination against parainfluenza-3 virus compared to calves that were supplemented daily during the entire study. These two viruses are major pathogens that can cause bovine respiratory disease.

# Conclusion

Calves can be preconditioned using a wide variety of supplemental feed ingredients. However, feed ingredient selection is not the only factor to consider during a preconditioning process. Increasing the protein supply to stressed, preconditioning beef steers led to greater growth performance and increased immune response to vaccination during a 42-day preconditioning period. Producers should not reduce the frequency of concentrate supplementation during the entire preconditioning period because it might lead to poorer vaccine response and average daily gain, resulting in lowered calf value at sale. However, a gradual reduction of frequency of supplementation is a supplementation strategy that can overcome these negative effects on growth and immunity. This strategy allows producers to save on feeding and labor costs without producing lighter calves that have weaker immune responses.

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Table 1. Growth performance of steers provided with 85%, 100%, and 115% of their metabolizable protein requirements during a 42-day preconditioning period.

| | **Protein Requirements** | | | | |
|---|---|---|---|---|---|
| **Item** | **85%** | **100%** | **115%** | **SEM**[1] | ***P*-value** |
| **Body weight, lb** | | | | | |
| Day 0 | 535[a] | 529[a] | 529[a] | 14.5 | 0.52 |
| Day 42 | 612[a] | 639[ab] | 654[b] | | |
| **Average daily gain, lb/day** | 1.83[a] | 2.64[b] | 2.97[b] | 0.150 | <0.0001 |
| **Feed:Gain**[2] | 5.26[a] | 4.34[b] | 4.17[b] | 0.180 | 0.002 |

[a-b]Within a row, means without a common superscript differ ($P \leq 0.05$).
[1] Standard error of the mean.
[2] Pounds of feed dry matter consumed for every 1 lb of body weight gained.

Table 2. Post-weaning growth performance of beef steers offered energy supplementation daily (S7) or three times weekly (S3).

| | **Treatments** | | | |
|---|---|---|---|---|
| | **S7** | **S3** | **SEM**[1] | ***P*-value** |
| **Body weight, lb** | | | | |
| Day 0 | 481 | 480 | 16 | 0.94 |
| Day 42 | 602 | 575 | 18 | 0.34 |
| **Average daily gain, lb/day** | 2.87 | 2.27 | 0.158 | 0.01 |
| **Dry matter intake, lb/day** | 419 | 365 | 8 | 0.02 |
| **Feed:Gain**[2] | 3.48 | 3.84 | 0.106 | 0.09 |
| **Plasma haptoglobin, mg/mL** | 0.55 | 0.78 | 0.041 | 0.002 |

[1] Standard error of the mean.
[2] Pounds of feed dry matter consumed for every 1 lb of body weight gained.

Table 3. Growth performance of steers provided similar weekly concentrate dry matter amount that was divided and offered daily from day 0 to day 42 (**7X**), three times weekly from day 0 to day 42 (**3X**; Monday, Wednesday, and Friday), or daily from day 0 to day 14 and then three times weekly from day 15 to day 42 (**7-3X**).

| | **Frequency of Supplementation** | | | | |
|---|---|---|---|---|---|
| **Item** | **3X** | **7-3X** | **7X** | **SEM**[1] | ***P*-value** |
| Final body weight day 42, lb | 509 | 522 | 520 | 5.50 | 0.59 |
| Average daily gain, lb/day | 1.87 | 2.11 | 1.96 | 0.136 | 0.44 |
| Total hay dry matter intake, lb | 218 | 242 | 230 | 9.05 | 0.27 |
| Feed:Gain[2] | 5.10 | 4.72 | 5.23 | 0.244 | 0.57 |

[1] Standard error of the mean.
[2] Pounds of feed dry matter consumed for every 1 lb of body weight gained.

Table 4. Blood measurements of steers provided similar weekly concentrate dry matter amount that was divided and offered daily from day 0 to day 42 (**7X**), three times weekly from day 0 to day 42 (**3X**; Monday, Wednesday, and Friday), or daily from day 0 to day 14 and then three times weekly from day 15 to day 42 (**7-3X**).

| | Treatment | | | | |
|---|---|---|---|---|---|
| **Item** | **3X** | **7-3X** | **7X** | **SEM**[1] | ***P*-value** |
| Plasma haptoglobin, mg/dL | 0.44[a] | 0.37[b] | 0.37[b] | 0.026 | 0.04 |
| *Infectious Bovine Rhinotracheitis Virus* | | | | | |
| Serum antibody, $\log_2$ | 0.29[a] | 0.88[b] | 0.79[b] | 0.179 | 0.05 |
| Calves responding to vaccination, % | 22.2 | 33.1 | 30.6 | 8.51 | 0.60 |
| *Parainfluenza-3 virus* | | | | | |
| Serum antibody, $\log_2$ | 3.54 | 4.46 | 3.66 | 0.606 | 0.52 |
| Calves responding to vaccination, % | | | | | |
| Day 15 | 36.0[a] | 76.6[b] | 57.0[b] | 8.24 | 0.04 |
| Day 42 | 100.0[a] | 98.0[a] | 98.9[a] | | |

[a-b] Within a row, means without a common superscript differ ($P \leq 0.05$).
[1] Standard error of the mean.