Animal Feed Science and Technology 209 (2015) 268–273

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Short communication

Delayed weaning of Holstein bull calves fed an elevated plane of nutrition impacts feed intake, growth and potential markers of gastrointestinal development

S.J. Meale[a], L.N. Leal[b], J. Martín-Tereso[b], M.A. Steele[a,*]

[a] Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada
[b] Trouw Nutrition Research and Development, Boxmeer, The Netherlands

ARTICLE INFO

Article history:
Received 27 March 2015
Received in revised form 18 August 2015
Accepted 19 August 2015

Keywords:
Elevated plane of nutrition
Growth
Holstein bull calves
Weaning age

ABSTRACT

Feeding calves an elevated plane of nutrition pre-weaning improves growth. However, some controversy remains about the optimal time of weaning required to minimize the decline in growth commonly associated to milk withdrawal. This experiment aimed to determine the influence of weaning age on performance of calves fed milk replacer on an elevated plane of nutrition (8 L d^{-1}, 150 g L^{-1}, 1.2 kg $calf^{-1}$ d^{-1}) and to further understand the impacts of weaning age on gastrointestinal development. To meet these objectives, 108 Holstein bull calves (18.7 ± 2.69 d old) were blocked by BW and randomly assigned to one of three treatments: step-down weaning at 8, 10 or 12 weeks of age. Daily milk replacer supply and refusals, and weekly starter and hay intakes were recorded throughout the 10 week experiment. Average daily gain (kg d^{-1}) and BW (kg) were measured weekly. Digestive tract development was assessed by sampling blood and fecal matter at 5, 7, 9, 11 and 13 weeks of age. Blood was analysed for βHBA as a marker of rumen development (ruminal ketogenesis) and fecal starch content was used to evaluate its total tract digestibility. Intakes of starter were higher in calves weaned at 8 weeks of age, from week 7 onwards, translating into differences in total starter consumption across the 10 week trial ($P < 0.01$). Weekly differences occurred in ADG ($P < 0.05$) during the weeks of weaning, resulting in differences in final BW and total weight gain between calves weaned at 8 and 12 weeks of age. No differences were observed in fecal starch content ($P > 0.05$), yet, βHBA presented smaller spikes at weaning with increasing weaning age ($P < 0.01$), indicating that older animals may experience a less abrupt activation of rumen function. Overall, the results suggest that delaying weaning of calves fed an elevated plane of nutrition may be beneficial to sustain growth performance and avoid stress during weaning.

1. Introduction

Debate regarding the optimal nutrition of dairy calves supports either accelerated ruminal development and reduced costs of feeding in early weaned calves (Kertz et al., 1979; Quigley and Caldwell, 1991), or improved growth and reduced welfare concerns in calves fed elevated planes of nutrition prior to weaning (Khan et al., 2011). As the ingestion of

Abbreviations: BW, body weight; ADG, average daily gain; βHBA, beta hydroxybutyrate.

* Corresponding author. Tel.: +1 519 400 6556; fax: +1 780 492 4265.
E-mail address: masteele@ualberta.ca (M.A. Steele).

http://dx.doi.org/10.1016/j.anifeedsci.2015.08.008
0377-8401/

solid feed results in metabolic and morphological adaptations in the rumen of calves (Baldwin et al., 2004), the strategy and timing of weaning becomes increasingly important when higher milk volumes are fed. The use of a step-down strategy has been suggested to stimulate starter consumption resulting in a faster development of the fore-stomach (Khan et al., 2007). Yet, despite the benefits to performance and health, feeding calves elevated planes of nutrition pre-weaning is still not widely implemented, likely reflecting the lack of studies published regarding the optimal age of weaning using this method for calves fed elevated planes of nutrition prior to weaning.

Increasingly in Europe, male dairy calves are being weaned for veal production (Berends et al., 2015) an industry which requires rapid growth rates. With concerns regarding animal welfare at the fore-front, feeding strategies that address both of these aspects are more likely to be widely adopted. Currently, there is considerable variation among European regions and farms with respect to dairy weaning practices, especially age of weaning, and very little information is available regarding weaning age of young beef calves. North American dairy herds commonly wean between 6 and 8 weeks, but can extend to over 10 weeks of age, as is common in European countries (USDA, 2010; Vasseur et al., 2010). Additionally, there is a paucity of information describing how age of weaning impacts energy balance, feed intake patterns and rumen development. It has recently been shown that calves fed elevated levels of milk and are weaned later in life, experience less weight loss and behavioral signs of hunger or stress during the weaning period (de Passillé et al., 2011). Thus, the overall objective of this experiment was to characterize the effect of weaning age on dietary intakes, growth and development, as we hypothesized that calves fed elevated planes of nutrition and weaned later in life using the step-down strategy, would have higher growth rates and improved gut development as a result of minimising abrupt changes which occur during weaning.

2. Materials and methods

2.1. Experimental design, animals and treatments

All experimental procedures and animal care were conducted in accordance with animal welfare legislation, and were approved by the animal experimentation committee (DEC Dierexperimentencommissie, Utrecht, approval #2013.III.11.120). One hundred and twelve male Holstein Friesian calves, with an average bodyweight (BW) of 49.5 ± 1.84 kg at 18.7 ± 2.69 d of age, were purchased from a local livestock dealer. Shortly after arrival to the calf experimental farm of Nutreco R&D (Winssen, the Netherlands), calves were weighed and their health was examined, with those failing to meet health standards being excluded from the trial, leaving a total of 108. Calves were blocked by BW and penned according to a randomized complete block design including 6 blocks of 3 pens each (with 5 calves per pen) and 2 blocks of 3 pens each (with 3 calves per pen). Within each block pens were randomly allocated to one of three weaning treatments (8, 10 or 12 weeks of age) such that there were equal numbers of calves in each treatment. All calves were then fed twice with 2.0 L of an electrolyte solution (20 g L^{-1} water, Emix, Sloten) in addition to 2.0 L of milk replacer (260 g kg^{-1} crude protein and 160 g kg^{-1} crude fat; DM basis; Sloten B.V., Deventer, The Netherlands) at 39–40 °C. From d 1 onwards milk replacer was fed individually with a pail in two meals of equal volume d^{-1} (at 07:00 and 15:00 h). The volume of milk replacer was increased 0.5 L $meal^{-1}$ every three days over a two week step-up period until a total of 8.0 L was being fed, such that from d 1 to 3, 4.0 L d^{-1} of milk replacer was fed, from d 4 to 6 the volume of milk replacer fed was 5.0 L d^{-1} and from d 7 to 9 6.0 L d^{-1} was fed. On d 10 volumes were increased to 7.0 L d^{-1} and further increased to 8.0 L d^{-1} on d 14. All calves continued to receive 8.0 L d^{-1} until their respected time of step-down weaning. There were no refusals of milk. The group weaned at 8 weeks of age was stepped-down to 4.0 L d^{-1} on d 49 and 0 L on d 56; the group weaned at 10 weeks was stepped-down to 4.0 L d^{-1} on d 63 and 0 L on d 70; and the group weaned at week 12 was stepped-down to 4.0 L d^{-1} on d 77 and 0 L on d 84. Calves also received *ad libitum* calf starter concentrate (pellet, 3 mm, 180 g kg^{-1} DM crude protein, 49 g kg^{-1} DM crude fat and 205 g kg^{-1} DM starch; AgruniekRijnvallei, Wageningen, The Netherlands) and chopped wheat straw from d 1. Calf starter and straw were fed in a trough (one per pen), where starter and straw were physically separated by a partition. Calves had free access to water at all times through a drinking nipple in each pen.

2.2. Intake and growth measurements

Calves were weighed at the beginning of the experiment and weekly thereafter to determine weekly BW and ADG. Intakes of starter and straw were recorded daily and orts measured weekly. Metabolizable energy (ME) content of starter, milk replacer and straw were estimated using NRC equations (NRC, 2001). Intakes of ME were calculated by dividing intake of each feed (starter, straw of milk replacer) by its ME content.

2.3. Measurement of potential markers of gut development

To assess undigested starch in faeces, fecal samples (50 g) were collected from 24 calves per treatment group (*i.e.*, 3 calves per pen) at 5, 7, 9, 11, and 13 weeks of age, frozen immediately and stored at −20 °C until analysis. In brief, calves were rectally stimulated with a sterile glove to facilitate the collection of a fecal sample. Fecal samples were dried at 60 °C for 48 h prior to grinding to a 1.0 mm particle size. The starch content in fecal samples was analyzed at Masterlab (Boxmeer, the Netherlands), using enzymatic starch technique (NEN-ISO 15914-2004). Means within weaning groups were obtained by averaging individual values.