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Effect of protein provision via milk replacer or solid feed on protein metabolism in veal calves

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ABSTRACT

The current study evaluated the effects of protein provision to calves fed a combination of solid feed (SF) and milk replacer (MR) at equal total N intake on urea recycling and N retention. Nitrogen balance traits and [$^{15}N_2$]urea kinetics were measured in 30 calves (23 wk of age, 180 ± 3.7 kg of body weight), after being exposed to the following experimental treatments for 11 wk: a low level of SF with a low N content (SF providing 12% of total N intake), a high level of SF with a low N content (SF providing 22% of total N intake), or a high level of SF with a high N content (SF providing 36% of total N intake). The SF mixture consisted of 50% concentrates, 25% corn silage, and 25% straw on a dry matter basis. Total N intake was equalized to 1.8 g of N·kg of $BW^{-0.75}$·d^{-1} by adjusting N intake via MR. All calves were housed individually on metabolic cages to allow for quantification of a N balance of calves for 5 d, and for the assessment of urea recycling from [$^{15}N_2$]urea kinetics. Increasing low-N SF intake at equal total N intake resulted in a shift from urinary to fecal N excretion but did not affect protein retention (0.71 g of N·kg of $BW^{-0.75}$·d^{-1}). Increasing low-N SF intake increased urea recycling but urea reused for anabolism remained unaffected. Total-tract neutral detergent fiber digestibility decreased (−9%) with increasing low-N SF intake, indicating reduced rumen fermentation. Increasing the N content of SF at equal total N intake resulted in decreased urea production, excretion, and return to ornithine cycle, and increased protein retention by 17%. This increase was likely related to an effect of energy availability on protein retention due to an increase in total-tract neutral detergent fiber digestion (>10%) and due to an increased energy supply via the MR. In conclusion, increasing low-N SF intake at the expense of N intake from MR, did not affect protein retention efficiency in calves. Increasing the N content of SF at equal total N intake decreased urea production, increased protein retention, and coincided with improved fiber degradation. Therefore, results suggest that low N availability in the rumen limits microbial growth and rumen fermentation in calves fed low-N SF (93 g of CP/kg of DM), and this effect cannot be compensated for by recycling of urea originating from MR.
Key words: urea kinetics, digestibility, concentrate, milk replacer

INTRODUCTION

Optimizing solid feed (**SF**) strategies for veal calves has gained interest since the European Union stipulated the provision of SF in addition to the traditional milk replacer diet in 1997 (97/2/EC Directive by EU Council). Increasing the dietary proportion of SF for veal calves affects gastrointestinal development (Berends et al., 2012b) and nutrient utilization (Berends et al., 2012a). In recent years, the contribution of SF in veal calf diets has been increasing rapidly. It has been shown that the contribution of SF to the N economy of calves increases with age (Berends et al., 2012a, 2014b). However, interactions between milk replacer (**MR**) and SF on protein utilization in calves are poorly understood. In calves fed only MR, urea recycling is of limited importance (Hayashi et al., 2006), as shown by the 80% recovery of an intravenous pulse dose of [^{13}C]urea in 48-h urine (Gerrits et al., 2001; van den Borne et al., 2006a). When milk-fed calves were supplemented with increasing amounts of low-N SF, the marginal efficiency of N retention was high (76%; Berends et al., 2012a), especially when compared with marginal efficiencies of 30 to 40% reported for calves fed only MR (van den Borne et al., 2006a). The contribution of a low-N SF to the increased N economy of milk-fed calves was partly explained by recycling of urea, likely from MR origin, and by an effect of an increase in absorbed energy on postabsorptive N efficiency (Berends et al., 2014b).

At equal N intake, however, it is currently not known how interactions between SF and MR affect N deposi-

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tion in calves. Also, the route of N supply (SF vs. MR) may affect whole-body protein metabolism. For example, ruminal microbes may prefer N in the form of AA from SF over ammonia-N from urea recycling, because ammonia is used less efficiently for microbial protein synthesis than degradable true protein (Blake et al., 1983; Argyle and Baldwin, 1989). In addition, due to diurnal fluctuations in rumen fermentation, urea recycling may not fully complement the actual N deficit in the rumen at specific times of the day. Improved insight in the utilization of N from MR and SF is required to mitigate N emissions from calves into the environment and to adapt feeding strategies to large fluctuations in MR ingredient prices. Apparent N digestibility of SF can be rather low: 45% in calves fed exclusively SF (Ortigues et al., 1990), whereas apparent N digestibility of MR ranges between 92 and 95% (van den Borne et al., 2006b; Labussière et al., 2009). In contrast, SF intake will contribute to energy supply of calves, whereas increased energy supply from lactose and fat (Gerrits et al., 1996) and timing of energy relative to protein availability (van den Borne et al., 2006b, 2007, 2012) have been shown to contribute to changes in efficiency of N utilization for growth in calves.

Therefore, the aim of the current study was to evaluate the effects of N administration (via SF vs. via MR) at equal total dietary N intake on urea recycling, N retention, and apparent total-tract digestibility in calves. We hypothesized that at equal total dietary N intake, an increased proportion of N intake via a high-N SF increases microbial protein production, but at the same time reduces urea recycling.

MATERIALS AND METHODS

This study was conducted at the research facilities of the VanDrie Group (Scherpenzeel, the Netherlands). Procedures complied with the Dutch Law on Experimental Animals and the ETS123 (Council of Europe 1985 and the 86/609/EEC Directive) and were approved by the Animal Care and Use Committee of Wageningen University.

Animals, Experimental Design, and Housing

Thirty Dutch Holstein-Friesian male calves were included in the experiment. Calves were gathered from commercial dairy farms at 2 wk of age (44 ± 0.5 kg of BW), and selected based on BW, uniformity, and clinical health. Upon arrival, calves were allocated to treatments based on BW. Measurements were conducted at an average BW of 180 ± 3.7 kg. Measurement periods were staggered from 20 and 25 wk of age, with 6 calves (2 of each treatment) per measurement period due to limited availability of metabolic cages and infusion apparatus. The 5-d measurement period was preceded by a 9-d adaptation period. Animal health was checked daily. Hemoglobin concentration in blood was monitored across the experiment at 3, 7, 11, 15, 19, and 23 wk and corrected by iron injection to comply with a minimum level of 4.5 mmol/L at 27 wk of age.

Before the adaption and measurement period, calves were housed indoors in groups of 5 calves in pens measuring 3 × 3 m equipped with wooden-slatted floors and railings, and without bedding material. Calves were exposed to daylight and to artificial light from 0500 to 2300 h and to darkness during the remainder of the day. During the 9-d adaptation period, calves were housed for 7 d in individual pens placed inside the group pen to facilitate individual feeding and monitoring, and for 2 d in metabolic cages (0.79 × 1.85 m), equipped with wooden-slatted floors and railings. When entering the metabolic cages, calves were harnessed to allow quantitative, separate collection of feces and urine. Calves remained on the metabolic cages during the subsequent 5-d measurement period. Cages enabled audio-visual contact between calves.

Diets and Feeding

Treatments included a low level of SF with a low N content providing 12% of total N intake (**LPLS**), a high level of SF with a low N content providing 22% of total N intake (**LPHS**), or a high level of SF with a high N content providing 36% of total N intake (**HPHS**). Total N intake of all treatments was equalized to 1.8 g of N·kg of $BW^{-0.75}$·d^{-1} by adjusting N intake via MR (Table 1). Dietary treatments LPLS and LPHS included a MR with a high N content, whereas HPHS included a MR with a low N content (Table 2). The N content was 13.7 g of N/kg of DM for the low-N SF and 22.6 g of N/kg of DM for the high-N SF (Table 1), which was achieved by exchanging starch-rich sources (corn and barley) for corn gluten meal in the concentrate (Table 3), aiming for similar rumen degradation rates of CP, starch, NDF, and nonstarch polysaccharides (CVB, 2007). The SF was composed of 50% concentrates, 25% corn silage, and 25% chopped wheat straw on a DM basis. The SF was prepared in a mixing wagon (Vliebo, Veenendaal, the Netherlands) and provided restricted to minimize feed refusals. When feed refusals exceeded 10% of total N intake, calves were excluded from further analyses. Provision of SF started at 10 d after arrival. The DMI from SF increased with equal weekly increments. From 10 d after arrival until 10 wk after arrival, all pens were exposed to their assigned SF