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Combination effects of milk feeding methods and starter crude protein concentration: Evaluation on performance and health of Holstein male calves

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ABSTRACT

The aim of this study was to examine whether the increasing crude protein (CP) content of starter feed together with the different milk feeding procedure would improve performance, and health responses in dairy calves. Two milk feeding procedures [step-down (STEP) or conventional (CON)] and two levels of starter crude protein (20 or 24% of starter DM) were combined in 2 × 2 factorial arrangements. Forty Holstein male calves were included in four following experimental treatments (10 calves per treatment): (1) conventional milk feeding with 20% CP starter (C20); (2) conventional milk feeding with 24% CP starter (C24); (3) step-down milk feeding with 20% CP starter (D20); (4) step-down milk feeding with 24% CP starter (D24). For the conventional method, calves (n = 20) received 5.5 L/d milk until day 56 of the study, and then they were fed 2 L/d milk from day 56 to 59 of the study. For the step-down method, calves (n = 20) received 7 L/d milk until day 35, and 4 L/d milk from day 35 to 49 of the study followed by feeding 2 L/d milk from day 50 to 59 of the study. The total amount of milk consumed with both milk feeding procedures (STEP and CON) was similar, during milk feeding period (311 L ± 3). Calves in all groups were weaned on day 60 and they were followed up until day 74 of the study. Starter dry matter intake, body weight, average daily gain, feed efficiency, and structural growth were not affected by experimental treatments. On d 35 and d 74 of the experiment, rumen fluid samples were collected with a stomach tube 4 h after morning feeding and were analyzed for volatile fatty acid (VFA) by gas chromatography. Rumen pH and molar concentration of ammonia-N were higher in STEP method during milk feeding period, while calves consuming 24% CP starter had a higher molar concentration of ammonia-N on d 74 ($P < 0.05$). Calves fed starter containing 24% CP had less rumen butyrate and valerate molar concentration on d 35 and 74, respectively ($P < 0.01$). There were interactions between milk feeding and CP concentration of starter for days with scours ($P < 0.05$). Calves fed D20 have greater pre-weaning fecal score and overall scour days than other treatments. Blood samples were taken on d 35 and d 74 of study for metabolites assessing and −7 and +1 d of weaning for evaluating hematological parameters. There was no effect of milk feeding procedure or CP level on lymphocyte levels; however, there was a significant CP x milk feeding procedure interaction at d 61. No treatment effects were observed on red blood cell (RBC) count, glucose, total protein, albumin, and hemoglobin concentration, but

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highest values of blood urea nitrogen (BUN) were found with the 24% CP starter diets on d 74 ($P < 0.05$). In conclusion, increasing starter CP concentration in both milk feeding procedures had no effects on calf performance, structural growth or health.

1. Introduction

Improved health and performance is the main goal of calves rearing programs (Drackley, 2008). Over the last decade, there has been an improvement in nutrition of calves, especially in pre-weaning period (Hill et al., 2013). Applying the appropriate strategy is the key factor to maximizing the daily weight gain while reducing the incidence of mortality and disease during this period. Milk feeding has a significant role in the health and growth of calves before weaning, and it has positive effects on future performance post-weaning (Khan et al., 2007b; Moallem et al., 2010). A common way of feeding milk to newborn calves is feeding 10% of body weight per day. According to previous studies, poor weight gain (Jasper and Weary, 2002), higher risk of diseases (Godden et al., 2005) and reduced welfare of calves (Von Keyserlingk et al., 2009) fed conventional milk feeding (both milk and milk replacer) was reported. It is important to note that providing greater amounts of milk does not always improve performance, because of the challenges that arise during weaning period such as reducing starter intake and consequently, impair rumen development (Khan et al., 2011b). On the other hand, Omidi-Mirzaei et al. (2015) reported greater average daily gain in calves fed milk in a step-up and step-down approach starting at 10% of BW, increasing to 20% of BW and decreasing to gradually back down to 10% BW before weaning. Thus, it is suggested that methods of milk delivery play a decisive role on calf performance.

The transition process of calves' nutritional requirements from liquid feed to solid feed is critical (Weary et al., 2008). Pre-weaned calves consumed a highly digestible milk-based diet high in ME. As the amount of ME increases, protein requirements for maximum performance also increases (Hill et al., 2008). Therefore, to evaluate calf's CP requirements, starter crude protein should also be considered in addition to milk protein. National Research Council has recommended 18% CP in starter feed on DM basis (NRC, 2001). Several researchers confirmed that this value is adequate for optimum performances (Akayezu et al., 1994; Luchini et al., 1991; Hill et al., 2007) but Drackley et al. (2003) stated that calves fed 22% CP starter feed were more efficient than calves consuming 18% CP starter. Recently, some researchers (Stamey et al., 2012; Hill et al., 2013) stated that, growth prediction models for protein needs of calves were not strong enough. Bartlett et al. (2006) reported, body protein storage of growing calves, was a linear function of the protein intake of rations. As long as enough ME is provided for nitrogen retention, this effect is exempt from calf energy intake (Donnelly and Hutton, 1976). Therefore, for calves younger than 2 months, supplying 20% CP starter feed seems to be sufficient (Luchini et al., 1991). However, there is a net decrease in CP digestibility and biological value (BV) as starter intake increases and milk intake decreases (Hill et al., 2013). Nevertheless, these ranges in crude protein concentrations in starter feed were not balanced according to different milk allowance and related procedures.

The purpose of this study was to compare conventional and step-down milk feeding with two levels of starter crude protein on calf performance, rumen fermentation, and health parameters. The hypothesis of the present study is that STEP milk feeding and greater starter crude protein concentration (24% per starter DM) has additive effects on improving performance and health responses.

2. Materials and methods

This experiment was conducted at the Ghiam Agri-Animal Production Co. (Isfahan, Iran), according to the guidelines of the Iranian Council of Animal Care (1995).

2.1. Calves, management, and treatments

Holstein calves born between December 2013 and January 2014 (with minimum, maximum, and average temperatures recorded as −10 °C, 24.5 °C, and 3.37 ± 3.09 °C, respectively) were used in the current study. A total number of 40 calves (male; 41 ± 3 kg of BW) were separated from their dams immediately after birth, weighed and in a 2 × 2factorial arrangements randomly (based on their initial BW on d 3 of age) allocated to one of four groups (n = 10/group): (1) conventional milk feeding with 20% CP starter (on DM basis) (C20); (2) conventional milk feeding with 24% CP starter (C24); (3) STEP milk feeding with 20% CP starter (D20); and (4) STEP milk feeding with 24% CP starter (D24). All the calves received the finely ground starter ration ad libitum and had free access to fresh water throughout the experiment. The ingredients and nutrient compositions of the finely ground starters are presented in Table 1. Experimental diets were formulated according to the Cornell Net Carbohydrate and Protein System, version 5.1. Calves were fed 3–4 L of mother's colostrum within 2 to 6 h after birth. Blood samples were collected from the jugular vein 24 h after the first feeding of colostrum by clot Activator Vacutainer tubes with 18-gauge needle (Vacutest®., Arzergrande, Italy), and serum total protein was determined using a commercially available hand-held refractometer (VET 360, Reichert Inc., Depew, NY). Only calves with a serum protein level > 5.5 mg/dL were included in the study (Table 2). Animals were housed outdoors in individual pens (1.5 × 2.5 m) bedded with sawdust