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RESEARCH ARTICLE

Effects of dietary forage to concentrate ratio and wildrye length on nutrient intake, digestibility, plasma metabolites, ruminal fermentation and fecal microflora of male Chinese Holstein calves

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Abstract

Twenty-eight male, weaned Chinese Holstein calves ((156.8±33.4) kg) were used to investigate the effects of dietary forage to concentrate ratio (F:C) and forage length on nutrient digestibility, plasma metabolites, ruminal fermentation, and fecal microflora. Animals were randomly allocated to four treatments in a 2×2 factorial arrangement: whole-length forage (WL) with low F:C (50:50); WL with high F:C (65:35); short-length forage (SL) with high F:C (65:35); and SL with low F:C (50:50). Chinese wildrye was used as the only forage source in this trial. The grass in the SL treatments was chopped using a chaff cutter to achieve small particle size (~50% particles >19 mm). Dry matter intake (DMI) and organic matter (OM) intake was increased by increasing both F:C (P<0.01) and forage length (FL) (P<0.05), while acid detergent fiber (ADF) and neutral detergent fiber (NDF) intakes were only increased by increasing the F:C (P<0.01). The digestibility of NDF was increased as the FL increased (P<0.01), and it was also affected by interaction between F:C and FL (P<0.05). Cholesterol (CHO) (P<0.01), leptin (LP) (P<0.05), and growth hormone (GH) (P<0.01) concentrations in plasma were increased as dietary F:C increased. A significant increase in plasma triglyceride (TG) (P<0.01), insulin (INS) (P<0.05), and GH (P<0.01) levels was observed with decreasing dietary FL. Ruminal pH values of calves fed with low F:C diets were significantly lower than those in high F:C treatment (P<0.05). Increasing the F:C enhanced ruminal acetic acid (P<0.05) and acetic acid/propionic acid (P<0.01). Fecal *Lactobacillus* content was significantly higher, while *Escherichia coli* and *Salmonella* contents were significantly lower in WL and high F:C groups (P<0.05). Lower fecal scores (higher diarrhea rate) were observed in calves fed with SL hay compared to WL hay (P<0.05). Denatured gradient gel electrophoresis (DGGE) bands and richness index (S) were significantly affected by the interaction between F:C and FL (P<0.05), under high F:C, band numbers and richness index from WL group were higher than that from SL group (P<0.05), whereas there were no differences between WL and

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SL groups under low F:C (P>0.05). Microflora similarity was 50–73% among the different treatments. It is concluded that the WL with high F:C (65:35) diet is suitable for weaned calves.

Keywords: forage to concentrate ratio, forage length, nutrient digestibility, plasma metabolites, ruminal fermentation, fecal microflora, male Holstein calves

1. Introduction

Increasing demand for beef in recent years is motivating Chinese farmers to introduce dairy bull calves into the beef industry to fulfill the beef requirements of the large Chinese population (Muhammad *et al*. 2016). To obtain maximum growth and higher profitability, high concentrate diets along with a forage source are usually used.

The forage to concentrate ratio (F:C) depends on dietary ingredients and nutritional requirements of ruminant animals. Small-scale farmers may alter the forage to concentrate ratio without knowing that it has negative consequences on the physiological system of the animal. It has been reported that forage level affects nutrient intake, utilization, and digestibility (Zebeli *et al*. 2006; Yang and Beauchemin 2007; Granja-Salcedo *et al*. 2016). Studies have also determined the influence of forage length (FL) on voluntary nutrient intake and apparent total tract nutrient digestibilities (Mooney and Allen 1997; Kononoff and Heinrichs 2003; Al-Saiady *et al*. 2010). It is also well established that the physical form of dietary forage plays important roles in the development and performance of the rumen in dairy calves (Montoro *et al*. 2013); inadequate dietary fiber or lack of fiber effectiveness reduces chewing time of ruminants, which may lead to reduced saliva secretion and lower rumen pH (Erdman 1988). However, the literature on growing calves, especially Chinese Holstein calves, is limited.

Previous research has shown that normal microflora plays an important protective and nutritional role in the gastrointestinal tract (Conway 1994). The gastrointestinal tract of young animals is vulnerable and can be easily invaded by pathogenic microorganisms, which can ultimately cause microbial flora imbalance (Ofek *et al*. 1975). Regulation of the numbers and species of beneficial microflora in the intestinal tract can be controlled by diet (Reid and Hillman 1999; Snel *et al*. 2002). Thomlinson and Lawrence (1981) demonstrated that dietary fiber could inhibit the proliferation of *Escherichia coli*, and effectively improve intestinal health. Results of another study indicated that a large amount of unfermented carbohydrate in the back end of the digestive tract might increase osmotic pressure and lead to excessive water secretion, ultimately causing diarrhea (Radecki and Yokoyama 1991). However, there is less research focus on the effects of dietary FL and F:C on intestinal microorganisms in calves.

Therefore, the objective of this trial was to determine the effects of F:C and FL on nutrient intake, digestion, plasma metabolites, ruminal fermentation, and fecal microflora of male Chinese Holstein calves.

2. Materials and methods

The current study was performed in Zhuozhou City in Hebei Province, China. All procedures were approved for animal welfare following instructions of the China Council on Animal Care. The experiment was authorized by the Animal Care and Use Committee of the China Agricultural University.

2.1. Animals, experimental design, and diets

Twenty-eight male Holstein calves (approximately 4–5 mon old) weighing (156.8±33.4) kg (mean±SD) were used in a completely randomized design with four treatments in 2×2 factorial design. Factors were FL and F:C. Each treatment contained seven replicates of one calve per replicate. Dietary FL levels were designated as whole-length (WL) and short-length (SL). At each FL level the calves were fed diets with one of two F:C levels: low F:C (50:50) and high F:C (65:35). Chinese wildrye was used as the only forage source in the present study. Chopped hay was obtained using a machine (STORTI HUSKY, 9SJW-500, Italy) set at 1 900 r min^{-1} to achieve short particle sizes (~50% particles >19 mm). Ingredients and composition of experimental diets are given in Table 1. Animals were fed the total mixed ration twice daily at 0800 h and 1700 h and the duration of the experiment was 2 mon. Experimental calves were individually reared, and offered feed *ad libitum* (5% residual was permitted).

2.2. Nutrient intake and apparent total tract nutrient digestibility

Feed intake data were collected daily. Feed and residual samples were collected for further analysis in the laboratory. At the end of the experiment, a digestion trial was conducted for 3 d. Feces were mixed, weighed, and subsampled twice daily. Approximately 200 g samples were collected, and tartaric acid (10%) was added at 5% fresh weight, and