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RESEARCH ARTICLE

Replacement of Forage Fiber Sources with Dried Distillers Grains with Solubles and Corn Germ Meal in Holstein Calf Diets

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Abstract

This study was carried out to determine the effect of replacement of forage fiber sources from alfalfa and *Leymus chinensis* with nonforage fiber sources (NFFS) from dried distillers grains with solubles and corn germ meal on calves growth, rumen development and blood parameters. 48 female and 12 male calves ((110.55±15.36) kg of body weight and 12 wk of age) were assigned randomly to four dietary treatments (15 calves/treatment) in a completely randomized design. Experimental diets were: 0% NFFS (control), 9% NFFS (group 1), 18% NFFS (group 2), 27% NFFS (group 3), and contained equivalent neutral detergent fiber and total digestible nutrients, respectively. The dry matter intake was similar among diets, averaging 3.33 kg d^{-1}, and no differences were detected for body weight, withers height, body length and heart girth. In addition, the development of rumen, reticulum, omasum and abomasum also were similar among diets. Dry matter, crude protein, and neutral detergent fiber digestibilities increased with the increasing levels of NFFS in the experimental diets, but had no significant effect. Blood urea nitrogen, total protein and glubulin were not affected by the dietary treatment, but group 3 resulted in the highest (P<0.05) concentrations of glucose and the lowest (P<0.05) concentrations of triglycerides and albumin. In conclusion, dried distillers grains with solubles (DDGS) and corn germ meal (CGM) were available and alternative fiber sources for Holstein calf diets.

Key words: neutral detergent fiber, dried distillers grains with solubles, corn germ meal, nonforage fiber sources

INTRODUCTION

Forages usually are the major source of fiber in dairy rations. In Holstein calves, adequate dietary fiber is essential for stimulating the muscular layer of the rumen (Norouzian *et al.* 2011), promoting rumination (Hodgson 1971; Phillips 2004) and maintaining the integrity and health of the rumen wall (Suárez *et al.* 2007). However, several nonforage fiber sources (NFFS) that provide some fiber and starch in the ration (NRC 2001) are also available, and partial replacement of forage with cost-effective NFFS represents a potential alternative to ration design. Studies conducted on partial substitution of forage with NFFS, including soybean hulls (Miron *et al.* 2003; Chung *et al.* 2008; Ranathunga *et al.* 2010), wheat middlings (Clark and Armentano 1997; Pereira and Armentano 2000), corn gluten feed (Pereira and Armentano 2000), and beet pulp (Dann *et al.* 2007), have led to the replacement of significant portions of forage from dairy cow rations.

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Dried distillers grains with solubles (DDGS) are a product of the ethanol industry and are traditionally fed as a protein supplement as an alternative to soybean meal (Ranathunga *et al.* 2010). Corn germ is separated, dried, and sent to a germ plant for extraction of the corn oil. After the oil is extracted, the remaining feed by-product is called corn germ meal (CGM), which used as an energy source in animal nutrition (Stock *et al.* 2000; Meyer *et al.* 2010). DDGS and CGM have been recognized as an excellent source of energy due to their high concentration of digestibility and fat (Schingoethe *et al.* 2009), but utilization as a forage fiber has not been reported.

We hypothesized that feeding equivalent concentrations of crude protein (CP) and neutral detergent fiber (NDF) in diets while maintaining similar concentrations of total digestible nutrients (TDN) would result in similar growth, rumen development, blood parameters and total tract digestibility of nutrients by Holstein calves.

RESULTS AND DISCUSSION

Dietary nutrient composition

The chemical composition of the diets were listed in Table 1. The control and NFFS groups were similar in ingredient composition except for the substitution of NFFS for a portion of the forages. Although concentrations of DDGS and CGM increased, NDF was similar among diets, about 336 g kg^{-1} of dietary dry matter. Forage NDF concentration in the diets decreased from 26.47 to 18.97%, but concentrate NDF increased from 7.22 to 14.61% as DDGS and CGM were included in the diets. Diets were also formulated to have similar concentrations of CP, ether extract (EE) and TDN, which are critical factors for ruminal tissue growth and fermentation (Greenwood *et al.* 1997; NRC 2001). In addition, calves consumed similar amounts of dry matter intake (DMI) in each group, averaging 3.33 kg d^{-1}.

Table 1 Ingredient and chemical composition of the four experimental diets used in this study

Item[1)]	Control	Group 1	Group 2	Group 3
Ingredient (% of DM)				
Alfalfa	31.36	26.45	23.00	20.19
Leymus chinensis	18.64	18.55	17.00	14.81
DDGS	0.00	5.59	7.15	8.57
CGM	0.00	3.41	10.85	18.43
Corn	33.61	30.55	28.33	25.41
Soybean meal	4.45	4.68	4.00	3.48
Cotton seed meal	5.00	2.00	1.28	0.00
Wheat mill bran	5.40	6.00	3.92	2.90
Salt	0.21	0.08	0.07	0.00
Limestone	0.01	0.18	0.24	0.37
$CaHPO_4$	0.36	0.31	0.32	0.30
KCl	0.00	0.18	0.21	0.35
Bentonite	0.16	1.43	3.00	4.56
Gypsum	0.05	0.02	0.07	0.00
MgO	0.03	0.03	0.04	0.04
$NaHCO_3$	0.02	0.19	0.16	0.22
Methionine	0.02	0.01	0.00	0.00
Lysine-HCl	0.01	0.04	0.06	0.07
Palm oil	0.37	0.00	0.00	0.00
Premix[2)]	0.30	0.30	0.30	0.30
Chemical composition (% DM)				
DM (g 100 g^{-1})	89.06	89.11	89.23	89.33
CP	16.28	16.27	16.25	16.23
EE	3.37	3.37	3.36	3.36
Ash	6.27	7.60	9.00	10.47
NDF	33.69	33.67	33.62	33.58
Forage NDF	26.47	24.32	21.73	18.97
Concentrate NDF	7.22	9.35	11.89	14.61
ADF	20.53	19.34	18.31	17.19
NFC[3)]	40.39	39.09	37.77	36.36
TDN	72.98	72.94	72.85	72.76
Ca	0.63	0.63	0.63	0.63
P	0.40	0.40	0.40	0.40

[1)] DM, dry matter; DDGS, dried distillers grains with solubles; CGM, corn germ meal; CP, crude protein; EE, ether extract; NDF, neutral detergent fiber; ADF, acid detergent fiber; NFC, nonfiber carbohydrates; TDN, total digestible nutrients. The same as below.

[2)] Contains (per kg of mix): 15 mg Fe, 15 mg Cu, 70 mg Mn, 70 mg Zn, 1 mg I, 0.22 mg Se, 1 mg Co, 7 500 IU vitamin A, 20 000 IU vitamin D, 25 000 IU vitamin E.

[3)] NFC=100-(CP+NDF+EE+ash)

Growth performance and rumen development

Average body weight and structural growth parameters (withers height, WH; body length, BL; heart girth, HG) were presented in Table 2. No differences were detected for WH, BL, and HG at 4 and 8 wk, and mean body weight was similar for all treatments. Although adding NFFS tended to increase ration concentrate, no growth performance differences were detected. Similar results were observed by Khan *et al.* (2007) and Hill *et al.* (2008). Suarez-Mena *et al.* (2011) found no differences in body weight and body measurements of calves fed starters with 0, 10 or 20% DDGS at high or low milk replacer intake. However, Suárez *et al.* (2006) reported that differences in carbohydrate composition would influence rumen development. The level of fiber and the physical nature of dry feed have been found to influence intake and consequently rumen growth in young calves (Beharka *et al.* 1998), and greater forage NDF and bulk of fibrous feed could provide mechanical stimuli to en-