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Effects of alfalfa and cereal straw as a forage source on nutrient digestibility and lactation performance in lactating dairy cows

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ABSTRACT

This study was conducted to investigate the nutrient digestibility and lactation performance when alfalfa was replaced with rice straw or corn stover in the diet of lactating cows. Forty-five multiparous Holstein dairy cows were blocked based on days in milk (164 ± 24.8 d; mean ± standard deviation) and milk yield (29.7 ± 4.7 kg; mean ± standard deviation) and were randomly assigned to 1 of 3 treatments. Diets were isonitrogenous, with a forage-to-concentrate ratio of 45:55 [dry matter (DM) basis] and contained identical concentrate mixtures and 15% corn silage, with different forage sources (on a DM basis): 23% alfalfa hay and 7% Chinese wild rye hay (AH), 30% corn stover (CS), and 30% rice straw (RS). The experiment was conducted over a 14-wk period, with the first 2 wk for adaptation. The DM intake of the cows was not affected by forage source. Yield of milk, milk fat, protein, lactose, and total solids was higher in cows fed diets of AH than diets of RS or CS, with no difference between RS and CS. Contents of milk protein and total solids were higher in AH than in RS, with no difference between CS and AH or RS. Feed efficiency (milk yield/DM intake) was highest for cows fed AH, followed by RS and CS. Cows fed AH excreted more urinary purine derivatives, indicating that the microbial crude protein yield may be higher for the AH diet than for RS and CS, which may be attributed to the higher content of fermentable carbohydrates in AH than in RS and CS. Total-tract apparent digestibilities of all the nutrients were higher in cows fed the AH diet than those fed CS and RS. The concentration of rumen volatile fatty acids was higher in the AH diet than in CS or RS diets, with no difference between CS and RS diets. When the cereal straw was used to replace alfalfa as a main forage source for lactating cows, the shortage of fermented energy may have reduced the rumen microbial protein synthesis, resulting in lower milk protein yield, and lower nutrient digestibility may have restricted milk production.

Key words: forage source, lactation performance, nutrient digestibility

INTRODUCTION

Alfalfa is an excellent forage used for dairy cattle (Viands et al., 1988), but the availability of this feed ingredient is limited. In contrast, large amounts of crop residue such as corn stover and rice straw are produced each year, with approximately 200 million metric tonnes of corn stover and similar amounts of rice straw produced annually in China (Pang et al., 2008). However, the nutritional value of crop residues such as corn stover and rice straw is low because of the low contents of CP, ME, minerals, and vitamins, which may restrict their use as feed for dairy cows (Kebede, 2006; Zhao and Li, 2009).

Milk yield and composition are affected by many factors, such as breed and nutritional factors, and a direct correlation exists between roughage intake and composition of milk yield (Sutton, 1989). Metabolizable protein is the main milk protein precursor and consists of microbial CP (**MCP**) synthesized in the rumen, dietary RUP, and endogenous protein (Clark et al., 1992). Microbial CP has well-balanced EAA and its yield is positively related to milk and milk protein yield (NRC, 2001; Zhu et al., 2013a). The efficiency of MCP synthesis in the rumen mainly depends on the availability of carbohydrates and N (Shabi et al., 1998). Maximizing MCP synthesis should increase the efficiency of N utilization and reduce N urinary excretion (Thomas, 1973). Alfalfa contains higher concentrations of soluble saccharides, NPN, easily available protein, RDP, RUP, and ME than rice straw and corn stover (NRC, 2001; Yari et al., 2012). The importance of readily fermentable carbohydrates to MCP yield has been documented (Lascano and Heinrichs, 2011). Dairy cows fed alfalfa-based diets had better production performance compared with cows fed corn stover- or Chinese wild rye grass (*Leymus chinensis*) hay-based diets (Zhu et al.,

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Table 1. Ingredients of the 3 experimental diets based on alfalfa, corn stover, and rice straw

Ingredient, % of DM	Treatment[1]		
	AH	CS	RS
Ground corn grain	27.0	27.0	27.0
Wheat bran	5.1	5.1	5.1
Soybean meal	12.7	12.7	12.7
Cottonseed meal	4.3	4.3	4.3
Beet pulp	1.0	0.0	0.0
Corn silage	15.0	15.0	15.0
Alfalfa hay	23.0	0.0	0.0
Chinese wild grass hay	7.0	0.0	0.0
Corn stover	0.0	30.0	0.0
Rice straw	0.0	0.0	30.0
Urea	0.0	1.0	1.0
Premix[2]	4.9	4.9	4.9

[1]AH = TMR containing alfalfa hay as the main forage; CS = TMR containing corn stover as the main forage; RS = TMR containing rice straw as the main forage.

[2]Formulated to provide (per kilogram of DM) 174 g of zeolite powder, 1.25 g of yeast, 25 g of mold adsorbent (Solis Mos; Novus International Inc., St. Charles, MO), 21.44 g of KCl, 41.25 g of MgO, 150 g of salt, 187.5 g of $NaHCO_3$, 84 g of Ca, 15 g of P, 125,000 IU of vitamin A, 750,000 IU of vitamin D_3, 937.5 IU of vitamin E, 1,750 mg of Zn, 17.5 mg of Se, 28.75 mg of I, 375 mg of Fe, 15 mg of Co, 556.5 mg of Mn, and 343.75 mg of Cu.

2013a). The digestibility associated with ME supply may also be a pivotal factor for milk production. When crop residues of low quality are fed as a forage source, production performance of dairy cows is compromised (Kebede, 2006; Agbagla-Dohnani et al., 2012). However, little research has been conducted to compare alfalfa and cereal straw as a main forage source for the supply of readily fermentable carbohydrate, and lactation performance. Therefore, this study was conducted to investigate the nutrient digestibility and lactation performance when alfalfa was replaced with rice straw or corn stover in diets formulated for lactating cows.

MATERIALS AND METHODS

Animals, Diets, and Experimental Design

The use of the animals was approved by the Animal Care Committee, Zhejiang University (Hangzhou, China), and experimental procedures used in this study were in accordance with the university's guidelines for animal research. Forty-five multiparous Holstein dairy cows (BW = 607 ± 55.6 kg, DIM = 164 ± 24.8, and milk yield = 29.7 ± 4.7 kg/d; mean ± SD) were blocked into 15 groups based on DIM and milk production, and were randomly allocated to 1 of 3 dietary treatments (Table 1). Diets were formulated to be isonitrogenous with a forage-to-concentrate ratio of 45:55 (DM basis) and contained similar concentrate mixtures and 15% corn silage, with different forage sources (on a DM basis): (1) a diet containing 23% alfalfa hay and 7% Chinese wild rye hay (**AH**), (2) inclusion of 30% corn stover replacing alfalfa hay and Chinese wild rye hay (**CS**), and (3) inclusion of 30% rice straw replacing alfalfa hay and Chinese wild rye hay (**RS**).

Diets were fed as TMR, which were mixed using a horizontal feed mixer (9SJW-300; National Science Makoto Farming Equipment Co. Ltd., Beijing, China). The experiment was conducted over 14 wk, with the first 2 wk for adaptation. Cows were housed in individually tethered stalls in a barn with good ventilation, and fed and milked 3 times daily at 0630, 1400, and 2000 h in a pipeline milking system. The cows had free access to drinking water.

Sampling, Measurements, and Analyses of Feed, Milk, Feces, and Rumen Fluid

During the 12 sampling weeks, milk production was recorded each week for the first 3 consecutive days, and milk samples were collected on the third day of each week using milk-sampling devices (Waikato Milking Systems NZ Ltd., Waikato, Hamilton, New Zealand). The amount of the feed offered was recorded every day and was adjusted to allow for 5 to 10% orts every week, and DMI was calculated based on the feed offered and orts. One 50-mL aliquot of the milk sample was collected at each milking of the sampling day, proportional to the yield (4:3:3, composite). The composited milk sample, with added bronopol tablets (milk preservative, D & F Control Systems, San Ramon, CA), was stored at 4°C for future analysis of protein, fat, lactose, MUN, TS, and SCC by infrared analysis (Laporte and Paquin, 1999) with a spectrophotometer (Foss-4000; Foss Electric A/S, Hillerød, Denmark).