Voluntary Intake, Digestibility and Nitrogen Balance in Spotted Deer (*Cervus nippon*) Fed Forest By-product Silage, Oak Leaf Hay and Commercial Mixed Ration**

B. T. Jeon, S. H. Moon*, S. M. Lee, K. H. Kim[1] and R. J. Hudson[2]
Korea Nokyong Research Center, Konkuk University, Chungju 380-701, Korea

ABSTRACT : Forest by-product silage (FPS) comprised of foliage, shrubs, and wild grasses was prepared to examine feeding value as sole roughage source for spotted (sika) deer. This diet was compared with imported oak leaf hay (OLH) and a commercial mixed ration (CMR) in digestion balance trials with spotted deer. Dry matter intake was highest ($p<0.05$) on the OLH, whereas intakes of the FPS and CMR were similar ($p>0.05$). Digestibility of dry matter was highest ($p<0.05$) for CMR. Digestibility of crude protein was highest in CMR and lowest in OLH and there were significant differences ($p<0.05$) among diets. Average daily gain, digestible dry matter intake and digestibility of crude fiber did not differ significantly among diets. Nitrogen intake, urinary and digestible nitrogen were highest ($p<0.05$) in CMR. However, nitrogen retention was not significantly different. Consequently, FPS is a good roughage source for deer having high digestibility, dry matter intake and availability of nitrogen. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 5 : 702-705)***

Key Words : Spotted Deer, Intake, Digestibility, Nitrogen Balance, Forest By-product Silage

INTRODUCTION

The main species of farmed deer in Korea, wapiti, red deer (*Cervus elaphus*), and spotted (sika) deer, are classified as intermediate feeding types according to Hoffman's morphophysiological criteria (Hoffman, 1988; Henke et al., 1988). These species select widely foliage, twigs, forbs and wild grasses (Currie et al., 1977; Blair and Brunett, 1980; Crawford, 1982: Lee et al., 1990). Natural mixed diets are seldom used on deer farms because they tend to be of variable quality and expensive with the high labor costs to harvest them. In Korea, oak leaf has been used as a roughage source for deer because of high palatability and presence of tannin that can have positive (Aerts et al., 1999) or negative effect (Natis and Malechek, 1981) on animal performance. However, oak leaves are mostly imported and thus expensive.

Kim et al. (1996) reported that imported oak leaf had low nutritive value and nitrogen availability compared with homegrown roughage sources such as corn silage and rye silage. In contrast, Jeon et al. (1998) showed that whole browses, shrubs, and wild grasses (forest by-products) from reforestation areas are valuable feed sources for deer. Reforestation efforts in the vast mountainous district in Korea may provide regional or national self-sufficiency in roughage supplies for deer. This experiment was conducted to compare intake, digestibility, and nitrogen balance in spotted deer fed forest by-product silage that contained foliage, shrubs, and wild grasses with oak leaf and commercial mixed diets.

MATERIALS AND METHODS

Feeding trials were conducted at the HANA Deer Research Institute in Chungju. Three female Korean spotted deer (*Cervus nippon*), 2 years old and weighing 41, 39, 42.5 kg at the beginning of the experiment, were held individually in metabolism cages with visual contact with neighboring animals. The metabolism cages were designed to allow separate collection of urine and feces. Trials consisted of a 10-day adjustment and 7-day collection period planned using a 3×3 Latin square design balanced for carryover effects.

Throughout the experiment, forest by-product silage (FPS), and oak leaf hay (OLH), and commercial mixed ration (CMR) were offered *ad libitum* to each deer as experimental diets, each fed along with a commercial concentrate as a basal diet offered at a level of 1% of body weight. The commercial mixed ration was based largely on alfalfa hay, beet pulp, lupin seed coat, brewer's grain, rice bran, wheat bran, other agricultural by-products, buffer, and mineral additive. Oak leaf hay imported from China was commercially available.

Forest by-product silage contained fresh leaves (about 67.5%, DM) and stems (about 32.5%, DM) of trees, shrubs (about 80-90%, DM) and wild grasses (about 10-20%, DM)

* Reprint request to: S. H. Moon, Tel: +82-43-8403527, Fax: +82-43-8518216, E-mail: moon0204@kku.ac.kr
[1] Nutrition Physiology Division, National Livestock Research Insitute, RDA. Suweon 441-350, Korea
[2] Renewable Resources, University of Alberta, Edmonton, Canada T6G 2P5
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Table 1. Chemical composition of experimental diets (%, DM)[1)]

Diet	DM	CP	EE	CF	ASH	NFE	NDF	ADF	TAN
Concentrate	88.7	19.4	2.9	18.1	7.4	52.2	36.7	11.7	0.4
CMR[2)]	85.5	15.5	6.1	18.9	6.6	52.9	50.7	22.1	1.1
FPS[3)]	36.5	8.2	2.0	43.2	5.0	41.6	69.9	53.2	2.3
OLH[4)]	96.7	8.5	4.6	35.2	5.1	46.6	52.9	36.3	6.7

[1)] DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fiber, NFE: nitrogen free extracts, NDF: neutral detergent fiber, ADF: acid detergent fiber TAN: tannin

[2)] CMR: Commercial mixed ration, [3)] FPS: Forest by-product silage

[4)] OLH: Oak leaf hay

collected in a reforestation area in August 1999 and ensiled with a little hydration (adjustment to a total moisture content of 65%) for fermentation after chopping to a length of 2.7±2.3 cm. Forest by-product consisted of oak (*Quercus aliena*, about 31.0% of fresh matter), lacquer tree (*Rhus verniciflua*, about 22.5% of fresh matter), hazel (*Corylus heterophylla*, about 7.2% of fresh matter), arrowroot (*Puerario thunbergiana*, about 7.0% of fresh matter), azalea (*Rhododendron mucronulatum*, about 1.2% of fresh matter), sedge (*Carex disticha*, about 0.5% of fresh matter), and others.

The experimental diets were offered to each deer at approximately 3.5% of body weight on a dry matter basis and offered twice a day at 0900 and 1800 h. Feed refusals and excreted feces and urine were collected just before the next feeding. H_2SO_4 (3N) of 20 ml was daily added in order to prevent volatilization of ammonia in urinary nitrogen. During the experimental period, deer had free access to water and mineralized salt.

Voluntary intake of each animal was estimated by subtracting refusals from the diet offered and apparent digestibility was determined by total fecal collection. Samples of diet, refusals, feces and urine were refrigerated or immediately oven-dried. Dried samples ground through a 1 mm sieve were analyzed for chemical composition following the standard methods of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to Goering and Van Soest (1970). Tannin content of experimental diets was analyzed by the phosphotungstomolybdic acid method of AOAC (1990). Deer were weighed pre- and post-collection periods and the accuracy of the scales used for these measurements was ±0.1 kg. Data were expressed as means and were analyzed with Tukey's multiple range test using SAS package (1989).

RESULTS AND DISCUSSION

Forest by-product silage had a fermentative quality of 4.1 pH and 8.9% lactic acid (DM basis). Chemical compositions of the experimental diets are presented in Table 1.

Apparent digestibility of dry matter, crude protein, and crude fiber are given in Table 2. The digestibility of dry matter was highest in CMR ($p<0.05$) but there was no significant difference in dry matter digestibility of the other two diets. The digestibility of crude protein was highest in CMR and lowest in OLH and there were significant differences ($p<0.05$) among treatments. Commercial mixed ration (CMR) and FPS tended to have greater digestibility of crude fiber than OLH but the differences were not significant.

Table 2. Digestibility (%, mean±SEM) of dry matter (DM), crude protein (CP) and crude fiber (CF) by spotted deer fed experimental diets

Diet[1)]	DM	CP	CF
CMR	76.7±2.3[a]	78.5±1.4[a]	54.6±8.0[a]
FPS	65.5±9.3[b]	64.7±7.2[b]	49.0±13.3[a]
OLH	57.8±2.1[b]	41.3±9.1[c]	47.4±5.4[a]

[1)] See Table 1 for details.

[a, b, c] Different letters in a line show differences ($p<0.05$) among treatments.

Henke et al. (1988) reported that relative ruminorecticular capacity, an index of digestive capability, varied among ruminant species. Because Korean spotted deer consumed near equal amounts of grass and forbs, the study concluded that they are able to use a variety of feed sources better than white-tailed deer (*Odocoileus virginianus*) which are concentrate selectors. Kim et al. (1996) also found that spotted deer have a good digestive capacity and adaptability for forages. Although there was a significant difference in dry matter digestibility, deer fed all three experimental diets showed digestibility above 57% in this experiment.

Digestibility in ruminants is affected by quality (Thomas et al., 1976), quantity (Brown, 1966), physical form (Balch and Campling, 1962), particle size (Forbes, 1986), and passage rate (Van Soest, 1982) of feed. The high digestibility of CMR was expected from its high protein and low fiber contents (Table 1). Low digestibility of FPS was also attributed to higher content of crude fiber than CMR. Lower digestibility of OLH may be related to the rapid passage rate of feed particle caused by higher level of intake (Kato et al., 1989) and friable structure of oak leaf hay (Kim, 1994). Particle breakdown is one of the main factors influencing digestion of feed (Welch, 1982) and this depends heavily upon feed types (Wilson et al., 1989; Kwak et al., 1996).

Another reason for low digestibility of oak leaf hay may be tannins. Previous research reported tannin contents of 8.5-11.3% on a dry matter basis in oak leaves (Nastis and Malechek, 1981; Lee et al., 1993) and it was 6.7% on a dry matter basis for OLH in this experiment (Table 1). At high levels, tannins are anti-nutritional and depress the digestibility of cellular constituents (Barry and Duncan, 1984). Sensitivity to tannins varies among ruminants and, at

Table 3. Voluntary intake (g/day, mean±SEM) of dry matter (DMI), digestible dry matter (DDMI) and daily body weight gain (DG, kg/day) of spotted deer fed experimental diets

Diet[1)]	DMI	DDMI	DG
CMR	1,065±159.6[a]	817±137.5[a]	0.16±0.09[a]
FPS	1,043±206.3[a]	683±240.3[b]	0.16±0.08[a]
OLH	1,368±95.7[b]	791±30.8[b]	0.14±0.09[a]

[1)] See Table 1 for details.

[a, b] Different letters in a line show differences ($p<0.05$) among treatments.

moderate levels, tannins may enhance performance and health of deer through their effect on by-pass protein and anti-parasitic effect (Aerts et al., 1999). In this experiment, OLH was less digestible than FPS, even though that contained higher concentrations of cellular constituents (Table 1). Because FPS had lower tannin content and dry matter intake than OLH, this may have reduced the negative effect on digestibility by tannin and increased retention time in reticulo-rumen.

Voluntary intake of dry matter (DMI) and digestible dry matter intake (DDMI) in spotted deer fed experimental diets is given in Table 3. Dry matter intake was highest ($p<0.05$) in OLH. Digestible dry matter intake tended to be highest in CMR and lowest in FPS but these differences were not significant. Because of the high DM intake and low digestibility in OLH, DDMI was a similar to other diets. The low DM intake in FPS was likely attributed to high moisture content (63.5%, Table 1), a well-known factor limiting intake of silages (Forbes and Jackson, 1971). Also, FPS contained a high proportion of stems (32.5%) and hence structural carbohydrates such as cellulose, hemicellulose, and lignin that are refractory to digestion.

Daily gain (DG) of body weight in spotted deer fed experimental diets is given in Table 3. Daily gain tended to be lowest in OLH and similar in CMR and FPS, but there were no significant differences.

Nitrogen intake, urinary and digestible nitrogen were higher ($p<0.05$) in CMR than in FPS and OLH (Table 4). However, although retained nitrogen tended to be higher in CMR and FPS than in OLH, these differences were not significant. The higher fecal nitrogen excretion in OLH was due to low digestibility, especially of protein (Table 2). Researchers reported that the increase of oak browse ratio in the diet increased the excretion of fecal nitrogen (Nastis and Malechek, 1981; Lee et al., 1994). Tannin compounds may form complexes with mucoprotein secreted from the gut wall (Kumar and Vaithiyanathan, 1990) and these complexes resist ruminal and caecal degradation, thus leading to the increase of fecal nitrogen excretion (Kim et al., 1996). Holter et al. (1979) determined that deer tended to excrete less fecal nitrogen and more urinary nitrogen with increasing nitrogen intake. In this study, deer fed FPS excreted less fecal nitrogen (34.6% of NI, $p<0.05$) than those fed OLH and less urinary nitrogen (17.1% of NI, $p<0.05$) than those fed CMR and thus, retained highest nitrogen (48.3% of NI, $p>0.05$). Forest by-product silage contained a variety of foliage, shrubs, and wild grasses and thus was expected to contain intermediate levels of tannin that may have lead to the improved nitrogen utilization.

Table 4. Nitrogen balance of spotted deer fed experimental diets

Item	Experimental diet[1)]		
	CMR	FPS	OLH
	g/head/day		
Nitrgen intake (NI)	28.6±3.8[a]	20.5±2.3[b]	23.7±1.1[b]
Fecal nitrogen (FN)	6.1±0.9[b]	7.1±0.8[b]	14.0±2.7[a]
Digestible nitrogen (DN)	22.5±2.4[a]	13.4±1.7[b]	9.7±3.5[b]
Urinary nitrogen (UN)	10.7±3.4[a]	3.5±2.2[b]	2.0±0.6[b]
Retained nitrogen (RN)	11.8±6.2[a]	9.9±4.6[a]	7.7±2.0[a]
		%	
FN/NI	21.3	34.6	59.1
UN/NI	37.4	17.1	8.4
DN/NI	78.7	65.4	40.9
RN/NI	41.3	48.3	32.5

[1)] See Table 1 for details.

[a, b] Different letters in a row show differences ($p<0.05$) among treatments.

As a result of this experiment, it is thought that FPS might be recommended as a roughage source for deer. The main limitations on use of FPS have been seasonal variability of quality and the relatively high labor cost to harvest and store it. Ensiling offers a way to preserve natural roughages and to reduce costs. In this study, we estimated that the cost of FPS to be 176 won/kg on dry matter basis. This is lower than costs of CMR and OLH which were determined to be 290 and 376 won/kg, DM, respectively. Additional research is needed on specific effect of tannin, improvement of nutritive value and reduction of cost for effective utilization of FPS.

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