FRACTIONS, RUMINAL DISAPPEARANCE AND DIGESTION RATE OF DEER FEED NUTRIENTS ESTIMATED USING *IN SITU* BAG TECHNIQUE IN THE ARTIFICIAL RUMEN*

W. S. Kwak[1], H. S. Ahn[2], B. T. Jeon, O. H. Kim, S. C. Roh and C. W. Kim

Animal Resources Research Center and Department of Animal Science, College of Natural Sciences, KonKuk University, Korea

Summary

A study was conducted to estimate nutritive value of forage sources used in deer diets. Bags containing feedstuffs were incubated four times for periods up to 72 hours in two chemostats filled with ruminal fluid from deer or cattle. Parameters estimated were water-soluble and 65 μm filterable plus insoluble digestible fractions (No. = 4) and extent of disappearance (No. = 8) of feed dry matter (DM), and digestible fraction (No. = 4) and extent of disappearance (No. = 8) of feed neutral detergent fiber (NDF). Among tested feeds, the ranking of values of these parameters were soybean hulls > alfalfa pellets > corn cobs or rice straw > cottonseed hulls or rice hulls > sawdust, indicating that soybean hulls and alfalfa pellets were more fermentable than other agricultural residues. It is possible to utilize variability among tested feeds of fraction, disappearance rate and (or) extent of DM and NDF when these feeds are used as roughage sources in deer diets.

(**Key Words** : Deer, Feed, Nutritive Value, Nylon Bag Technique, Artificial Rumen)

Introduction

The *in vivo* evaluation of nutritive value of feeds for farmed spotted deer (*cervus nippon*) is expensive in terms of investment, labor and time. The *in situ* bag technique requires cannulated animals, but spotted deer are particularly difficult to restrain for cannulation and indoor experimentation. The artificial rumen technique has been successfully used for estimating the nutritive value of feeds (Kafkewitz et al., 1973; Isaacson et al., 1975; Czerkawski and Breckenridge, 1977; Jayasuriya et al., 1987). The combined technique of *in situ* bags and artificial rumen as an alternative for avoiding the difficulties associated with the *in situ* bag technique could be used for estimating nutritive values of deer feeds (Kim et al., 1995).

The search of forage resources for farmed deer is important in countries with limited grazing areas. Little information is available on the evaluation of nutritive values of forage sources used in formulated feeds for deer.

The present study was conducted to estimate nutritive values of deer forage sources using the *in situ* nylon bag technique in the artificial rumen.

Materials and Methods

Experimental Preparations

Two chemostats (EYELA, Tokyo Bikakikai Co., Ltd.) as described by Kafkewitz et al. (1973) and Isaacson et al. (1975) with some modifications were used in this study. Chemostat manipulation and medium preparation were as described in a previous study (Kim et al., 1995) in our laboratory. The method of feeding solid medium (9.6 g/d) was as described by Czerkawski and Breckenridge (1977).

Fresh rumen fluid was collected from spotted deer slaughtered on farms and from the slaughter house of beef cattle. The fluid was strained through four layers of surgical gauze, handled as in Palmer et al. (1976), and used as inoculum for the chemostats.

[1]Address reprint requests to Dr. W. S. Kwak (Ph. D.) Department of Animal Science, College of Natural Sciences, KonKuk University, Danwoldong-322, Chungju city, Chung-Buk province 380-701, Korea.

[2]Daeho Co., LTD., Daeho bldg., 812-11, Bangbae-Dong, Seocho-Ku, Seoul, Korea.

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Tested feed ingredients possibly used in deer diets included soybean hulls, alfalfa pellets, corn cobs, rice hulls, rice straw, cottonseed hulls and sawdust. In order to minimize the wash-out portion of fine feed particles through nylon bag pores, the ground feeds were mechanically sieved and particle sizes in the range of 250 μm and 1.14 mm were used for chemostat incubations.

Trials and periods

Four duplicate trials were conducted. Each trial consisted of a 5-d adaptation and a 8-d collection period. During the 8-d collection period, the *in situ* nylon bag technique was that of Nocek (1985) with modifications. Incubation times were 0, 3, 6, 9, 12, 24, 48, and 72 hours. The time order of incubation was decided randomly by lot through the 8-d collection period. Two wire nets at fixed with nylon bags containing samples (approximately 1.5 g on an air dry basis) were submerged vertically on the wall side of the fermentor and incubated for the assigned time. After removal, bags were rinsed in a continuous flow of tap water for approximately 24 hours, then dried at 60℃ for 48 hours.

Analysis

Samples collected were analyzed for nitrogen (AOAC, 1985), NDF and acid detergent fiber (ADF) (Van Soest et al., 1991). Fractionation of feed DM and NDF was made only in ruminal inoculum of deer. Feed DM was classified into three fractions (Armentano et al., 1986). Fractionation of NDF was made using the method of Smith et al. (1971). The method for determination of NDF digestion rates was that of Nocek and English (1986) with no lag time. Residues at each incubation time minus the indigestible fraction were converted to percentage, transformed to the natural logarithm, and subjected to linear regression. The model used to estimate disappearance for DM and NDF was that of Mertens and Loften (1980). In the present study, ruminal inoculum source of deer or cattle did not statistically change disappearance of feed DM and NDF and digestion rate of feed NDF. Thus, data were pooled with the removal of inoculum effect from the model. Statistical analysis was by one-way analysis of variance (SAS, 1982). Regression analysis was used to test correlation coefficients of means (SAS, 1982).

Results and Discussion

Chemical composition of feeds

Judging from their chemical composition (table 1), the quality of the test feeds varied markedly. Among feeds, crude protein (CP) was highest in alfalfa pellets and soybean hulls. NDF concentration was highest in corn cobs and lowest in alfalfa pellets. Generally, chemical composition was similar to that in NRC (1988), with the exception of relatively low CP in alfalfa pellets, high NDF and ADF in corn cobs, and low NDF and ADF in cottonseed hulls.

TABLE 1. CHEMICAL COMPOSITION (% ON A DM BASIS) OF FEEDS EVALUATED

	DM	OM	CP	EE	NDF	ADF	Ash
Soybean hulls	93.9	94.4	10.4	1.4	70.5	48.5	5.6
Alfalfa pellets	93.0	91.0	13.2	2.0	54.6	40.9	9.0
Corn cobs	90.7	98.5	2.3	.9	93.9	53.7	1.5
Rice hulls	92.1	84.7	2.0	.1	87.4	72.0	15.3
Rice straw	92.2	80.7	4.2	1.4	78.7	52.9	19.3
Cottonseed hulls	99.7	96.3	6.1	3.0	82.9	60.5	3.9
Sawdust	76.7	99.4	.8	2.1	89.6	77.9	.6

Feed DM fractions

Results are summarized in figure 1. Values in decreasing order of Water-soluble and 65 μm filterable, and insoluble digestible fractions of feeds were ranked as follows; soybean hulls > alfalfa pellets > corn cobs > rice straw > cottonseed hulls > rice hulls > sawdust. Water-soluble and 65 μm filterable DM fractions were highest for alfalfa pellets. Water-soluble and 65 μm filterable DM and concentration of NDF were negatively correlated to each other in deer inoculum ($r = -.96$). Seoane (1982) related DM intake by sheep to DM solubility in water.

Feed DM disappearance

The pooled extents of DM disappearance (No. = 8) at 24 hours of incubation in either ruminal inoculum of deer or cattle are presented in figure 2. Soybean hulls and

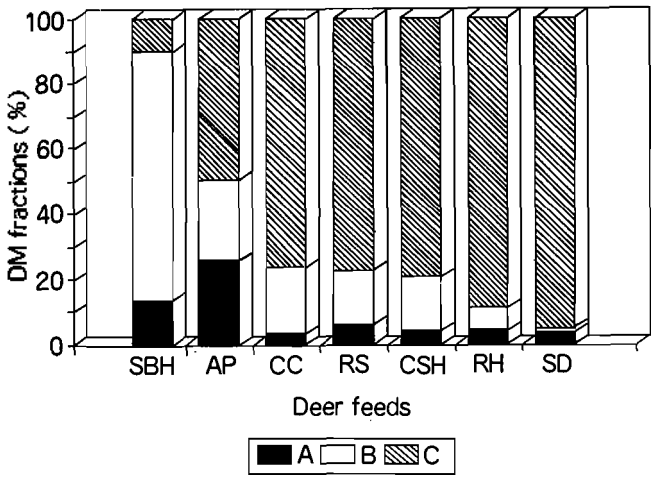

Figure 1. Water-soluble and 65 μm filterable (A), insoluble digestible (B), and indigestible (C) fractions of dry matter (DM) of deer feeds as evaluated in ruminal inoculum of deer for 72 hours (SBH = soybean hulls, AP = alfalfa pellets, CC = corn cobs, RS = rice straw, CSH = cottonseed hulls, RH = rice hull, and SD = sawdust. No. = 4).

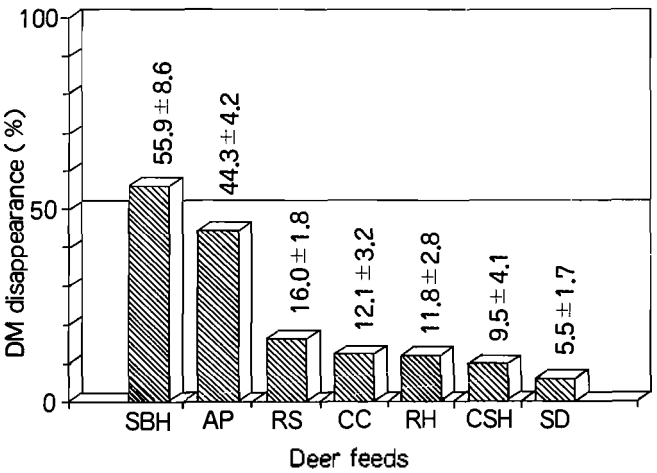

Figure 2. Extents of feed dry matter (DM) disappearance at 24 hours of incubation in either ruminal inoculum of deer or cattle (SBH = soybean hulls, AP = alfalfa pellets, CC = corn cobs, RS = rice straw, CSH = cottonseed hulls, RH = rice hull, and SD = sawdust, No. = 8).

alfalfa pellets were the most digestible and swadust the least. Feed DM disappearance was highly correlated with water-soluble and 65 μm filterable plus insoluble digestible fractions (r = .96). Hsu et al. (1987) also reported that soybean hull was most fermentable in the rumen (90.6% of DM disappearance at 27 hours), compared with corn fiber, oat hulls, and cottonseed hull.

Feed NDF fractions

The digestion of NDF fractions determined in ruminal inoculum of deer are as shown in figure 3. Except for soybean hulls, which contained the highest digestible NDF, the major NDF fraction among feeds was indigestible (66.5 to 93.6%).

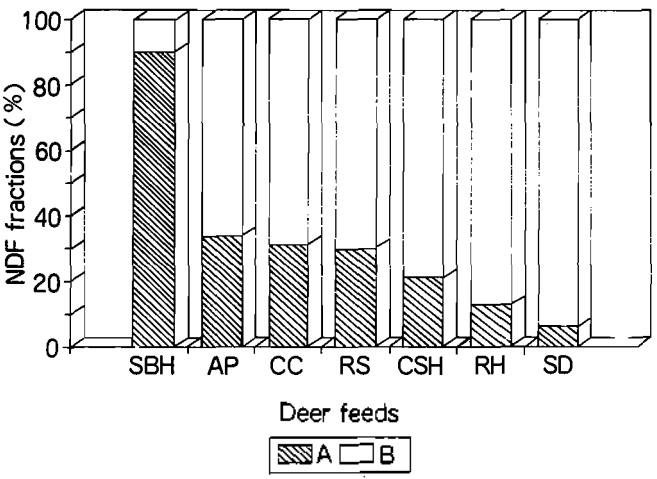

Figure 3. Digestible (A) and indigestible (B) fraction of neutral detergent fiber (NDF) of deer feeds as evaluated in ruminal inoculum of deer for 72 hours (SBH = soybean hulls, AP = alfalfa pellets, CC = corn cobs, RS = rice straw, CSH = cottonseed hulls, RH = rice hull, and SD = sawdust. No. = 4).

Feed NDF disappearance

The pooled extents of NDF disappearance (No. = 8) at 24 hours of incubation in either ruminal inoculum of deer or cattle are presented in figure 4. The ranking of soybean hulls > alfalfa > corn cobs was similar to that from *in situ* findings (38.4% of soybean hulls > 34.6% of alfalfa > 27.5% of corn cobs) that Varga and Hoover (1983) obtained using dairy cattle. High correlation coefficients (r = .94) between NDF and DM disappearance were found, as in Varga and Hoover (1983). Extent of NDF disappearance was highly correlated with digestible fraction of NDF (r = .98). Extent of NDF disappearance appeared to be dependent mainly upon digestible NDF fraction rather than digestion rate of NDF.

Digestion rates of feed NDF

Digestion rate (%/h) of feed NDF in ruminal inoculum

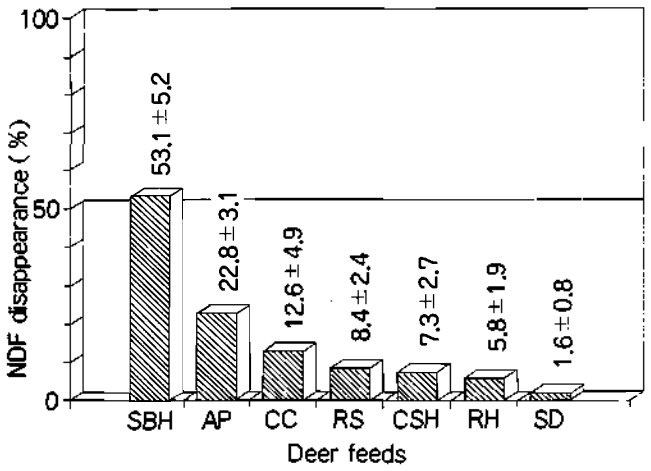

Figure 4. Extents of feed neutral detergent fiber (NDF) disappearance at 24 hours of incubation in either ruminal inoculum of deer or cattle (SBH = soybean hulls, AP = alfalfa pellets, CC = corn cobs, RS = rice straw, CSH = cottonseed hulls, RH = rice hull, and SD = sawdust. No. = 8).

of deer for 72 hours was 3.5 ± 0.7 for soybean hulls, 6.1 ± 1.5 for alfalfa pellets, 2.3 ± 1.2 for corn cobs, 4.6 ± 1.2 for rice hulls, 3.0 ± 0.8 for rice straw, 1.6 ± 0.6 for cottonseed hulls, and 4.0 ± 1.8 for sawdust. Alfalfa pellets showed the highest digestion rates, which were similar to 6.2%/h for alfalfa hay observed in Nocek and English (1986). In general, variation within feedstuff tended to be high. The digestion rate of feed NDF did not conistently changes with NDF concentration, as in Nocek and Kohn (1988), nor with extent of NDF disappearance. In consequence, tested feed NDF disappearance was affected mainly by digestible NDF fraction rather than NDF digestion rate. Mertens (1977) suggested that digestion rate of NDF may be related to non-chemical entities such as morphological, crystalline, or physical nature of the NDF.

In addition, particle breakdown is one of the major factors influencing the digestive process (Mertens and Ely, 1982; Welch, 1982) and occurs through chewing during eating and rumination, microbial fermentation, and rumen movement (Poppi et al., 1982; Smith et al., 1983; Moseley and Jones, 1984). A few studies (Moseley and Jones, 1984; Murphy and Nicoletti, 1984) indicated a minor role of microbial action in particle breakdown. However, Nocek and Kohn (1988) suggested that microbial fermentation and ruminal movement appear to contribute substantially to particle breakdown. In our study, where the experimental condition allowed mainly microbial digestion, the considerable role of microbial action was evidenced by data on extents of feed DM disappearance (5.5 to 55.9%) and NDF disappearance (1.6 to 53.1%) at 24 hours of incubation. The extent of microbial contribution to particle breakdown was highly dependent upon feed types.

Conclusions

Under the conditions of this study, the estimated water-soluble and 65 μm filterable plus insoluble digestible fractions and extent of disappearance of feed DM, and digestible fraction and extent of disappearance of NDF were ranked in decreasing order of soybean hulls > alfalfa pellets > corn cobs or rice straw > cottonseed hulls or rice hulls > sawdust. Soybean hulls and alfalfa pellets were more digestible than other agricultural residues; with soybean hulls being the most fermentable and sawdust the least fermentable. These results may be considered for the effective deer feeding when tested feeds are used as roughage sources in deer diets.

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