EFFECTS OF CELLULOSE LEVELS ON THE APPARENT DIGESTIBILITY OF FEEDS EATEN BY MULE DEER[1]

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Abstract: Three artificial diets that varied in cellulose content but were similar in protein and energy levels were fed to three mule deer according to a latin square design. Food intake for each deer, on each diet, during each feeding period was similar. Energy and dry matter digestion varied between diets ($P < 0.05$) and both digestible energy and digestible dry matter were inversely related to dietary cellulose content. Cellulose digestion was somewhat variable between animals, feeds, and feeding trial periods. Protein digestion was similar in all feeding trials but crude fat digestion was somewhat greater on the low-cellulose diet. Limited cellulose digestion occurs in mule deer and affects energy and dry matter digestion of foodstuffs.

The proximate analysis of important species of deer browse has many times been shown to have little value in predicting how a deer digests a particular forage item. Digestion trials with wild forages have been performed many times with deer of the genus *Odocoileus*. These investigations have shown differences in the value of particular forages to deer and have compared the manner in which domestic and wild ruminants utilize the same forage. A digestion trial using wild forages and deer is seriously limited when the food presented to the deer has been selected by the investigator rather than by the animal. Sometimes this selected forage has been extensively modified by air drying, grinding, pelleting, or other treatment so that the foodstuff may bear little resemblance to the growing plant. Information about the comparative digestibility of the ration must then be analyzed with the realization that some circumstances were artificial. Important generalities describing how deer utilize foodstuffs should therefore be cross-checked with experiments that remove as many variables as possible from the digestion trials. Artificially compounded rations in which the variable components are reduced to only one may be used to allow a more rigorous statistical and biological analysis. This is a popular technique for examining, among other things, a general relationship between the level of a particular dietary constituent within a feed and the digestibility of that feed.

Digestion trials with mule deer (*O. hemionus*) and feeds compounded from native browse plants demonstrated (Short and Remmenga 1965) a significant relationship between the cellulose content and the digestible energy of the feed. These findings suggested that the normal seasonal variation in the fiber content of natural forages might appreciably influence the nutritional availability of these forages to deer. However, the limited amount of feed available made possible too few replications to demonstrate the strength of the inverse relationship between dietary cellulose and digestible energy. The present study was undertaken to further clarify the relationship between dietary cellulose and the digestibility of a feed by mule deer.

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Table 1. Percentage composition and chemical analysis of three compounded feeds used in the deer feeding trials.

Diet	Percentage Composition							Chemical Analysis (percent)				
	Ground corn	Cellulose	Soy bean meal	Corn oil	Trace mineral salt	Bone meal	Vitamin A & D	Crude protein	Crude fat	Dry matter	Cellulose	kcal/g
Low cellulose	59	16	22	1	1	1	*	19.9	2.8	92.4	14.8	4.39
Medium cellulose	37	31	26	4	1	1	*	18.8	3.4	92.2	33.8	4.46
High cellulose	15	46	30	7	1	1	*	20.2	4.2	94.1	41.0	4.57

* Two g vitamin D_3 (15,000 IU/g) and 1 g vitamin A (30,000 IU/g) added per 150 lb of feed.

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METHODS AND MATERIALS

Three dietary rations were compounded from cellulose, feedstuffs, and supplements (Table 1). Solka Floc BW-40 (a purified wood cellulose obtained from the Great Lakes Carbon Company, St. Louis, Missouri) and ground corn were added in varying ratios to provide differences in the cellulose content. Solvent extracted 50 percent soybean meal was used as the essential source of dietary protein and corn oil was added to equalize the gross energy content of the feeds. Trace mineral salt, bone meal, and Vitamin A and D supplements were added to each feed. The three rations were compounded, mixed, and pelleted with steam. These rations were formulated to yield very similar protein (16.3–16.5 percent), and gross energy values, and cellulose at three levels (17.9, 32.6, and 47.3 percent). The differences between these expected values and the observed composition listed in Table 1 (crude protein levels between 18.8–20.2 percent, gross energy between 4.39–4.57 kilocalories per gram, and cellulose levels of 14.8, 33.8, and 41.0 percent) are believed to result from the difficulty of passing small feed samples (150 pounds of each ration) through the large pelleting dies of a commercial feedhouse. The feed pellets were about ⅛ by ½ inch and were generally of medium firmness. The pellets on the high-cellulose diet were the least firm because the Solka Floc is powdery.

Three 7-month-old female fawns, born in captivity and conditioned to the presence of man, were fed the experimental feeds according to a 3 × 3 latin square design. Each deer was assigned a particular diet during a particular trial period and each digestion trial was assigned to one of two digestion-trial pens. The nine feeding trials required 14 weeks from mid-February to mid-May, 1963.

Deer were weighed at least six times during each digestion trial. No deer varied much in weight during the 12- or 13-day period of a digestion trial (the coefficient of variation of a deer's weight during a trial never exceeded 2.8 percent of the mean weight). The mean weights of the three deer at feed trial periods nos. 1, 2, and 3, were as follows: deer no. 148—76, 79, 84 pounds; deer no. 150—76, 76, and 79 pounds; deer no. 151—98, 101, 110 pounds. Although of the same age and from the same herd, deer no. 151 was larger and more tame than the other animals—possibly reflecting a "pet-deer" status. This was an unavoidable variable in this study.

The trials were conducted within two 12- × 14-foot covered enclosures. Each enclosure was floored by a canvas tarpaulin laid on a paper mat. Two entrances into the feeding pens allowed the deer to move into

Table 2. The apparent digestion coefficients of five components of three artificial diets fed to each of three deer.

DIET	DEER NO.	ENERGY	DRY MATTER	CELLULOSE	CRUDE PROTEIN	CRUDE FAT
Low cellulose	148	74.0	72.0	4.1	77.3	84.6
	150	77.2	75.7	13.5	81.4	85.8
	151	77.1	75.3	4.0	82.3	85.5
Medium cellulose	148	65.6	62.4	17.8	83.8	83.4
	150	64.7	62.6	23.4	77.5	83.5
	151	64.5	61.8	17.7	78.3	83.2
High cellulose	148	57.6	53.4	14.0	82.0	81.6
	150	50.3	46.1	–4.0	82.4	84.9
	151	56.2	50.6	8.2	80.2	82.8

portable carrying crates when the investigator entered the area to inspect or make fecal collections. Water was offered ad libitum and feed and water were presented from a covered box placed adjacent to the test pen. Deer were fed at a constant rate (3 percent of body weight per day) to minimize the effect on food consumption of the period when they were fed. Food consumption was measured to the nearest 4 grams. Water consumption and urine production were not measured. The deer were weighed (inside the carrying crates) every second day, using a Fairbanks platform scale. All fecal matter was collected by vacuuming the pen floor each day. An estimated 10 percent of the fecal pellets came in contact with urine held in folds of the tarpaulin flooring. Such wet deer pellets were used to obtain the total dry weight of a day's fecal production but were not used in assaying the fecal material chemically. The pen floor was cleaned every day after the pellets were collected.

Each deer was conditioned to a particular test diet and the experimental situation for 7 days, followed by a 5-day total fecal collection period. The appearance of markers —the white pellets produced on the high cellulose diet or coloration produced by chromium oxide—established that a lag period of 1 day existed between feed ingestion and fecal excretion. Each deer was rested for 14 days between feeding trials under standard penned conditions, and was fed a pelleted ration compounded from corn and alfalfa.

The collected fecal material was ovendried at 110 C, cleaned of debris and analyzed, as was the feed material, for crude protein and crude fat (procedures of the Association of Official Agricultural Chemists); for cellulose, using the procedure of Salsbury et al. (1956); and for energy (Parr Instrument Company, Manual 130).

RESULTS

Because the deer usually were quite consistent in their daily food intake, the ratios of food eaten to fecal material excreted were considered reliable. This is especially true for the feeding trials on the low- and medium-cellulose diets. Note that deer no. 150 consumed about 400 grams less feed than usual on day 4 of the fecal collection period on the high-cellulose diet. This seems to have affected the feed–fecal matter ratio and possibly is reflected in the decreased energy, dry matter, and cellulose digestion values recorded in Table 2. Food intake, grams of ovendry weight per kilogram of deer body weight, (Table 3), was not different between diets, animals, and feeding trial periods. These data seem to indicate that the diets were all similarly palatable to the three deer, and that earlier feeding trials did not appreciably affect the behavior of deer on later trials.

Table 3. Analysis of variance of feed trial data to test feed palatability, effectiveness of trial procedure, and effect of diet on energy, dry matter, cellulose, protein, and fat digestion.

Variable	Variable Mean Square (df =2)	Error Mean Square (df = 2)
Energy digestion between feeds	343.69*	12.02
Dry matter digestion between feeds	442.87*	11.90
Cellulose digestion between feeds	169.96	57.31
Protein digestion between feeds	2.22	4.56
Fat digestion between feeds	4.32†	0.38
Food intake (g/kg body wt.)		
Between feeds	501.41	511.24
Between animals	52.14	511.24
Between feed trial periods	75.72	511.24

* Significant at 5 percent level.
† Significant at 10 percent level.

The apparent digestion of (1) energy and (2) dietary dry matter varied significantly between diets ($P < 0.05$). The digestible energy and the digestible dry matter of the nine feeding trials were related to cellulose content according to the two regression equations, $\hat{Y} = 88.24 - 0.77X$, and $\hat{Y} = 88.20 - 0.87X$, respectively. The slopes of both equations are significantly different from zero. The small error mean square listed in Table 3 indicates that there was little variation among the deer in the efficiency of digestion of the energy and dry matter of the trial rations. The effect of dietary cellulose on dry matter digestion is further illustrated by the comparison of feed and fecal dry matter on the three diets. Deer produced fecal material equal to 24–28 percent of the dry matter eaten on the low-cellulose diet; 37–38 percent of the dry matter consumed on the medium-cellulose diet; and 46–54 percent of the consumed dry matter on the high-cellulose diet.

Cellulose digestion was somewhat variable between animals, diets, and feeding trial period, as indicated by the relatively large error mean square listed in Table 3. The analysis of variance suggests that there were no significant differences in cellulose digestion attributable to diet, deer, or feeding trial period. The negative cellulose digestion by deer no. 150, on the high-cellulose diet, apparently reflects a slightly incomplete collection of fecal material. The consistently higher cellulose digestion on the medium-cellulose diet might possibly represent a sampling error—the feed sample assayed a somewhat higher cellulose content than anticipated.

The protein content of the test feeds was similar, and the apparent digestion coefficients (Table 2) indicate that there were no differences in protein digestion. Variations attributable to deer, diet, or test period were low. The apparent digestibility of crude fat in these experiments suggests ($P < 0.10$) that fat digestion of the low-cellulose diet might be slightly greater than that of the other diets. However, no difference is evident between crude fat digestion on the medium- or high-cellulose diets. No variation in fat digestion is evident between animals or feeding trial periods.

DISCUSSION

These data show a statistically significant relationship between the cellulose content and the apparent digestibility of dry matter and energy in the experimental rations, and substantiate results reported by Short and

Remmenga (1965) using rations formulated from selected browse species. Results of the two experiments indicate that for mule deer the available energy of feed materials is inversely related to the cellulose content of the feed. The cellulose digestion recorded for these three rations might have been limited to some degree because the rations were adequate in protein and energy content. Energy requirements could apparently be satisfied by food components more available than the cellulose fraction. The use of corn oil might have decreased cellulose digestion somewhat, but it seems unlikely that the limited quantity used in these feeds would depress cellulose digestion to the observed low levels.

In an earlier paper, Short (1963) demonstrated that the in vitro digestion of purified cellulose and forage plant fiber, by rumen liquor from white-tailed deer (*O. virginianus*), was frequently less than that recorded for rumen material from a steer fed similar diets under similar conditions. Explanations of this difference between deer and the bovine are at this time vague. One, there is a possible difference in the rumen microorganisms of the two species. Two, the earlier paper also indicated that deer have a stomach capacity relatively smaller than that of the bovine. For rumen fermentation products to provide necessary energy to deer, it is quite possible that a high turnover rate of readily fermented foodstuffs is necessary. Cellulose degradation takes time. Perhaps deer cannot retain fibrous foodstuffs within their relatively small rumen long enough to allow substantial cellulose digestion to occur.

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