Chemical Composition of Tobosa Grass Collected by Hand-Plucking and Esophageal-Fistulated Steers[1]

H. E. KIESLING, A. B. NELSON, AND C. H. HERBEL[2]

Graduate Student and Professor, Department of Animal, Range and Wildlife Sciences, New Mexico State University, Las Cruces; and Range Scientist, Jornada Experimental Range, Crops Research Div., Agricultural Research Service, U.S.D.A., Las Cruces.

Highlight

Organic matter recovery of seven feeds collected through esophageal fistulae of three steers averaged 90.4%. Six of the seven fistula samples contained significantly more ash than the feeds offered. Fistula samples of grazed tobosa (*Hilaria mutica* (Buckl.) Benth.) contained less A.O.A.C. fiber but more silica, ash, protein, ether extract, detergent fiber and detergent lignin than hand-plucked grass. Except for ash, the differences in chemical composition between hand-plucked and esophageal-fistula samples were apparently due to selectivity by the grazing steers. We assume that samples collected by means of an esophageal fistula are more nearly representative of the forage consumed by grazing steers than samples hand-plucked by a technician.

Esophageal-fistulated animals have been proposed as a means of determining the nutrient content of the diet of grazing animals. Several researchers (Bath et al., 1956; Lesperance et al., 1960; Lombard and Van Schalkwyk, 1963; Marshall et al., 1967; Campbell et al., 1968) have compared the chemical composition of feeds offered with samples of these feeds collected through an esophageal fistula. Some (Edlefsen et al., 1960; Campbell et al., 1968) have compared the chemical composition of fistula samples with hand-plucked grass while others have compared fistula samples with clipped forage (Bath et al., 1956; Weir and Torell, 1959; Bredon et al., 1967).

The purpose of this study was to compare the chemical composition of esophageal-fistula samples with both feed and hand-plucked grass samples.

Methods

Experiment 1.—Each of seven feeds was divided into four portions. One portion was used for chemical analysis and the others were fed to each of three esophageal-fistulated Hereford steers which had been kept off feed overnight. Two hundred and fifty grams of tobosa hay and 451 to 454 g each of alfalfa hay, ground milo, cottonseed meal, pelleted mixture, alfalfa hay mixture and cottonseed hull mixture were fed to and consumed by each steer (see Table 1 for ingredient content of mixtures). There were no feed refusals. Esophageal-fistula samples were collected in a plastic bag within a canvas bag positioned below the fistula. All saliva collected remained as part of the sample. All samples were weighed and dried at 70 C in a forced-air oven, ground through a 60-mesh screen in a Wiley mill and analyzed for dry matter, ash, crude protein, ether extract, and fiber (A.O.A.C., 1960).

Experiment 2.—Three hand-plucked and three fistula samples of dormant tobosa grass were collected in each of seven pastures at the Jornada Experimental Range. The pasture treatments were (1) control, (2) feeding cottonseed meal, (3) spraying molasses on forage, (4) spraying molasses and urea on forage, (5) nitrogen fertilizer on forage, (6) burning, and (7) mowing and feeding of hay plus aftermath grazing. The steers were those used in experiment 1 and were penned overnight before collecting samples the next morning. This procedure of keeping the animals off feed for several hours before collecting was also used by Edlefsen et al. (1960), Bredon et al. (1967), and Campbell et al. (1968) and was recommended by Torell (1954). All samples were collected during the morn-

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Table 1. Time required for feed consumption and organic matter recovery through the esophageal fistula.[1]

	Consumption		Organic Matter		
			Grams	Recovery	
	Total min	G/min	consumed	%	S.E.[2]
Alfalfa hay	12	32	381.3	88.0	1.22
Tobosa hay	12	17	205.6	92.0	0.72
Pellets[3]	8	47	378.9	95.2	0.61
Alfalfa hay mixture[4]	7	56	388.2	87.5	1.91
Cottonseed hull mixture[5]	6	65	387.9	91.7	1.04
Ground milo	7	57	397.0	90.4	2.95
Cottonseed meal	9	45	403.9	88.2	4.58
Average				90.4	

[1] Average of three steers.
[2] Standard error.
[3] Alfalfa hay, 70%; milo, 25%; molasses, 5%.
[4] Steam rolled milo, 74.5%; ground alfalfa hay, 20.0%; molasses, 5.0%; salt, 0.5%.
[5] Steam rolled milo, 66.9%; cottonseed hulls, 20.0%; cottonseed meal, 7.0%; molasses, 5.0%; ground limestone, 0.6%; salt, 0.5%.

Table 2. Chemical composition of feeds and esophageal fistula samples.

	Percent composition		
		Fistula	
Nutrient and feed	Feed	Mean[1]	S.E.
Ash, % of dry matter			
Alfalfa hay	11.1**	14.2	0.17
Tobosa hay	12.7**	15.6	0.16
Alfalfa-milo pellets	10.9**	12.6	0.10
20% alfalfa hay mixture	5.0*	6.1	0.22
20% cottonseed hull mixture	5.2*	6.2	0.14
Ground milo	1.5*	2.6	0.19
Cottonseed meal	7.1	8.3	0.30
Protein, % of organic matter			
Alfalfa hay	22.5	23.6	0.48
Tobosa hay	12.2	12.5	0.15
Alfalfa-milo pellets	17.1	17.4	0.10
20% alfalfa hay mixture	12.4	12.2	0.01
20% cottonseed hull mixture	12.5	12.4	0.24
Ground milo	7.9*	8.2	0.05
Cottonseed meal	48.1	47.4	0.20
Ether extract, % of organic matter			
Alfalfa hay	1.2	1.0	0.06
Tobosa hay	1.2	1.0	0.00
Alfalfa-milo pellets	1.5**	1.0	0.01
20% alfalfa hay mixture	2.8**	2.4	0.02
20% cottonseed hull mixture	2.8**	2.3	0.04
Ground milo	3.0**	2.1	0.03
Cottonseed meal	4.0	3.8	0.12
Fiber, % of organic matter			
Alfalfa hay	30.5*	32.4	0.21
Tobosa hay	36.4*	35.2	0.26
Alfalfa-milo pellets	24.3	25.5	0.55
20% alfalfa hay mixture	6.1	6.4	0.16
20% cottonseed hull mixture	10.3	10.5	0.42
Ground milo	2.8	3.2	0.26
Cottonseed meal	10.4	11.7	0.19
Nitrogen-free extract, % of organic matter			
Alfalfa hay	45.8	43.0	0.75
Tobosa hay	50.2	51.2	0.42
Alfalfa-milo pellets	57.2	56.1	0.51
20% alfalfa hay mixture	78.7	79.0	0.28
20% cottonseed hull mixture	74.3	74.8	0.30
Ground milo	86.3	86.5	0.24
Cottonseed meal	37.5	37.1	0.46

[1] Average of three steers.
* $P < .05$ for feed vs. fistula samples.
** $P < .01$ for feed vs. fistula samples.

ings of three consecutive days. Three pastures were sampled on the first day, two pastures on the second day and two pastures on the third day. The pastures were nearly pure stands of tobosa and the steers were restricted to areas where tobosa was the only forage. The hand-plucked samples were obtained by a technician breaking off, or plucking, parts of plants similar to those observed being consumed by a steer grazing for about 15 minutes.

The hand-plucked samples were ground and analyzed for dry matter, ash, silica, crude protein, ether extract, and fiber according to the A.O.A.C. (1960) methods and for acid-detergent fiber and lignin by the Van Soest (1963) method. The fistula samples were frozen and a representative sample was taken from each collection by sawing out cross sections. Part of each sample was dried at 70 C in a forced-air oven, ground and analyzed for dry matter, ash, silica, crude protein, ether extract, and A.O.A.C. fiber. Wet fistula samples were used for the acid-detergent fiber and lignin determinations.

The Student's t was used as a test of significance for the chemical composition between feed and fistula samples. Analysis of variance and Duncan's multiple range tests were used for the hand-plucked and fistula comparisons (Steel and Torrie, 1960).

Results and Discussion

Experiment 1

The feeds offered were eaten in a relatively short period (Table 1), and no difficulty was encountered in collecting the samples through the fistula. The pellets, concentrates and high-concentrate mixtures were consumed at a much faster rate than the hays. Tobosa was consumed at the slowest rate with alfalfa hay intermediate between tobosa hay and the other feeds. The organic matter recoveries varied from 87.5 to 95.2% and were similar to those reported by Campbell et al. (1968) for concentrate-type feeds but considerably higher than those for clipped grasses.

Chemical composition of the feeds offered and of the fistula samples is shown in Table 2. The ash

content was significantly higher in the fistula samples for all feeds except cottonseed meal. This increased ash was apparently due to saliva contamination, and is in agreement with the results reported by other researchers including Campbell et al. (1968), Hoehne et al. (1967) and Lesperance et al. (1960). Because of increased ash, McManus (1961) and Grimes et al. (1965) suggested that chemical composition be expressed on an ash-free or organic matter basis.

Only in the case of ground milo was the protein content significantly higher in the fistula samples than in the feed samples. Since saliva dry matter contains about 4.51% protein (Bailey and Balch, 1961), large amounts of saliva collected with a sample could increase the protein content. However, Bath et al. (1956), Edlefsen et al. (1960), Lesperance et al. (1960) and Campbell et al. (1968) have reported no increase of protein in esophageal fistula samples. Hoehne et al. (1967) found that fistula samples of prairie sandreed and blue grama, which were squeezed to remove excess saliva, were lower in protein than feed samples, and that non-squeezed fistula samples of prairie sandreed were significantly higher than squeezed samples.

The ether extract content of the three mixed feeds and ground milo was significantly higher in the feed than in the fistula samples. Bath et al. (1956), Campbell et al. (1968), Lesperance et al. (1960) and Lombard and Van Schalkwyk (1963) have reported no significant difference in ether extract for similar feeds.

Fiber content of the fistula samples was significantly higher for alfalfa hay and lower for tobosa hay than the feed offered. Lesperance et al. (1960) reported an increase of fiber in fistula samples while Bath et al. (1956), Lombard and Van Schalkwyk (1963) and Campbell et al. (1968) reported no significant change in fiber.

None of the differences in nitrogen-free extract was significant. This agrees with the findings of Bath et al. (1956) for alfalfa hay, and with Campbell et al. (1968) for concentrate-type feeds. With their clipped grass, however, the fistula samples were lower in nitrogen-free extract. Lombard and Van Schalkwyk (1963) also reported a decrease in nitrogen-free extract of fistula samples for hays and green feeds.

Experiment 2

Chemical composition of hand-plucked grass and esophageal-fistula samples is given in Table 3. The fistula samples contained significantly more ash and protein, but less A.O.A.C. fiber, than hand-plucked grasses. This agrees with the results of most researchers and apparently reflects the ash added by saliva and selection of a higher quality diet by grazing steers. Weir and Torell (1959) reported that sheep consistently selected forage higher in protein and lower in fiber than hand clipped grasses. Bredon et al. (1967) stated that fistula samples of tropical forage contained more protein and less fiber than clipped forage.

Fistula samples also contained more silica, ether extract, detergent fiber, and detergent lignin. Edlefsen et al. (1960), however, found that fistula samples were significantly lower in lignin; and Campbell et al. (1968) reported that fistula samples of bermudagrass were lower in ether extract than hand-plucked grass.

Acid-detergent fiber was significantly higher than A.O.A.C. fiber for both hand-plucked and fistula samples in all pastures. Pasture differences were also significant for both methods. Since detergent fiber was determined on wet fistula samples which were not ground and, therefore, contained many large particles of forage, incomplete digestion during refluxing could have resulted in higher values for the detergent fiber. However, this was not true for hand-plucked samples, since the preparation of the samples was the same for both fiber determinations. Pasture differences were significant for all constituents except ash. The forage sprayed with molasses plus urea was highest in protein and lowest in nitrogen-free extract, but that sprayed with molasses only contained the least protein and most nitrogen-free extract. These pasture samples also contained significantly less A.O.A.C. fiber and detergent fiber. Samples of grass from pasture 3 (fed tobosa hay) contained more lignin than samples from the other pastures.

The pasture x method interaction was significant for ash, protein, and detergent fiber. These interactions were probably due to the pasture treatments. Pasture differences within methods were considerable and are shown in Table 3. For ash there was a significant difference between methods in all pastures. The fistula samples from the pasture in which cottonseed meal pellets were fed and the control pasture contained more protein, while fistula samples from the pasture sprayed with molasses plus urea contained less protein than hand-plucked grass.

Conclusions

Organic matter recovery of seven feeds collected through esophageal fistulae of three steers averaged 90.4%. The fistula samples were significantly higher in ash for all feeds except cottonseed meal, in protein for ground milo, and in A.O.A.C. fiber for alfalfa hay; but they were lower in ether extract for a pelleted mixture, alfalfa hay mixture, cottonseed hulls mixture, and ground milo and in A.O.A.C. fiber for tobosa hay. Chemical composition of feed samples collected through an esophageal fistula should be expressed on an organic matter basis.

Fistula samples of grazed forage contained sig-

Table 3. Chemical composition (%) of hand-plucked grass and esophageal-fistula samples.[1]

Pasture	Method	Silica	Ash	Composition of organic matter: Protein	Ether extract	A.O.A.C. fiber	N-free extract	Detergent fiber	Detergent lignin
1	Plucked	7.23	2.46^{j}	5.06^{j}	1.06	40.42	53.46	58.26^{j}	8.59
Fertilized	Fistula	7.66	5.51^{y}	6.26^{xy}	1.01	38.21	54.52	59.98^{y}	8.98
	Difference	0.43	3.05*	1.20	0.05	2.21	1.06	1.72	0.39
	Mean	7.44^{bc}	4.08	5.66^{b}	1.04^{d}	39.31^{a}	53.99^{b}	59.11^{cd}	8.79^{b}
2	Plucked	6.06	2.15^{j}	3.64^{jkl}	0.99	40.62	54.76	57.08^{j}	8.80
Cottonseed	Fistula	8.53	6.25^{xy}	5.58^{y}	1.27	39.04	54.12	64.92^{x}	9.38
meal	Difference	2.47	4.10*	1.94*	0.28	1.58	0.64	7.84*	0.58
pellets	Mean	7.30^{bc}	4.20	4.61^{cd}	1.13^{bcd}	39.83^{a}	54.44^{b}	61.00^{bc}	9.09^{b}
3	Plucked	9.74	2.77^{j}	4.76^{jk}	0.94	41.38	52.92	62.76^{l}	10.60
Tobosa hay	Fistula	10.08	5.90^{y}	6.36^{xy}	1.20	37.98	54.45	67.77^{x}	10.42
	Difference	0.34	3.13*	1.60*	0.26	3.40	1.53	5.01*	0.18
	Mean	9.91^{a}	4.22	5.56^{bc}	1.07^{d}	39.68^{a}	53.68^{b}	65.27^{a}	10.51^{a}
4	Plucked	8.83	2.14^{j}	3.33^{kl}	1.13	40.80	54.74	60.22^{ij}	8.62
Burned	Fistula	9.75	5.87^{y}	4.87^{yz}	1.71	37.65	55.77	67.70^{x}	9.64
	Difference	0.92	3.73*	1.54*	0.58	3.15	1.03	7.48*	1.02
	Mean	9.20^{ab}	4.00	4.10^{d}	1.42^{a}	39.23^{a}	55.26^{b}	63.96^{ab}	9.13^{b}
5	Plucked	7.48	3.62^{i}	2.29^{kl}	0.98	35.28	61.45	53.13^{k}	7.54
Molasses	Fistula	9.72	6.34^{xy}	3.79^{z}	1.55	34.06	60.60	58.28^{y}	9.21
	Difference	2.24	2.72*	1.50	0.57	1.22	0.85	5.15*	1.67
	Mean	8.60^{abc}	4.98	3.04^{e}	1.27^{abc}	34.67^{b}	61.02^{a}	55.70^{e}	8.38^{b}
6	Plucked	5.83	3.62^{i}	10.06^{i}	0.90	36.29	52.75	53.12^{k}	7.86
Molasses	Fistula	8.43	6.08^{xy}	7.51^{x}	1.31	36.85	54.33	60.92^{y}	9.72
and urea	Difference	2.60	2.46*	2.55*	0.41	0.56	1.58	7.80*	1.86
	Mean	7.13^{bc}	4.85	8.78^{a}	1.10^{cd}	36.57^{b}	53.54^{b}	57.02^{de}	8.79^{b}
7	Plucked	6.33	2.80^{ij}	3.76^{jkl}	1.16	41.88	53.22	58.90^{j}	8.04
Control	Fistula	7.01	6.78^{x}	5.43^{y}	1.44	38.17	55.30	59.91^{y}	9.88
	Difference	0.68	3.98*	1.69*	0.28	3.71	2.08	1.01	1.84
	Mean	6.67^{c}	4.79	4.58^{d}	1.30^{ab}	40.02^{a}	54.26^{b}	59.40^{cd}	8.96^{b}
Mean	Plucked	7.36	2.79	4.70	1.02	39.52	54.76	57.64	8.58
	Fistula	8.71	6.13	5.68	1.36	37.42	55.58	62.78	9.60
	Difference	1.35**	3.34**	0.98**	0.34**	2.10**	0.82	5.14**	1.02**

[1] Average of three samples for each method.
[abcde] Pasture means within the same column with different letter superscripts are significantly different ($P < .05$).
[ijkl] Pasture means within hand plucked samples in the same column with different letter superscripts are significantly different ($P < .05$).
[xyz] Pasture means within fistula samples in the same column with different letter superscripts are significantly different ($P < .05$).
* $P < .05$ for method differences.
** $P < .01$ for method differences.

nificantly more silica, ash, protein, ether extract, detergent fiber, and detergent lignin, but less A.O.A.C. fiber than hand-plucked samples obtained from seven pastures of tobosa. Pasture differences were significant for all constituents except ash and the pasture x method interaction was significant for ash and protein.

Except for ash, the differences in chemical composition between hand-plucked and esophageal-fistula samples were apparently due to selectivity by the grazing steers. We assume, therefore, that samples collected by means of an esophageal fistula are more nearly representative of the forage consumed by grazing steers than samples hand-plucked by a technician.

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