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Determination of nutrient content and digestibility characteristics of *Prangos ferulacea* (L.) on grazing lands of Eastern Anatolia

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Abstract: The aim of this study was to compare nutrient content, and in situ protein and organic matter degradation kinetics of *Prangos ferulacea* (L.) (locally called helis), a naturally growing plant on the top of Mount Artos, with those of alfalfa. *P. ferulacea* plants used in the study were collected from three different parts of Mount Artos in Van Province over two years. While organic matter content and in vitro organic matter digestibility of *P. ferulacea* were significantly higher, neutral detergent fiber, acid detergent fiber, and acid detergent insoluble nitrogen contents were significantly lower compared with those of alfalfa ($P < 0.01$). In general, in situ dry matter, and organic matter and crude protein degradability of *P. ferulacea* were significantly higher compared with those of alfalfa starting from 6 h of incubation ($P < 0.05$). Organic matter and crude protein degradability of *P. ferulacea* was 79.15% and 85.31%, respectively, after 48 h of incubation. By-pass protein content and both organic matter and crude protein degradation rates were similar between samples ($P > 0.05$). It can be concluded that *P. ferulacea* has a better nutrient quality compared with even high quality alfalfa based on nutrient contents and digestibility values, and therefore substitution of alfalfa by *P. ferulacea* in the diet of ruminant animals is feasible.

Key words: *Prangos ferulacea*, nutrient content, in situ degradation kinetics

1. Introduction

It is well known that feeding of ruminants can only be economical when their diets are based on high quality forages. Thus, forages can comprise 40%–70% of dairy cows' diet, 90%–100% of breeding heifers' diet, and 90%–95% of sheep's diet (1).

There have been great problems concerning the paucity of animal production due to lack of high quality forage production in Turkey. Pastures, the most important forage sources, are becoming useless due to overgrazing. To reduce the grazing density on the pastures, efforts have been concentrated on agriculture of cultivated feedstuff production. However, it is very difficult to solve this problem where there is a lack of farmable land such as in Eastern Anatolia. Maximum benefit needs to be obtained by utilizing all kinds of natural and industrial (by-products) materials that have feeding value.

Prangos ferulacea (locally called helis) is a naturally growing plant in the highlands of the Eastern Anatolian region. This plant produces seeds every other year, but it is not cultivated yet; therefore, there is no information in the literature regarding yields. It is perennial plant and spontaneously grows each year on the north side of mountains. It is mainly grazed by sheep because it grows on the steep sides of mountains. It is also utilized as dried hay during winter for all ruminant animals, especially for young lambs. Thus, different varieties of *P. ferulacea* have been utilized as feedstuff for ruminants for years by farmers in the region. *P. ferulacea* is mainly used by sheep raisers. It is claimed that it is utilized for ruminal development of lambs and has very high nutritive value. The work by Coşkun et al. (2) seemed to prove the claims of farmers. In the only study conducted about *P. ferulacea* in Turkey, Coşkun et al. (2) noted that neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of *P. ferulacea* were quite low; however, its energy value was significantly greater when compared to that of alfalfa. In another study, carried out in Iran, substituting alfalfa with *P. ferulacea* at varying levels had no negative effect on the fattening performance of lambs (3).

Therefore, the aim of the present study was to compare nutrient content, and in situ protein and organic matter degradation kinetics of *P. ferulacea*, a naturally growing plant on the top of Mount Artos, with those of alfalfa.

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2. Materials and methods

P. ferulacea was collected at three different locations (Gevaş, Çatak, and Tatvan districts) around Mount Artos, which is located at the border of Van Province, over two consecutive years. *P. ferulacea* was sampled as 5 replicates from each district (a total of 15 samples), when plants were fully mature in June. To compare the nutrient value of *P. ferulacea*, alfalfa was chosen because it is known as one of the most nutritious forages fed to ruminants. Alfalfa samples for this purpose were also collected in the form of ground hay from three different farmers who live in the same region. *P. ferulacea* samples were air-dried before analysis because they were collected as fresh plants from the mountain. Dry matter (DM) of samples was determined by oven drying of triplicate subsamples at 65 °C for 72 h, after air-drying (4). All of the analyses were performed on dried samples. Dried samples were ground to pass through a 1-mm screen before analysis. Ash concentrations of samples were determined in a muffle furnace at 550 °C for 8 h (4). All samples were analyzed for crude protein (CP) by Kjeldahl procedure (4), and NDF (5), ADF (6), and acid detergent insoluble nitrogen (ADIN) (6) concentrations. In vitro organic matter digestibility (IVOMD) of samples was determined by the procedure described by Tilley and Terry (7), as modified by Marten and Barnes (8). Ruminal ingesta from an alfalfa-fed ruminally fistulated ram were hand-collected and strained through 4 layers of cheesecloth to provide the inocula for the IVOMD determination. Metabolizable energy (ME) was calculated from in vitro digestibility values using the following equation (9):

ME, (Mcal/kg) = Digestible energy × 0.82

To estimate the in situ degradation kinetics and fractions of OM and CP, oven-dried samples were ground through a 2-mm screen. Approximately 3.5 g of each *P. ferulacea* sample was weighed into a Dacron bag. The bags used were constructed of Dacron polyester, having an average pore size of 50 µm and internal dimensions of 15 × 7 cm. The suspension of the bags in the rumen was accomplished by tying them onto Tygon tubing with nylon string. Four bags were affixed to each Tygon tube for each incubation time.

Four mature fistulated Morkaraman × Kıvırcık lambs (averaging 40 kg) fed chopped alfalfa hay were used for the incubation of samples in Dacron bags in this study. Samples in Dacron bags were placed in the rumen and incubated for 0, 3, 6, 12, 18, 24, 48, and 72 h. Two bags of sample for each forage were inserted into the rumen of each ram for each incubation time. After the removal of the bags from the rumen, they were washed under running water until the water ran clear. Then all bags were dried for 24 h at 65 °C in a drying oven and DM recovery was determined. Undigested residues were analyzed for nitrogen by the micro-Kjeldahl procedure (4) and ash.

In situ degradability of OM and CP was calculated using the following equation (10):

$$\text{Nutrient degradability} = a + b\,(1 - e^{-ct})$$

Loss of DM from the bags caused by exposure of substrates to the digestive action of the rumen and the washing process that followed resulted in the partitioning of OM and CP in each of the varieties into 3 fractions: 1) soluble fractions of OM and CP (WSOM, WSCP) were determined as the differences between initial OM and CP contents and amounts of OM and CP recovered at the beginning of incubation; 2) potentially degradable fractions of OM and CP (PDOM, PDCP) were determined as 100 - (nondegradable fraction and water soluble fractions of OM and CP); 3) nondegradable fractions of OM and CP (NDOM, NDCP) were determined as the differences between initial OM and CP contents and amounts of OM and CP recovered after 48-h incubation of samples in the rumen (11,12). The kinetic parameters associated with the disappearance of OM and CP fractions from bags were estimated from a one-pool version of Mertens'(13) discrete lag model of cell wall digestion. Modifications of the model by Wechsler (14), which allow estimation of both digestion and lag functions from a single formula, were also incorporated. Model estimates of residual potentially digestible OM and CP fractions, rate of degradation (OM k^{-1}, CP k^{-1}), and discrete lag times (OM lag time, CP lag time) were obtained by fitting recovery data to the model, using nonlinear regression analysis of SAS (15).

A modified technique reported by Mullahey et al. (16) was used to determine the percentage of *P. ferulacea* protein that escaped ruminal degradation.

The proportion of total protein that would escape ruminal digestion was calculated as total residual N remaining after 12-h incubation, adjusted for the indigestible N (ADIN) using the following equations:

By-pass Protein Percentage, % of total protein = (Total residual N – ADIN of total residue) / (Total plant N – ADIN of total plant) × 100.

All data were subjected to analysis of variance (17) using the GLM procedure of SAS (15). $P < 0.05$ was accepted as significant unless otherwise noted.

3. Results

Nutrient contents of alfalfa and *P. ferulacea* samples used in the study are shown in Table 1, in situ degradation data are shown in Table 2, and in situ degradation kinetics data are presented in Table 3.

Table 1. Nutrient contents of sun-dried *P. ferulacea* and alfalfa samples used in the study (%).

	P. ferulacea	Alfalfa	SEM	P-value
DM	94.12 ± 1.23	95.72 ± 1.25	0.87	0.43
OM, %DM	90.26 ± 1.48	84.37 ± 0.57	1.12	0.01
CP, %DM	17.01 ± 0.70	15.93 ± 1.50	1.17	0.24
ADIN, %Total N	0.969 ± 0.131	1.573 ± 0.126	0.13	0.01
NDF, %DM	35.77 ± 2.22	57.75 ± 1.12	2.06	0.01
ADF, %DM	21.66 ± 1.42	38.14 ± 1.87	1.49	0.01
IVOMD, %OM	79.88 ± 2.63	61.83 ± 1.14	2.67	0.01
ME, Mcal/kg*	2.895 ± 0.13	2.232 ± 0.08	0.09	0.01

DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, ADIN: Acid Detergent Insoluble Nitrogen, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, IVOMD: In vitro OM Digestibility Values, ME*: Metabolizable Energy: Calculated by Yavuz (9).

Table 2. Degradability values of *P. ferulacea* and alfalfa samples used in the study.

	Dry Matter Degradability, % DM						
	3 h	6 h	12 h	18 h	24 h	48 h	72 h
P. ferulacea	29.50 ± 2.65	38.13 ± 2.31	56.05 ± 4.97	60.78 ± 3.50	74.39 ± 2.19	79.15 ± 3.09	78.53 ± 1.58
Alfalfa	22.82 ± 3.46	26.24 ± 2.50	45.73 ± 1.72	53.82 ± 3.20	59.17 ± 1.85	59.71 ± 1.23	61.32 ± 2.44
SEM	3.94	2.21	4.05	1.65	1.02	1.88	1.08
P-value	0.16	0.01	0.12	0.03	0.01	0.01	0.01
	Organic Matter Degradability, % OM						
P. ferulacea	27.88 ± 2.76	37.66 ± 2.33	55.20 ± 4.52	60.24 ± 3.55	73.85 ± 2.24	78.76 ± 3.56	78.18 ± 1.62
Alfalfa	22.80 ± 3.22	25.77 ± 2.50	45.70 ± 3.45	53.46 ± 3.42	58.68 ± 1.87	59.51 ± 1.30	61.28 ± 2.61
SEM	3.00	2.42	4.12	1.69	1.03	1.91	1.09
P-value	0.27	0.01	0.15	0.03	0.01	0.01	0.01
	Crude Protein Degradability, % CP						
P. ferulacea	31.27 ± 2.5	52.63 ± 1.77	65.61 ± 4.28	67.41 ± 2.91	84.61 ± 1.32	85.31 ± 3.62	85.30 ± 1.09
Alfalfa	24.12 ± 3.17	30.75 ± 2.35	53.77 ± 1.47	67.69 ± 2.24	72.66 ± 1.24	76.32 ± 0.75	77.17 ± 1.54
SEM	2.86	2.07	3.20	1.30	0.64	1.31	0.67
P-value	0.13	0.03	0.04	0.88	0.01	0.01	0.01

4. Discussion

As seen in Table 1, all nutrient compositions, except CP content, of *P. ferulacea* were significantly higher than those of alfalfa. While OM, in vitro OM digestibility, and ME energy values were significantly higher, the concentrations of NDF, ADF, and ADIN-N were significantly lower in *P. ferulacea* compared with those in alfalfa ($P < 0.01$). The nutrient composition of alfalfa, except OM content, was similar to the value reported in the literature for alfalfa at the late blooming stage (18,19). The lower OM content observed in this study might have resulted from soil contamination. The nutrient composition of *P. ferulacea*, except CP content (Coşkun et al. 9.98%; our study 15.9%), was similar to values reported by Coşkun et al. (2). In

Table 3. OM and CP fractions and degradation kinetics of *P. ferulacea* and alfalfa samples used in the study.

	P. ferulacea	Alfalfa	SEM	P-value
WSOM, %OM	9.35 ± 3.06	6.05 ± 1.31	2.21	0.32
WSCP, %CP	12.12 ± 3.84	7.71 ± 1.29	2.12	0.19
PDOM, %OM	77.78 ± 1.76	65.45 ± 1.50	1.31	0.01
PDCP, %CP	83.19 ± 1.1	77.62 ± 1.09	0.89	0.02
NDOM, %OM	21.84 ± 1.62	38.72 ± 2.62	1.09	0.01
NDCP, %CP	14.71 ± 1.09	22.83 ± 1.54	0.64	0.01
By-pass CP, %CP	26.38 ± 2.36	24.54 ± 1.76	1.02	0.25
OM k^{-1}	0.116 ± 0.026	0.141 ± 0.015	0.02	0.37
OM Lag time, h	0.117 ± 0.008	0.105 ± 0.007	0.008	0.26
CP k^{-1}	0.116 ± 0.025	0.107 ± 0.016	0.02	0.70
CP Lag time, h	0.190 ± 0.03	0.370 ± 0.175	0.19	0.53

WSOM: Water Soluble Fractions of Organic Matter, WSCP: Water Soluble Fractions of Crude Protein, PDOM: Potentially Degradable Fractions of Organic Matter, PDCP: Potentially Degradable Fractions of Crude Protein, NDOM: Nondegradable Fractions of Organic Matter, NDCP: Nondegradable Fractions of Crude Protein, By-pass CP: By-Pass Crude protein, OM k^{-1}: Rate of Degradation of Organic Matter, OM Lag Time: Discrete Lag Times of Organic Matter, CPk^{-1}: Rate of Degradation of Crude protein , CP Lag Time: Discrete Lag Times of Crude Protein

vitro digestibility and ME energy value (2.895 Mcal/kg) were considerably high, indicating a significantly higher nutrient value for forage. Moreover, Coşkun et al. (2) noted that even though *P. ferulacea* is a forage, it has a high energy value that is comparable to that of cereal grains such as barley. The finding of Coşkun et al. (2) in terms of energy value of *P. ferulacea* confirmed the results of the current study. The metabolizable energy value (ME, MJ/kg) reported by Coşkun et al. (2) was calculated using the following equations: ME (MJ kg^{-1} DM): 2.20 + 0.136GP + 0.0057 CP + 0.00029 EE^2

The higher CP content observed in this study could be due to two reasons: this plant has at least 4 varieties and varieties may differ in nutrient content (12). *P. ferulacea* used in this study was collected from mountains in the form of fresh plants in June and air dried in the laboratory so that nutrient loss due to environmental factors during drying was minimal. The differences between the two studies may be attributed to those reasons.

In situ degradation values of *P. ferulacea* are given in Table 2. DM, OM, and CP degradation patterns of *P. ferulacea* were somewhat similar to those of alfalfa; however, percentages of DM, OM, and CP degraded were generally higher in *P. ferulacea* compared with those of alfalfa.

In general, percentages of DM, OM and CP degraded were similar at the initiation of incubation between both forages but percentages of DM, OM, and CP degraded were significantly higher ($P < 0.01$) in *P. ferulacea* compared with those of alfalfa after 72-h incubation. Degradation rates of DM and OM were high until 24-h incubation; however, it slowed down and reached an asymptote from that point on in both forages. Similarly, CP degradation reached an asymptote 48 h after incubation in both forages. Thus, these similarities showed that degradation patterns of these forages were similar. Percentage of DM degraded after 48-h incubation was 79.15%, which was similar to the value reported for stem (78.47%) but lower than the value reported for the whole plant by Coşkun et al. (2). Degradation values can be affected by many factors such as washing procedure and period, type of feed fed to the animal, and time of incubation. The differences between the two studies could have resulted from one or more of the above factors.

OM and CP degradation kinetics and fractions of samples are shown in Table 3. Water soluble OM and CP contents of *P. ferulacea* were numerically greater compared with those of alfalfa but neither was significantly greater ($P > 0.05$). Nondegradable OM and CP contents were significantly higher in alfalfa than in *P. ferulacea*, indicating that degradability of nutrients was greater in *P. ferulacea* compared with alfalfa. Degradable OM and CP pools, which indicate potential degradability, were significantly higher in *P. ferulacea* compared with alfalfa ($P < 0.01$).

Percentage of protein escaping ruminal degradation, and rate of OM and CP degradation were similar between alfalfa and *P. ferulacea* (P > 0.05). Lag time, which represents the time required for initiation of degradation, also did not differ between alfalfa and *P. ferulacea* (P > 0.05). While percentage of water soluble DM observed in this study was lower, rate of OM degradation was higher than the DM degradation rate reported by Coşkun et al. (2) (10.38 vs. 34.00 and 0.00774 vs. 0.116). Washing method and duration of washing of the bags can affect these results. The method used for determination of the rate can also influence the rate of degradation. Percentage of protein escaping ruminal degradation in alfalfa was similar to the value reported by Karslı and Russell (18) for alfalfa at the late blooming stage.

In conclusion, *P. ferulacea* has a better nutrient quality compared with even high quality alfalfa based on nutrient contents and digestibility values. It can be used by local producers instead of alfalfa in the diet of especially young growing small ruminants.

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