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Nutritional Value Determination of Five Plants Species in Darab Rangeland Using Gas Production Technique

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Abstract. This investigation was conducted to determine the chemical composition and nutritional value of five dominant plant species in the vegetative stage, namely *Artemisia herba-alba*, *Acer monspessulanum*, *Amygdalus lycioides*, *Amygdalus scoparia*, and *Atriplex leucoclada*, in the pastures of Rustaq and Fedami areas, Darab in April, 2020. After collecting samples, the chemical compositions of plants including Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), Ash, Neutral Detergent Fiber (NDF), and Acid Detergent Fiber (ADF) were determined according to the standard methods. Three 12-month-old Sistani bulls weighing 277±27 kg were used for the degradation test. The CP value ranged from 5.30 (*Amygdalus scoparia*) to 11.72% (*Atriplex leucoclada*) while NDF value ranged from 52.62 (*Amygdalus lycioides*) to 69.05% (*Amygdalus scoparia*) ($P < 0.01$). After 96 hours of incubation, the highest and lowest gas productions with values of 54.83 and 38.66 (ml/200 mg DM) were related to *Amygdalus lycioides* and *Amygdalus scoparia*, respectively. The higher values of gas production were due to lower values of ADF (38.66%) and NDF (52.62%) in *Amygdalus lycioides*. The highest amounts of Ca (0.28%), P (0.15%), and Mg (0.12%) were recorded in *Atriplex leucoclada*. Through the gas production technique, the range of organic matter digestibility (OMD), digestible organic matter in dry matter (DOMD) and metabolisable energy (ME) were varied from 36.67 to 53.27%, 34.67 to 49.11%, and 5.57 to 8.08 (MJ/kg), respectively. The highest values of OMD (53.28%), DOMD (49.11%), and ME (8.08 MJ/kg) were recorded in *Amygdalus lycioides*, which were significantly higher than other studied plants ($P<0.01$). The nutritional value of *Amygdalus lycioides*, *Atriplex leucoclada*, *Acer monspessulanum*, and *Artemisia herba-alba*, respectively, were acceptable based on their composition and digestibility. The results of this experiment showed that range plants can meet a part of the livestock nutritional requirements.

Key words: Chemical composition, Dry matter digestibility, Gas test

Introduction

The daily requirements of livestock depend on body weight and environmental factors (Porto *et al*., 2012; Grace *et al*., 2018) and pasture is a suitable source to meet the needs of livestock. Different climates have a variety of vegetation with differences in quantity and quality of forage (Lee, 2018).

Rangeland ecosystems are generally unstable and these fragile biological systems are easily affected by various factors, especially changes in rainfall and temperature (Izaurralde *et al*., 2011; Hatfield and Prueger, 2015; Yahdjian *et al*., 2015; Kumar and Purohit, 2020). In the field of natural resources, the effect of drought due to severe decrease in rainfall and increase in temperature leads to a decrease in quantity and quality of forage (Breshears *et al*., 2016; McCollum *et al*., 2017). The effects of this phenomenon are intensified when on one hand, it continues for several consecutive years and on the other hand, it coincides with inappropriate and uncontrolled activities of these resources, which ultimately reduces vegetation, livestock production, and income of rangeland users (Finch *et al*., 2016). The dominant plant species in the rangeland of southern Darab included *Amygdalus lycioides*, *Amygdalus scoparia*, *Atriplex leucoclada*, *Artemisia herba-alba*, and *Acer monspessulanum*. The *Amygdalus lycioides* has many branches and grayish-white spines, its leaves are very thin, sharp spears without a tail, and it grows up to 3 cm long. *Amygdalus scoparia* is found in the steppe and semi-arid highlands of the country. It is resistant to adverse environmental conditions (severe dehydration, thermal fluctuations, and severe frosts) and is environmentally friendly on sloping and smooth slopes with weak soils. *Atriplex leucoclada* grows in saline soils with about 200 mm of rainfall. *Artemisia herba–alba* is a hardy and succulent species that can be propagated by seeds. This plant can tolerate temperatures between -20 and +40 ˚C (Shahbazi and Fayaz, 2020). In spring and summer, due to the presence of aromatic substances and essential oils, it is less considered and desired by livestock (Rabiee, 2009). *Acer monspessulanum* is also distributed in Fars and Kerman. The flowering branches of this small tree are smooth and the margins of its lobes are large and its dimensions are 1.5-2 cm in both directions (Sabeti, 2008). The growing season of these rangeland plants is in April, which is the best time for use in animal nutrition.

Rangelands of different climatic regions have different plant composition and nutritional value (Mountousis *et al*., 2008; Keba *et al*., 2013; Hatfield and Prueger, 2015; Polley *et al*., 2017; Koutsoukis *et al*., 2019; Kumar and Purohit, 2020). Researchers stated that the highest quality was obtained in the initial stage of the growing period (Ball *et al*., 2001; Wood *et al*., 2020).

Rangelands are the most important part of the country's renewable resources, which due to the low cost of providing fodder compared to the cost of producing fodder through the industrial agriculture, puts a lot of pressure on them (Bel *et al*., 2020). One of the important information pieces for proper management of rangelands is knowledge of the quality and nutritional value of species in the rangeland. The quality of rangeland species varies in different places and times because various factors affect the quality and nutritional value of species. One of the most important factors is the phenological stages (Erfanzadeh and Arzani, 2002). The maturation stage of the plant affects its minerals. One of the most important effects is the reduction of phosphorus, which is associated with plant maturity. The value of nitrogen, phosphorus, and potassium in young plants and young plant tissues is high while the amount of calcium, manganese, iron, and boron is higher in older plants (Erkovan *et al*., 2009; Bumb *et al*., 2016; Aghili Poor *et al*., 2019).

Currently, most of the world problems in livestock production are high production costs; low food efficiency due to insufficient food and lack of optimal use of available resources which are two important factors for proper management and maximum production. The use of rangeland plants can play an important role in reducing the cost of nutrients (Al-Masri, 2013; DiTomaso *et al*., 2017). Therefore, to obtain fodder at a reasonable price, rangeland conservation, vegetation maintenance, and proper management are very important in establishing livestock and rangeland balance (Critchley *et al*., 2004; Levine and Pavanello, 2012; Vickers *et al*., 2012). Rangeland conservation methods, plant species and animal breeds, production, physiological condition and season of the year can be effective in using rangelands (Fuhlendorf *et al*., 2012; Askar *et al*., 2013).

Pastures, as the widest land area of the world, also occupy a significant part of Iran. According to the latest estimates, Iran's rangeland was estimated at more than 90 million ha in 50 years, but now, it is about 84.7 million ha, which covers about 52% of the country's area. 8.5%, 25.3%, and 66.2% are dense rangelands, semi-dense rangelands, and low-density rangelands, respectively. This vast area is considered as one of the basic sources of production in the country and has a special place in providing fodder needed by livestock. About 10.7 million tons of fodder is produced annually under normal rainfall in the country's rangelands (ISNA, 2018).

The method of *in vitro* digestion and gas production for determining digestibility and metabolizable energy is quickly expanding because of an increased need for routine and reproducible methods to gather data on bioavailability of feeds in addition to the chemical composition (Blu and Ørskov, 1993). Awareness of the nutrients in forage that is available for grazing animals will be an effective aid in their timely use, predicting nutrient deficiencies as well as assessing nutritional supplement needs. The amount of unstructured carbohydrate reserves in the plant is a good indicator of changes in stress in the plant and is a useful measure for estimating the digestibility of forage consumed by livestock (McDonald *et al*., 1996; Arzani *et al*., 2004). Then, determining the nutritional value of plant species, calculating livestock units and proper rangeland management in addition to reducing the cost of livestock products can prevent from overgrazing and destruction of rangelands. This study was conducted to determine the nutritional value of five plant species in Darab rangeland and determine pasture ability to meet the livestock requirements.

Materials and Methods

Description of sampling site

Darab plain is located in the Southeast of Fars province and in the range of 54˚11′ to 54˚47′E and 28˚33′to 28˚49′N at a distance of 250 km from Shiraz (Fig. 1). The climate of the region based on the Köppen classification was very hot and dry. According to Zahak meteorological station website, the long-term average rainfall was 63 mm with the annual evaporation rate of 4500-5000 mm.

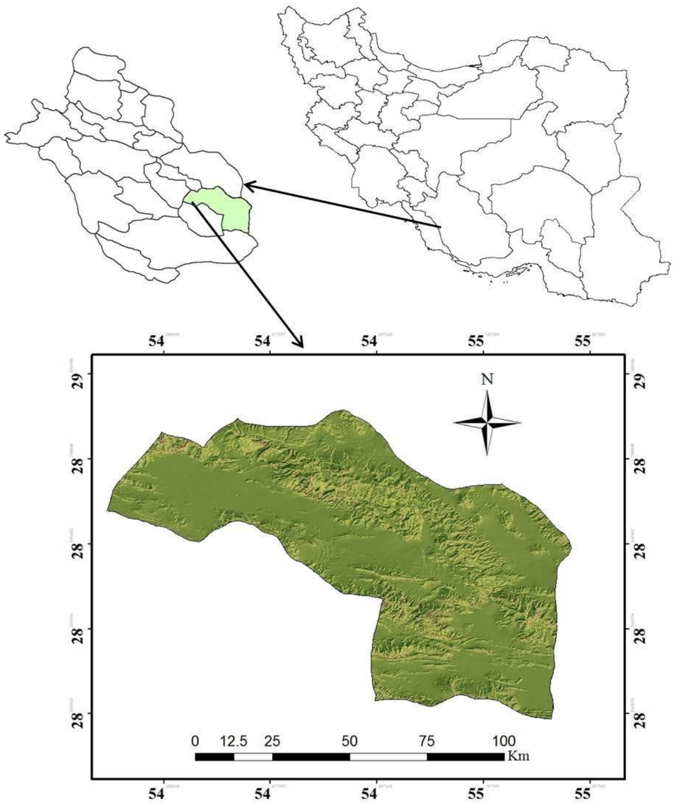

Fig. 1. Map of the geographical location of the study basin

Livestock maintenance

The predominant grazing animals in the studied pastures were native cows and goats. Three 12-month-old Sistani bulls weighing 277±27 kg were used for the degradation test with a fistula installed in the rumen. Bull's diets were adjusted to the maintenance level (NRC, 2001) using dried alfalfa, wheat straw, and concentrate. The amount of energy and protein was 1.2 MJ/kg and 14%. The feed was fed in two meals at 8:00 am and 17:00 pm and the water was supplied *ad libitum* to the animals.

Sampling of species

Five species of rangeland plants including *Amygdalus lycioides*, *Amygdalus scoparia*, *Atriplex leucoclada*, *Artemisia herba-alba* and *Acer monspessulanum* were used in the vegetative stage. All experiments were performed in animal nutrition laboratory, Department of Animal Sciences, Agriculture Laboratory, Agriculture and research farm located in Sistan, Iran.

Experiment 1

This experiment was performed to determine the chemical composition and nutritional value of five tropical rangeland plants. Sampling of aerial parts of plant species was done by a random method and plants were harvested in three replicates per each at an average of 500 g in the rangelands of Rustaq and Fedami areas Darab, Fars province, Iran in April 2020. After the visit, a sample plot with dimensions of 200×200 m (4 ha) was selected, which as far as possible, represented the community of shrub species. For the sampling of rangeland shrubs, 20 plants were selected and transferred to the laboratory for chemical analysis after pruning the herbaceous parts of the plant (head of branches). The species after harvesting and mixing replicates of each species separately were exposed to open air and shade for 72 hours. After drying, plant samples were ground with a sieve mill (diameter of 2 mm).

Chemical composition

Data measurements were made for dry matter (DM) using an oven at 60 °C for 48 hours, crude fat (EE) through organic solvent extraction method (Soxhlet apparatus), ash by AOAC (Horwitz, 2010), crude protein (CP) by Kjeldal method, organic matter (OM) by computational method, insoluble fibers in neutral detergent (NDF) and insoluble fibers in acid detergent (ADF) measured using the method of Van Soest (1990). Neutral detergent solution (NDS) and fiber bag device were used to measure NDF and acid detergent solution (ADS) and fiber bag device were used to measure ADF. The amount of calcium and magnesium was measured by atomic absorption spectrometry and the quantity of phosphorus was measured by spectrophotometry (Horwitz, 2010).

Experiment 2

Dry matter degradability method (*in situ*)

In this study, three Sistani male Bulls with an average weight of 380±12.5 kg and 36 months of age with a fistula installed in their rumen were used for degradability testing (Ørskov and McDonald, 1979). The value of 5 g of dried and ground sample from each plant (with a diameter of 2 mm) was prepared inside polyester bags with dimensions of 8×15 cm and pore diameter of 50 µm. Then, bags containing the sample for 6, 12, 24, 36, 45, 72 and 96 hours (14 bags each time and 3 repetitions per treatment) were placed in the bulls rumen and after the end of each of the desired incubation times, removed from the rumen and rinsed with cold water and dried in an oven at 65°C for 48 hours. From the difference between the original sample and the remaining sample in the bag, the decomposed or disappearance part was calculated.

Degradability parameters [soluble fraction of coefficient (a), non-soluble fraction of coefficient (b) and constant rate of decomposition of coefficient (C)] were determined using the NLIN procedure through the SAS, 2007 and based on the exponential equation (Ørskov and McDonald, 1979).

$$P= a + b\,(1–e^{-ct})$$

Where:
P: the percentage of degradability in time (t).
a: fast decomposition section
b: slow decomposition section
c: the rate of degradability (percentage per hour).

Effective degradability (ED) at the levels of 2, 5 and 8% per hour was also calculated as follow:

$$ED= a + [(b \times c) /(c + k)]$$

a: fast decomposition section
b: slow decomposition section
c: the rate of degradability (percentage per hour)
k: is the amount of ruminal out flow.

Gas production test

The volume of gas produced from the fermentation of the samples was determined according to Menke *et al*. (1979) method. To test for gas production in the incubator, ruminal fluid was taken from 3 fistulated Sistani male bulls before feeding in the morning and transferred to the laboratory in a flask containing carbon dioxide and smoothed with a 4-layer cleaning cloth. Samples were milled using a 1 mm sieve. The 210±0.5 mg (3 replicates) was poured into each syringe and 30 ml of purified ruminal fluid mixture containing buffer (2: 1 ratio) was added to syringes (Makkar, 2004).

Solutions for gas production test were prepared according to Table 1. The volume of gas produced was read at 2, 6, 8, 12, 24, 48, 72, and 96 hours. This test was repeated in 2 days.

Table 1. Amounts of chemicals to prepare the reagents for the gas production test

Solution	Chemical materials	Weight (g)
Macro mineral	Sodium hydrogen phosphate ($Na_2 HPO_4$)	5.7
	Potassium dihydrogen phosphate (KH_2PO_4)	6.2
	Magnesium sulfate ($MgSO_4$, 7H2O)	0.6
Micro mineral	Calcium chloride ($CaCl_2$. 2H2O)	13.2
	Manganese chloride ($MnCl_2$. 4H2O)	10
	Cobalt chloride ($CoCl_2$. $6H_2O$)	1
	Iron chloride ($FeCl_3$. $6H_2O$)	0.8
Buffer solution	Sodium hydrogen carbonate (NaHCO3)	70
	Ammonium hydrogen carbonate HCO3 (NH4)	4
Resazurin solution	100 mg of Resazurin, which was increased to 100 ml by adding, distilled water.	

Estimation of quality traits

For measuring OMD, the volume of gas produced based on 200 mg of DM during 24 hours and the following equation were used (Menke *et al*., 1979):

$$\mathrm{OMD} = 14.88 + 0.8893\mathrm{GP} + 0.0448\mathrm{CP} + 0.0651\mathrm{ASH}$$

Where:
OM: Digestibility of organic matter (g/kg DM)
GP: Corrected gas volume for 24 hours (ml/200 mg of DM).
CP: crude protein (g/kg DM)
ASH: Crude ash (g/kg DM)
Digestible Organic Matter in Dry Matter (DOMD) was obtained using the below equation:

$$\mathrm{DOMD} = \mathrm{OMD} \times \%\,\mathrm{OM}$$

Where:
DOMD: Digestible Organic Matter in Dry Matter (%)
OMD: Organic matter digestibility (%)
OM: Sample Organic Matter (%)
Also, estimation of ME was calculated based on the following equation (Menke *et al*., 1979):

$$\mathrm{ME}=2.2+0.1357\mathrm{GP}+0.0057\mathrm{CP}+0.00002859\mathrm{CP}^2$$

Where:
ME: Metabolisable energy (MJ/kilogram of DM)
GP: Volume of gas produced (ml/200mg DM in 24h)
CP: Crude protein (g/kg DM)

Statistical analysis

The data on chemical composition were analyzed using one-way analysis of variance *(*ANOVA*)* and mean values were compared by Duncan's multiple range method using SAS 9.1 software. The data of *in situ* test and gas production were computed using Neway software and Proc NLIN program (Nonlinear regression), respectively.

Results

Chemical composition

The chemical compositions of the plant species are shown in Table 2. The DM and OM values ranged from 94.73 to 96.80% and 83.52 to 94.51%, respectively. Other chemical compounds presented different variation, which was not unexpected due to the genetic of species and other factors affecting plant growth. In this way, *Atriplex leucoclada* had the highest value of ash (16.48%), CP (11.72%), Ca (0.2749%), P (0.15%), and Mg (0.12%).The quantity of DM (96.80%) and EE (7.81%) of *Artemisia herba-alba* was the highest value and *Amygdalus scoparia* also recorded the highest amount of OM (94.51%), ADF (52.55%) and NDF (69.05%).

Factors affecting the DM and OM digestibility and metabolizable energy are the values of NDF and ADF in plants. Due to the significant difference between these two compounds among the studied plants, the most inappropriate quantity was recorded in *Amygdalus scoparia* (69.05 and 52.55%, respectively) ($p<0.01$) and *Amygdalus lycioides* showed acceptable values.

Table 2. The average chemical composition and minerals of the plants

Chemical composition (%)	*Amygdalus lycioides*	*Acer monspessulanum*	*Amygdalus scoparia*	*Artemisia herba –alba*	*Atriplex leucoclada*	SEM	P-value
DM	96.70^{a}	94.73^{b}	96.56^{a}	96.80^{a}	96.76^{a}	0.783	0.0080
OM	92.20^{a}	94.26^{a}	94.51^{a}	93.41^{a}	83.52^{b}	1.511	0.0001
ASH	7.80^{b}	5.73^{b}	5.48^{b}	6.59^{b}	16.48^{a}	1.511	0.0001
CP	8.13^{b}	7.47^{c}	5.30^{d}	7.36^{c}	11.72^{a}	0.275	0.0001
EE	5.10^{b}	4.50^{b}	5.46^{b}	7.81^{a}	6.01^{b}	0.893	0.0090
ADF	38.66^{c}	43.62^{b}	52.55^{a}	44.50^{a}	43.11^{b}	1.780	0.0001
NDF	52.62^{d}	56.39^{c}	69.05^{a}	59.05^{b}	53.97^{cd}	1.444	0.0001
Ca	0.21^{2b}	0.19^{c}	0.15^{d}	0.09^{e}	0.28^{a}	0.220	0.0001
P	0.07^{c}	0.09^{bc}	0.08^{bc}	0.10^{b}	0.15^{a}	0.013	0.0002
Mg	0.09^{b}	0.090^{b}	0.09^{b}	0.09^{b}	0.12^{a}	0.003	0.0001

*Numbers with dissimilar letters in each row have statistically significant difference (P<0.01),
SEM: Standard error mean, DM: dry matter, OM: organic matter, CP: crude protein, EE: crude fat, ADF: cell wall without hemicellulose, NDF: cell wall, Ca: calcium, P: phosphorus, Mg: magnesium

In vitro gas test

Fermentation parameters

Average volume of gas produced at different incubation times was displayed in Table 3. This factor after 24 hours of incubation ranged from 23.72 (*Amygdalus scoparia*) to 41.52 ml (*Amygdalus lycioides*) and after 96 hours, it recorded 38.66 (*Amygdalus scoparia*) to 54.83 ml (*Amygdalus lycioides*). It is clear that with increasing incubation time, the amount of gas produced also raised, accumulatively. According to the results, from 12 to 96 hours after incubation, the volume of gas produced by the tested plants followed the same pattern.

Table 3. Average volume of gas produced (ml/200 mg of DM) of the plants at different incubation times

Incubation (hr)	*Amygdalus lycioides*	*Acer monspessulanum*	*Amygdalus scoparia*	*Artemisia herba –alba*	*Atriplex leucoclada*	SEM	P-value
2	6.17^{b}	7.17^{a}	4.83^{c}	6.17^{b}	7.17^{a}	0.341	0.001
4	12.50^{b}	11.69^{a}	8.58^{c}	10.87^{b}	13.22^{a}	0.428	0.001
6	19.07^{a}	16.13^{b}	11.98^{c}	15.34^{b}	19.65^{a}	0.783	0.001
8	22.76^{a}	18.77^{b}	13.93^{c}	18.06^{b}	22.74^{a}	1.077	0.001
12	30.13^{a}	23.55^{c}	17.17^{d}	23.34^{c}	27.78^{b}	1.162	0.001
24	41.52^{a}	30.63^{c}	23.72^{d}	28.46^{c}	37.04^{b}	1.490	0.001
48	49.06^{a}	37.22^{c}	31.50^{d}	32.50^{d}	41.43^{b}	1.567	0.001
72	52.42^{a}	41.73^{b}	34.22^{b}	40.22^{c}	44.05^{b}	1.684	0.001
96	54.83^{a}	46.67^{b}	38.66^{b}	45.34d	48.02^{bc}	1.722	0.001

*Numbers with dissimilar letters in each row have a statistically significant difference (P<0.01), SEM: Mean standard error

Gas production parameter

There was a significant difference between plants in the component of fractions (b) and (c) (p<0.01). In Table 4, the fraction (b) was ranged from 33.84 (*Artemisia herba-alba*) to 53.01 (*Amygdalus lycioides*) (P<0.01). The value of (c) (decomposition constant rate), which indicated the instantaneous decomposition rate of fraction (b), showed a significant difference between the plant species (p<0.01). The OMD ranged from 36.67 (*Amygdalus scoparia*) to 53.27% (*Amygdalus lycioides*) and by comparing OMD and DOMD values, it was observed that DOMD trend followed from OMD and caused a change in a ratio. Values of OMD and DOMD were influenced by both fractions (b) and (c) so that *Amygdalus scoparia* due to having a higher value of (b), and the lowest of fractions (c), showed less OMD and DOMD, which this may be due to chemical compounds and cell walls. Metabolisable energy was determined between 5.57 and 8.08 MJ/kg.

Table 4. Gas production parameters of the plants

Treatment	*Amygdalus lycioides*	*Acer monspessulanum*	*Amygdalus scoparia*	*Artemisia herba –alba*	*Atriplex leucoclada*	SEM	P-value
b (ml)	53.01^{a}	40.77^{b}	52.76^{a}	33.84^{c}	43.14^{b}	1.684	0.001
c	0.07^{a}	0.06^{c}	0.02^{d}	0.09^{a}	0.09^{a}	0.004	0.001
OMD%	53.27^{a}	42.54^{c}	36.67^{d}	41.27^{c}	48.68^{b}	1.329	0.001
DOMD%	49.11^{a}	40.02^{b}	34.67^{c}	38.55^{b}	40.66^{b}	1.248	0.001
ME (MJ/kg)	8.08^{a}	6.44^{c}	5.57^{d}	6.26^{c}	7.42^{b}	0.202	0.001

*Numbers with dissimilar letters in each row have a statistically significant difference (P<0.01), SEM: standard error of the means, OMD: digestibility of organic matter, DOMD: digestibility of organic matter in DM, ME: metabolisable energy, b: total volume of gas produced c: constant rate of gas production

Degradability parameters

The results of dry matter degradability at various incubation times are shown in Table 5. It is quite clear that the disappearance of DM from the nylon bags incubated in the rumen rose was with increasing incubation time. Throughout the period, *Amygdalus lycioides* and *Amygdalus scoparia* manifested the highest (61.43%) and lowest (42.36%) dry matter disappearance, respectively. The results explicated that there was a positive correlation between the cell wall composition and the dry matter digestibility. *Amygdalus lycioides* had the lowest ADF and NDF; therefore, it recorded the highest digestibility among experimental plants.

Table 5. Mean dry matter degradability (%) of the plants at different incubation times

Incubation (hr)	*Amygdalus lycioides*	*Acer monspessulanum*	*Amygdalus scoparia*	*Artemisia herba –alba*	*Atriplex leucoclada*	SEM	P-value
3	25.31^{a}	22.03^{b}	16.26^{c}	18.31^{b}	24.07^{b}	1.548	0.0001
6	32.94^{a}	25.38^{b}	22.21^{d}	22.76^{c}	28.74^{b}	1.339	0.0001
12	37.40^{a}	30.35^{b}	26.69^{d}	28.69^{c}	31.82^{b}	1.037	0.0001
24	44.70^{a}	35.95^{b}	31.81^{d}	33.77^{c}	38.59^{b}	1.142	0.0001
48	50.57^{a}	39.45^{b}	35.48^{d}	37.94^{c}	42.12^{b}	1.574	0.0001
72	55.33^{a}	44.70^{b}	38.65^{d}	40.65^{c}	47.36^{b}	1.465	0.0001
96	61.43^{a}	47.46^{b}	42.36^{d}	45.16^{c}	53.36^{b}	1.020	0.0001

*Numbers with dissimilar letters in each row have a statistically significant difference (P<0.01), SEM: standard error of the means

According to Table 6, *Amygdalus lycioides* had the highest value, and also, *Amygdalus scoparia* noted the lowest values of fast decomposition section (a) and decomposition rate constant (c). On the other hand, the potential degradability coefficients (a+b) ranged from 58.48 (*Acer monspessulanum*) to 68.16% (*Amygdalus scoparia*). The mean percentage of effective degradability (ED) of DM at the passage rate of 0.02, 0.05, and 0.08 was significantly different between plants (P<0.01). With reference to (a) and (c), the most acceptable percentage of effective degradability was recorded from *Amygdalus lycioides*, and the unsuitable was recognized in *Amygdalus scoparia*. With increasing incubation time, the amount of gas produced (ml/200 mg of DM) increased and the most of the gas was obtained after half of the whole period (48 hours). According to the nonlinear regression equation (R^2 close to 1), it was found that the volume of gas followed the logarithmic function (Fig. 2). The slope of the nonlinear regression was sharp until the first 20 hours of incubation. With increasing incubation time, the intensity of produced gas reduced, and the slope of the line became gentle. The main reason for the increase in the gas produced in the early hours was due to the activity of the microbial population and the presence of substrate (organic matter). With increasing incubation, gas production decreased due to the consumption and non-replacement of organic matter. The results showed that the digestibility of OMD and DOMD decreased with increasing of ADF and NDF%.

Table 6. Percentage of degradability parameters of the plants

Treatment	*Amygdalus lycioides*	*Acer monspessulanum*	*Amygdalus scoparia*	*Artemisia herba –alba*	*Atriplex leucoclada*	SEM	P-value
a	25.28^{a}	23.67^{a}	17.20^{c}	20.97^{b}	24.93^{a}	0.907	0.001
b	39.54^{c}	34.86^{d}	50.95^{a}	39.83^{b}	51.10^{b}	0.796	0.001
c	0.04^{a}	0.011^{b}	0.005^{d}	0.007^{c}	0.01^{c}	0.001	0.001
a + b	64.82^{b}	58.48^{d}	68.16^{a}	61.02^{c}	66.04^{b}	0.680	0.001
ED							
0.02	50.40^{a}	35.76^{c}	27.60^{e}	31.06^{d}	36.33^{b}	0.286	0.001
0.05	41.50^{a}	29.80^{b}	21.90^{d}	25.70^{c}	30.40^{b}	0.389	0.001
0.08	37.16^{a}	27.73^{b}	20.30d	24.06^{c}	28.53^{b}	0.486	0.001

* - Numbers with dissimilar letters in each row have a statistically significant difference (P <0.01), SEM: standard error mean, a: fast decomposition section, b: slow decomposition section, c: decomposition rate constant, a + b: potential degradability of food, ED: Effective degradability

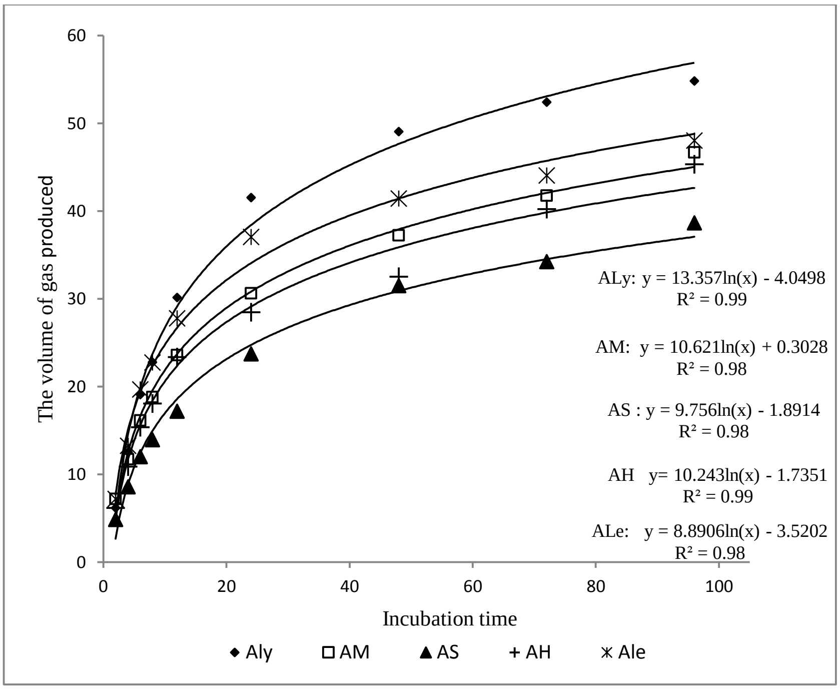

Fig. 1. Logarithmic nonlinear regression of gas produced at different incubation times (hr)
ALy: Amygdalus lycioides, AM: Acer monspessulanum, AS: Amygdalus scoparia, AH: Artemisia herb–alba, ALe: Atriplex leucoclada

Discussion

Genotypic variation between species, growth stage and the effect of environmental factors will undoubtedly change the chemical composition of plants (Izaurralde *et al*., 2011; Dumont *et al*., 2014; Bhattarai *et al*., 2020; Gusmão Filho *et al*., 2020). Researcher declared that genetic diversity in rangeland plants caused significant differences in chemical composition and digestibility. In addition, maturity time, leaf to stem ratio, growth rate and plant resistance to stress could be other factors influencing the chemical composition of forage (Milford and Haydock, 1965; Hunt and Hay, 1990; Melesse *et al*., 2012; Kfoury *et al*., 2019; Sgarbossa *et al*., 2019; Somasiri *et al*., 2020). The scientific reports also showed that the differences in the chemical composition of different species were related to their inherent ability to take nutrients from the soil and convert into plant tissues (Towhidi *et al*., 2007; Zanella and Vianello, 2020).

In this experiment, the volume of gas produced had a negative correlation with NDF and ADF; the results were in harmony with prior studies (Sommart *et al*., 2000; Mokhtarpour *et al*., 2012). Higher gas production has a positive correlation with dry matter digestibility and negative correlation with NDF and ADF contents; this indicated that gas production was an integral part of feed fermentation (Kumar *et al*., 2013; Kulivand and Kafilzadeh, 2015).

The highest rate of effective degradability (ED) was reported in *Amygdalus lycioides* with the highest coefficient of slow decomposition fraction (a) and decomposition rate constant (c) and the lowest rate was belonged to *Amygdalus scoparia* due to the low coefficient of (a) and (c). The outcomes of this research revealed a positive correlation between ED and coefficients of (a) and (c). Researchers reported that red berry leaves and white berry leaves showed the different degradability coefficient of insoluble part (b) in the rumen, which can be due to the amount of crude protein led to promote the growth of microorganisms and greater protein degradability (Ferlemi and Lamari, 2016; Biel and Jaroszewska, 2017; Ojah, 2020). An extra factor affecting the quantity of ED is the growth stage of the plant. Blu and Ørskov (1993) estimated that the dry matter digestibility of alfalfa was 0.93 through a multiple regression model. The disappearance of dry matter in the leaves within 48 hours of incubation was equivalent to degradability (Ørskov *et al*., 1980).

The difference in logarithmic nonlinear regression between gas accumulated at different incubation times was due to differences in the chemical components among rangeland plants. By increasing the incubation time to 24 hours, a significant volume of produced gas was obtained, which was the result of microbial digestion. Various factors affect the technique of gas production in laboratory conditions. To get accurate results, standard techniques must be applied (Tedeschi *et al*., 2008).

Conclusion

Due to the lack of rainfall and fodder to satisfy the nutritional requirements of livestock, understanding of the current capacity and potential for optimal usage in animal nutrition appears essential. Patton *et al*. (2007) reported that determining the minerals in forage is important, and knowledge of the type and amount of minerals in the plant is necessary to manage pasture grazing. If some minerals are not present in the plant, livestock requirements will not be provided by eating that plant and will graze more fodder, consequently increasing the grazing to compensate for the lack of minerals lead to destroying the pasture. According to the outcomes of the chemical composition in this trial, the CP value of plants was scored between 5.30 to 11.72%, which usually, the level of 7.5% of CP is considered as a suitable quality for forage (NRC 2001). Based on the results of CP, ADF, and NDF as well as the results of *in-situ* and *in-vitro* digestibility tests, it could be concluded that the species of *Amygdalus lycioides*, *Atriplex leucoclada*, *Acer monspessulanum*, *Artemisia herba-alba*, and *Amygdalus scoparia*, respectively, could be considered as suitable range plants under the condition of the current experiment.

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تعیین ارزش غذایی پنج گیاه مرتعی با استفاده از تکنیک تولید گاز

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چکیده: این تحقیق در اردیبهشت ۱۳۹۹، جهت تعیین ترکیب شیمیایی و ارزش غذایی پنج گونه گیاه مرتعی در مرحله رویشی گیاهان مورد استفاده در تغذیه نشخوارکنندگان، انجام شد، نمونه های مورد آزمایش شامل: بادامک (بادام‌خاردار) (*Amygdalus lycioides*)، بادام کوهی (*Amygdalus scoparia*)، سلمه‌تره(*Atriplex leucoclada*) ، درمنه (*Artemisia herba –alba*) و کیکهم (*Acer monspessulanum*) بودند. پس از جمع آوری نمونه ها ، ترکیبات شیمیایی گیاهان شامل ماده خشک (DM) ، ماده آلی (OM) ، پروتئین خام (CP) ، عصاره اتری (EE) ، خاکستر، دیواره سلول (NDF) و دیواره سلولی بدون همی‌سلولز (ADF) با استفاده از روش های استاندارد، تعیین شد. برای آزمایش تجزیه‌پذیری ، از روش کیسه نایلون با استفاده از سه راس گاو نر بومی فیستوله‌دار سیستانی استفاده شد. قابلیت هضم مواد آلی (OMD) و انرژی قابل سوخت و ساز (ME) از طریق روش تولید گاز تعیین گردید. دامنه تغییرات مقدار CP از ۵/۳۰ (*Amygdalus scoparia*) تا ۱۱/۷۲٪ (*Atriplex leucoclada*) و مقدار NDF از ۵۶/۶۲ (*Amygdalus lycioides*) تا ۶۹/۰۵ (*Amygdalus scoparia*) تعیین شد (p<۰/۰۱). بیشترین حجم گاز تولیدی بر اساس میلی لیتر در ۲۰۰ میلی گرم ماده خشک و پس از ۹۶ ساعت انکوباسیون مربوط به*Amygdalus lycioides* (۵۴/۸۳) و کمترین آن در *Amygdalus scoparia* (۳۸/۶۶) بود که می تواند به دلیل کم بودن مقدار NDF (۳۸/۶۶٪) و ADF (۵۲/۶۲٪) در*Amygdalus lycioides* باشد. دامنه تغییرات قابلیت هضم مواد آلی (OMD) ، ماده آلی قابل هضم در ماده خشک (DOMD) و انرژی قابل سوخت و ساز (ME) به ترتیب از ۳۶/۶۷ تا ۵۳/۲۷٪ ، ۳۴/۶۷ تا ۴۹/۱۱٪ و ۵/۵۷ تا ۸/۰۸ (MJ/kg) تعیین گردید. نتایج نشان داد که بالاترین مقادیرOMD (۵۳/۲۷٪)، DOMD (۴۹/۱۱٪) و ME (۸/۰۸ MJ/kg) و کمترین مقادیرADF (۳۸/۶۶٪) و NDF (۵۲/۶۲٪) مربوط به *Amygdalus lycioides* بود. به طوری که OMD ، DOMD و ME با افزایش سطوح ADF و NDF در سایر گیاهان مورد مطالعه، کاهش یافت (p<۰/۰۱). در مجموع گونه های بادامک، سلمه تره ، کیکهم، درمنه و بادام کوهی به ترتیب دارای ترکیب شیمیایی و قابلیت هضم قابل قبولی بودند.

کلمات کلیدی: ترکیبات شیمیایی، قابلیت هضم ماده خشک، آزمایش گاز