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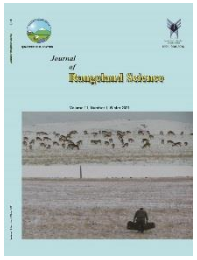

Research and Full Length Article:

Forage Quality of *Salsola turcomanica* (Litv) in Semi-arid Region of Gomishan, Golestan Province, Iran

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Abstract. The information about the forage quality of rangeland species is essential to supply a reasonable diet to livestock and determine thestocking rate and grazing time on rangelands. Salsola turcomanica is one of the important species of semi-arid rangelands in the Western part of Golestan province, Iran. The present study was conducted to provide information about the nutritive value of S.turcomanica at different growth stages in 2019. Plant samples (with three replications) were randomly collected in four growth stages (vegetative stage, early flowering, late flowering and seed maturity) from Gomishan rangelands during the summer and autumn 2019. Seven quality indices, including Acid Detergent Fiber (ADF), Crude Protein (CP), Dry Matter Digestibility (DMD), Metabolizable Energy (ME), Digestible Energy (DE), Total Digestible Nutrient (TDN) and Ash content (Ash) were analyzed. Data analysis was performed using One-way analysis of variance (ANOVA) method and mean comparisons were done by Duncan test. The results demonstrated that there are significant differences among phenological stages for all the traits ($p<0.05$). The results demonstrated that the content of CP (from 25.66% to 8.33%), DMD (from 84.45% to 56.31%), ME (from 12.35 to 7.57 MJ/Kg), Ash (from 40.03% to 35.60 %), DE (from 36.17 to 24.12 Mcal/Kg) and TDN (from 82.55% to 53.41%) were decreased by the progress of growth stages. Regarding its growth seasons and high values of CP, ME and DMD in all phenological stages, it is suggested that this species can have aprominent place in the grazing livestock diet in semi-arid rangelands.

Key words: *Salsola turcomanica*, Forage quality, Phenological stages, Semi-arid rangelands

Introduction

Fodder shortage is a severe challenge in the arid and semi-arid regions due to their harsh climatic conditions that limit the growth of plant species. Over the 500,000 ha of rangelands in Golestan province, Iran are salty and alkaline (Bakhshi-Khaniki and Maroof, 2006). Halophytes and other salt-resistant plants have a high potential for forage production and are considered as aproper and practical solution for the fodder shortage in developing countries (Squires and Ayoub, 1994). There is an increasing interest in the rational use of these potential and available livestock fodder resources due to the huge extension of degraded rangelands and halophyte species in Iran (Kashki *et al.*, 2016).

Knowing the nutrition value of rangeland species is crucial to supply a rational diet to livestock and determine stocking rate and grazing time in rangelands (Ashrafzadeh *et al.*, 2019). The grazing capacity of rangelands, the most proper time of rangeland utilization, prediction of malnutrition and evaluation of nutrition requirements of plants, as well as, recognizing probable deficiencies in the nutrition of grazing livestock to higher livestock performance without damage to vegetation and select suitable plant species for rangeland restoration, can be achieved using the information of investigation on forage quality of different species during their phenological stages in different habitats (Asaadi and Khoshnood-Yazdi, 2011; Panahi *et al.*, 2012; Arzani *et al.*, 2004; Ghanbari and Sahraei, 2012; Arzani et al, 2010; Zare *et al*., 2019). In this regard, 7% of CP, 50% of DMD and 8 MJ of ME/Kg DM have been recommended as a forage critical limit to keep grazing livestock in the rangelands (Holechek *et al*., 2005).

Crude protein (CP), total digestible nutrients (TDN) and metabolizable energy (ME) are some of the most important factors in an investigation of the forage quality (Arzani, 1994). Reduction of CP and DMD of forage and the increase in Acid Detergent Fiber (ADF%) and Neutral Detergent Fiber (NDF%) have reported by many researchers when plants are mature (Behnamfar *et al.*, 2009; Goorchi, 1995 and Ghadaki *et al.*, 1974). McDonald *et al. (*1995) reported that in early spring, DMD of plants might reach 80% or higher and it will decrease when plant growth is completed. Digestible energy, ME and DMD of forage decrease whereas fiber and lignin increase with the maturity of plants (Asaadi and Khoshnood-Yazdi, 2011). There are reverse relationships between CP and fiber of a given species and significant differences between the quality of plant organs and growth stages (Azarnivand *et al.*, 2006). As fiber increases, forage quality declines (Ball *et al.*, 2001). Cabalero *et al.* (2001) reported the variations of CP of forage in three phenological stages for *Vicia sativa*. Their results indicated that fiber content of forage increased in the maturity stage.

Generally the nutritional value of halophytes plants depends on kind of plant species, phenological stage, soil chemical properties, climate and harvest time (Harrocks and Valentine, 1999). Rayburn (2002) found that phenological stages are the most effective factor among forage quality influence factors. The species of Salsola genus plays an important role in dry and saline rangelands. High seed and forage production are advantages of this genus over other genus (Bakhshi Khaniki and Maroof, 2006). An investigation on the forage quality of three species belonging to Salsola genera during their phenological stages has demonstrated that CP content of *Salsola tomentosa, Salsola dendroides* and *Salsola arbusculiformis* was varied from 13.16% to 6.69%, from 10.79% to 6.23% and from 10.37% to 7.83%, respectively (Arzani *et al.*, 2013). Zare *et al*. (2019) after investigation on forage quality of *S. yazdiana* and *S. tomentosa* stated that the late winter and

early spring are the suitable times for grazing of these species. *Salsola foetida*, with 5.4 to 22.3 % CP and 20.1 to 48.4% ADF in different growth stages, is a popular fodder species in Tank district of Peshawar, Pakistan (Hanif *et al*., 2018). It has been reported that *S. yazdiana* in different growth stages have from 7.67 to 11.18% CP and from 25.49 to 42.33% ADF, while *S. tomentosa* have from 6.29 to 10.12% CP and from 34.28 to 44.51% ADF. It has been reported that 53% of 163 halophytes species in Iran belong to Chenopodiaceae family (Jafari, 1994). The Chenopodiaceae (an angiosperm family) are mostly xerophytes and halophytes. The most diverse genus of the sub-family Salsoloideae in Central and Middle Asia is Salsola which mostly grows in typical deserts and semi desert zones. The salt and drought tolerance of *Salsola* spp., in addition to their halophytic nature, good forage value and biomass production potential, makes these plants potential candidates for land reclamation (Gintzburger *et al*., 2003).

Salsola turcomanica (Litv), is an important and relatively palatable halophyte species of Turkmen Sahara in the northern part of Iran (Pasandi *et al.*, 2017; Abarsaji *et al*, 2011). According to the native stockholders statement, this species has an important role in forage supply for goats and camels during the summer and early autumn. Based on the field observation, the seeds of this species emerge in February, but its main vegetative growth begins from June and continue to early September. The flowering stage lasted in late October. The seed maturity stage continues until late November when ripen seeds fall. So, considering the importance of summer forage shortage in winter rangelands (Ahmadi-Beni *et al.*, 2014; Zare *et al*., 2019) and the growing season of *S. turcomanica* in the east of Golestan province, Iran, the present study was conducted to evaluate its forage quality in the four phenological stages (vegetative, early flowering, late flowering and seed maturity) during the growing season.

Material and Methods

Study area

This study was conducted in North West of Golestan province, Iran. The area is located at 54°1´ to 54°2´ longitude and 37°8´ to 37°11´ latitude (Fig. 1), with a flat topography (-11 to -24 m above sea level). Its climate is semiarid with mean annual precipitation of 343 mm mainly in the autumn. Its mean annual temperature is 16.6°C. The growth form of this region is shrubs and grasses and the dominant plant species are *Halostachys blanyesiana, Puccinellia distance, Halocnemum strobilaceum, Aeluropus littoralis* and *Aeluropus lagopoides* (Niknahad-Gharmakher *et al*., 2015; Niknahad-Gharmakher *et al*., 2017).

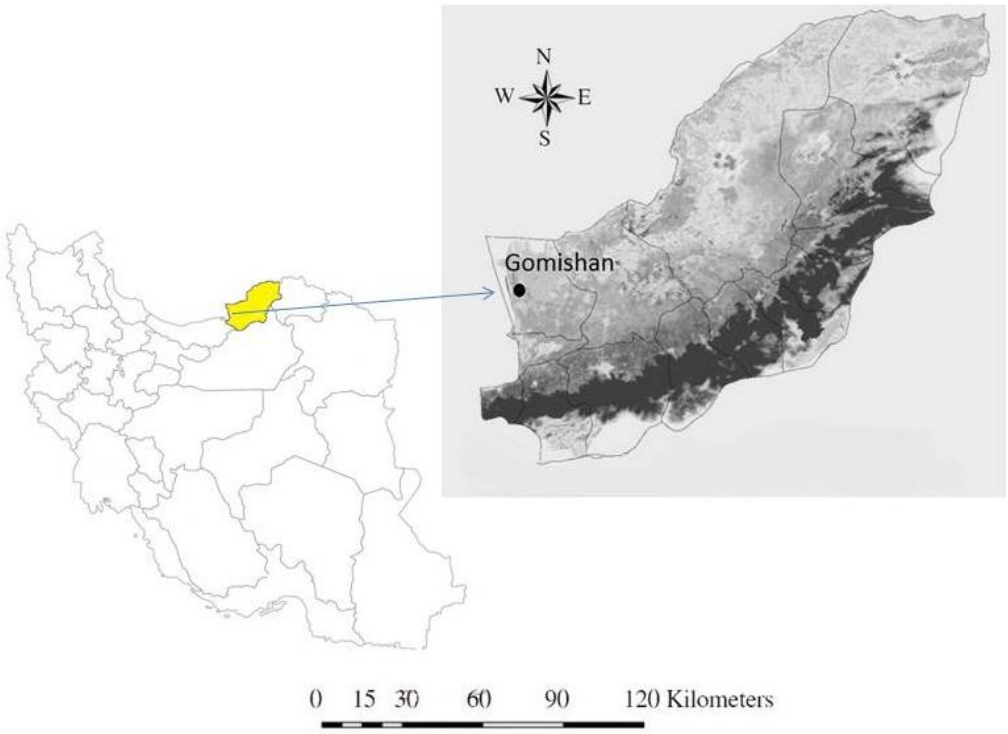

Fig. 1. Geographical location of Gomishan in Northwestern Golestan province

Sampling Method

Based on the field observation, the seeds of this species emerge in February, but its main vegetative growth begins from June and continues to early September. The flowering stage lasted in late October. The seed maturity stage continues until late November when ripen seeds fall. Plant samples (with three replications) were randomly collected and clipped manually, with special scissors at four phenological stages in the first of July (vegetative growth), early September (early flowering), late October (late flowering) and late November (seed maturity) in 2019. All samples were chopped and then passed through a 1 mm mesh screen for chemical analysis. Electric furnace and Kjeldal method were used for measuring Ash and Nitrogen (N) content of the plant samples, respectively. The crude protein was calculated as N×6.25. Acid Detergent Fiber percent (ADF) was measured using the guidelines of AOAC (1980) by Fibertec device. The digestible Dry Matter (DMD) and Metabolic Energy (ME) were measured using Oddy *et al.* (1983) proposed formula and the Australian Agricultural Standard Committee-SCA (1990) proposed equation, respectively. Digestible Energy (DE) estimated using the regression equations presented by Fonnesbeck *et al.* (1984), and the equation proposed by Linn and Martin (1999), was used to Total Digestible Nutrient percent (TDN)calculation.

Statistical methods

Data was analyzed using one-way analysis of variance method. Mean comparisons were made using Duncan test. The SPSSversion21 software was used for statistical analysis.

Results

There were significant differences ($p<0.05$) for all investigated traits in four phenological stages (Table 1). Mean values of the measured quality indicators of *S. turcomanica* at each sampling date are shown in Table 2 and Fig. 2.

Table 1. Analysis of variance of seven quality traits of *S. turcomanica* at four phenological stages

SOV	DF	MS						
		ADF	CP	DMD	ME	DE	TDN	Ash
Phenological stage	3	331.6**	174.8**	415.1**	12.0**	76.0**	438.6**	26.4**
Error	8	7.25	4.32	6.08	0.18	1.11	9.58	1.34

**=Significant at ($p< 0.05$)

ADF =Acid Detergent Fiber; CP = Crude Protein; DMD: Digestible Dry Matter; ME: Metabolic Energy; DE: Digestible Energy; TDN: Total Digestible Nutrient

Acid Detergent Fiber (ADF)

According to the results, the ADF values were 12%, 25.66%, 28.66% and 37.33% at vegetative growth, early flowering, late flowering and seed maturity stages, respectively. The results revealed that the values of ADF significantly changed across all investigated stages. Not only a significant increase in ADF values from vegetative to flowering stages (early and late flowering) was observed, but also, there was a significant difference between flowering and seed maturity stages (Table 2 and Fig.2).

Crude protein (CP)

The crude protein content of *S. turcomanica* was ranged from 8.33 (seed maturity) to 25.66% (vegetative growth) and decreased with the progress of growth stages (Table 2). CP content at vegetative growth stage (25.66%) was significantly higher than three other stages of early flowering (20.33%), late flowering (13.33%) and seed maturity (8.33%) (Table 2 and Fig. 2). There was a significant difference among the crude protein content of all phenological stages ($p<0.01$). The highest decrease (7%) was observed between early flowering and late flowering stages (Table 2).

Digestible Dry Matter (DMD)

The obtained results on variation of DMD content for *S. turcomanica* are given Fig.1. The highest DMD% was observed at vegetative growth stage (84.45%) and the lowest one (56.31 %.) at seed maturity stage (Table 2). The DMD% at vegetative growth stage was significantly ($p<0.05$) higher than other stages. The DMD value of early flowering stage (70.95%) was significantly higher than late flowering stage (65.54%), while the DMD value of seed maturity stage (56.31%) was significantly lower than late flowering stage (Table 2 and Fig. 2).

Metabolizable Energy (ME)

The results demonstrated that metabolizable energy for *S. turcomanica* ranged from 7.57 MJ/kg in the vegetative stage to 12.35 MJ/kg dry matter in seed maturity stage (Table 2). According to the results, at the vegetative growth stage, the value of ME was significantly higher than other stages ($p<0.01$). The ME of early flowering stage (10.06 MJ/kg) was significantly higher than late flowering stage (9.14 MJ/kg) and it was significantly higher than seed maturity stage (7.57 MJ/kg) (Table 2 and Fig. 2).

Digestible Energy (DE)

According to the results, the highest DE content was observed in vegetative growth stage (36.17 Mcal Kg^{-1}) and the lowest one (24.12 Mcal Kg^{-1}) was recorded at seed maturity stage (Table 2). The DE content of *S. turcomanica* was significantly decreased ($p<0.01$) with the progress of growth stages (Table 2 and Fig. 2).

Total Digestible Nutrient (TDN)

TDN values for *S. turcomanica* ranged from 82.55% at vegetative stage to 53.41% at seed maturity stage and decreased with the progress of growth stages (Table 2). The TDN content of *S. turcomanica* in vegetative growth stage was significantly higher than other stages ($p<0.05$). Its values in early and late flowering stages (66.83% and 63.38%)

were significantly higher than seed maturity stage, but there was no significant difference between them (Table 2 and Fig. 2).

Ash

The ash content of *S. turcomanica* ranged from 35.6 % in the seed maturity stage to 41.93% in the early flowering stage. The ash content in the vegetative growth (40.03%) and early flowering stages were significantly higher than two other stages ($p<0.01$). There was not any significant difference between the ash content of vegetative growth and early flowering stages. There was no significant difference between the ash content of late flowering (35.6%) and seed maturity stage, too (Table 2 and Fig. 2).

Table 2. Mean± Standard Deviation values of seven quality traits of *S. turcomanica* in four phenological stages

Phenological stage	ADF%	CP %	DMD %	ME (Mj/Kg)	DE (Mcal/Kg)	TDN %	Ash %
Vegetative growth	12.00±2.00^{c}	25.66±2.08^{a}	84.45±2.04^{a}	12.35±0.34^{a}	36.17±0.87^{a}	82.55±2.30^{a}	40.03±0.50^{a}
Early flowering	25.66±2.51^{b}	20,33±2.51^{b}	70.95±2.89^{b}	10.06±0.49^{b}	30.39±1,24^{b}	66.83±2.89^{b}	41.93±2.22^{a}
Late flowering	28.66±2.51^{b}	13.33±0.57^{c}	65.54±2.06^{c}	9.14±0.35^{c}	28.08±0.88^{c}	63.38±2.89^{b}	36.46±0.22^{b}
Seed maturity	37.33±3.51^{a}	8.33±2.51^{d}	56.31±2.74^{d}	7.57±0.46^{d}	24.12±1.17^{d}	53.41±4.03^{c}	35.6±0.10^{b}

Means within column with different letters have significant differences based on Duncan test ($p< 0.05$).

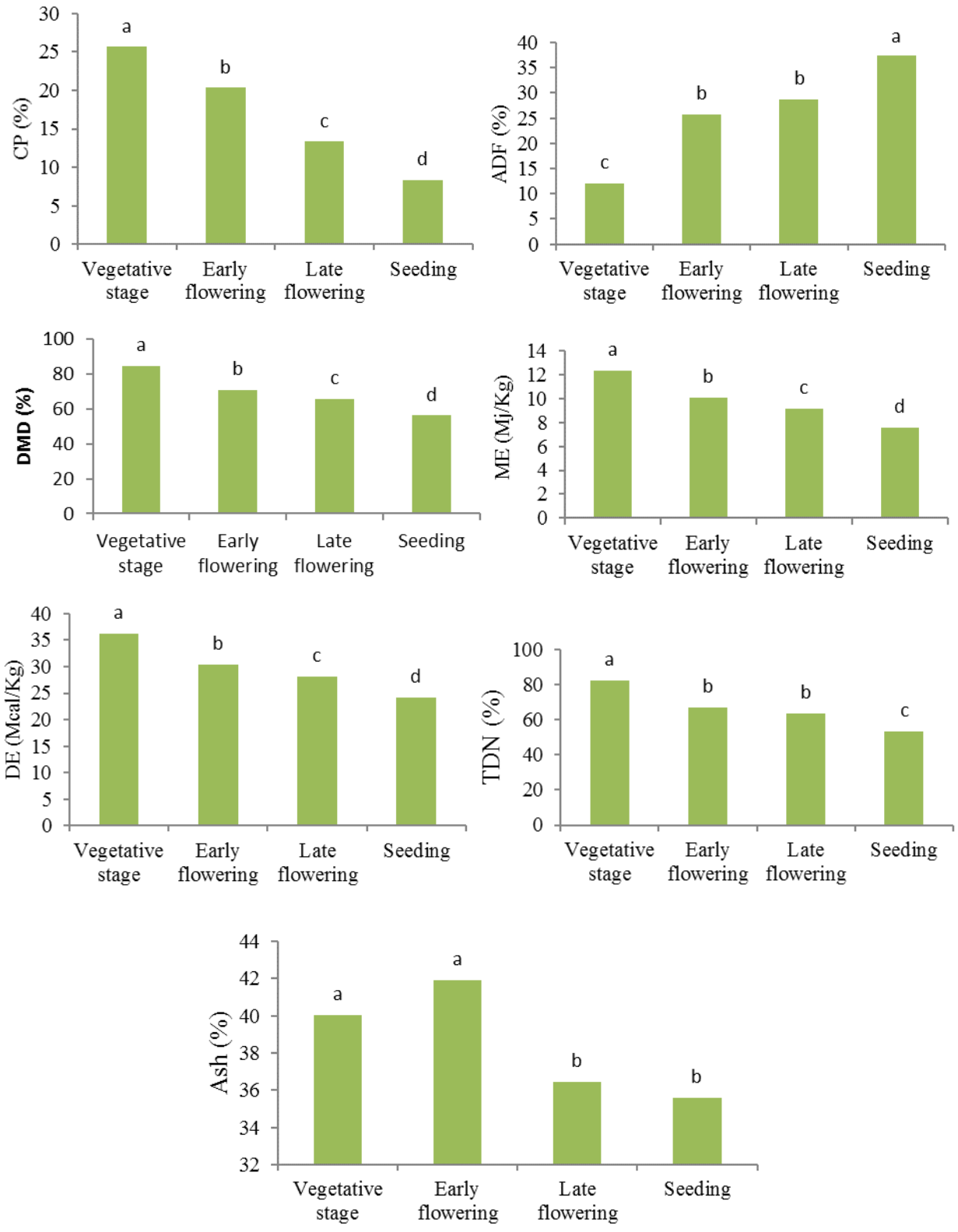

Fig. 2. Mean comparison of seven quality traits of *S. turcomanica* in four phenological stages using Duncan test ($p< 0.05$)

Discussion

Forage quality of *S. turcomanica* decreased as plants age increased that is a well-known trend in many forage species (Givens *et al*, 1990; Daalkhaijav and Daltanzul, 2000; Ahmadi Beni *et al*., 2014; Zare *et al*., 2019). However, its CP content and ADF percent were comparable with *Medicago sativa* in the early flowering stage (Kazemi and Valizadeh, 2019).

In present study, CP content of *S. turcomanica* was different among phenolgical stages, so it was significantly decreased when the plant became older. Its CP content was higher than *S. yazdiana and S. tomentosa* (Zare *et al*., 2019) but it was comparable with *S. foetida* (Hanif *et al*., 2018). The lower CP contents in the seed maturity stage can be probably due to its higher stem to leaf ratio as compared to other stages. Arzani *et al*. (2004) stated that different organs such as stems, leaves, and flower stalks at various stages of different plants growing season affect their nutritional value. For CP, its values even in the seed maturity stage was higher than the minimum level of 7-8% CP required for optimum feed intake in ruminant livestock (Van Soest, 1994; Arzani *et al*., 2013). Due to high content of CP in tissues of *S. turcomanica*, this plant can be a valuable source of CP for livestock feeding.

The results of measured ADF revealed significant differences among the phenolgical stages. However, the ADF value of *S. turcomanica* was lower than *S. yazdiana*, *S. tomentosa* (Zare *et al*., 2019) and *S. foetida* (Hanif *et al*., 2018) in different growth stages. An increasing trend of ADF was observed during the progress of plant growth that is in accordance with Ahmadi-Beni *et al*. (2014) and Zare *et al*. (2019). The formation of secondary cell wall in plant cells with plant maturity can explain the increasing trend of ADF as plant growth stages develop. Arzani *et al*. (2001) have stated that with the development of plant growth, ratios of protector and firmness tissues which generally contain structural carbohydrates (celluloses, hemicelluloses and lignin) are increased. So, plant maturity and an increase in structural carbohydrates lead to more fiber quantities in forage at the end of growing season. Our results are in agreement with Torkan (1999) that stated forage quality is decreased during plant growth due to the increase of ADF and decrease of the CP content of forage.

S. turcomanica has higher DMD than *S. yazdiana* and *S. tomentosa* in all growth stages except flowering stage as compared with *S. tomentosa* (Zare *et al*., 2019). The results demonstrated that the value of DMD of *S. turcomanica* in all phenological stages was higher than the critical level (Squires, 1981; Arzani *et al*., 2013) of DMD (50%) for feeding of one animal unit in the maintenance mode. The decrease of DMD was recorded as plant growth developed. It has been reported that DMD reduce with maturity of plants because of the increase of structural tissues in the stems (Akbarinia and Koocheki, 1992; Asaadi and Khoshnood-Yazdi, 2011; Arzani *et al.,* 2004). Rayburn (2002) pointed out to the reduction of digestibility in the matured plants, which may be partly attributed to the changes in cell wall content and composition (Boufennara *et al.,* 2012). A close relationship between forage dry matter digestibility and its cell wall characteristics has been reported by Pinkerton (1996) and Arzani *et al.* (2004). The increase in the proportions of structural carbohydrates to the non-structural carbohydrates can explain DMD reduction trend from vegetative growth to seed maturity stage (Ahmadi *et al.*,2013).

Fiber content of cell walls increases by the plant growth, hence the forage dry matter digestibility decrease. Since lignin is an indigestible cell wall fraction and limit the access of microbial enzymes to the cell wall structural polysaccharides, the cell wall

content and its lignification is the most effective factor in forage degradation in the rumen (Ahmadi-Beni *et al*., 2014).

The obtained values of ME and DE of *S. turcomanica* were decreased with the development of growth stages that agreed with the results obtained by Arzani *et al*. (2006) and Ahmadi-Beni *et al*., (2014). The results of this study demonstrated that the value of ME of *S. turcomanica* in three phenological stages was higher than *S. yazdiana*, *S. tomentosa* (Zare *et al*., 2019). In all phenolgical stages, its value was higher than critical level (Arzani *et al.,* 2013) of ME (8 MJ/Kg) for feeding one animal unit in the maintenance mod. It is worth to mention that its ME value in the seed maturity stage (7.57 MJ/Kg) was close to the critical level.

Decrease in TDN% was observed with the progress of plant growth and development. Arzani *et al., (*2001) have stated that structural carbohydrates such as celluloses, hemicelluloses and lignin in plant textures increase, as plant becomes mature. As a complex phenolic polymer, lignin enhances plant cell wall rigidity, hydrophobic properties and promotes mineral transport through the vascular bundles in plant (Schuetz *et al*., 2014). Hence, higher fiber content in forage is observed in the last stage of the plant growing season.

Halophytes regularly contain high levels of Ash (Prasad, 2008). The ash content of *S. turcomanica* was declined by progressing of growth stages that is in contrast with the findings of Zare *et al*., (2019) for *S. yazdiana* and *S. tomentosa*. However, its Ash content was higher than *S. yazdiana* and *S. tomentosa* in all phenological stages.

Conclusion

Our results revealed that *S. turcomanica* has acceptable forage quality and can be recommended in plantation projects in winter rangelands of Golestan province, Iran. Moreover, the results of this study could be useful in ley-farming projects in dry lands, too.

Acknowledgment

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References

Abarsaji, G., Mahdavi, M., Jouri, M.H. 2010. Determination of Concentration of Sodium Chloride under Grazing and Exclosure in Saline and Alkaline Rangelands of Golestan Province (Case Study: Inchehboroun Saline Rangelands). Journal of Natural Ecosystems of Iran. 4: 9-15 (In Persian).

Ahmadi, A., Gomarian, M., Sanjari, M. 2013. Variations in Forage Quality of Two Halophyte Species, *Camphorosma monspeliaca* and *Limonium iranicum* at Three Phenological Stages, Journal of Rangeland Science, 3 (3): 245-251.

Ahmadi- Beni, A., Niknahad Gharmakher, H., Sadat Azimi, M., Gholi, Maramaei, M. 2014. Investigation of forage quality of Vetiveria zizanioides in semi-steppe region of Maravehtappeh, Golestan Province, Iran, Journal of Rangeland Science, 4(4): 287-297.

Akbarinia, A., and Koocheki, A. 1992. Investigation on effects of different harvesting stages on growth, productivity and quality of some barley's varieties. Journal of Pejouhesh and Sazandegi 15:40–43.

AOAC, Association of Official Analytical Chemists, 1980. Official Methods of Analysis. 13th edn. AOAC, Washington, DC.

Arzani, H., 1994. Some aspects of estimating short term and long-term rangeland carrying capacity in the Western Division of New South Wales, Ph.D. Thesis, University of New South Wales, Australia.

Arzani, H., Motamedi (Torkan), J., Yari, R., Ghasemi-Aryan, J., Khatir-Nameni, J.2013. Forage quality of important range species in Pashaylogh-e-Maravetapeh rangeland ecosystem in Golestan province. Journal of Plant Ecosystem Conservation, 1(1): 87-103. (In Persian).

Arzani, H., Ghasemi Arian, N., Moetamedi, J., Filekesh, E. and Moammeri, M., 2013. Investigation of forage quality index of some range species and comparison with their critical levels for daily requirement of grazing animal in estepi rangelands of Sabzevar. Arid Biome Scientific and Research Journal, 3(1): 13-21.

Arzani, H., Motamedi (Torkan), J., Jafari, M., Farahpoor, M. and Zare Chahoki, M. A., 2013. Classification of forage quality index in highland rangelands of Taleghan. Iranian Jour. Range and Desert Research, 20(2): 250-271. (In Persian).

Arzani, H., Ahmadi, Z., Azarnivand, H. and Bihamta M.R. 2010. Forage quality of three life forms of rangeland species in semi-arid and semi-humid regions in different phenological stages. Desert. 15: 71-74.

Arzani, H., Zohdi, M., Fish, E., Zahedi Amiri, G. H., Nikkhah, A. and Wester, D., 2004. Phenological effects on forage quality of five grass species. Jour. Range Management, 57:624-629. (In Persian).

Arzani, H., Torkan, J., Jafari, M., and Nikkhah, A. 2001. Investigation on effects of phenological stages and environmental factors (soil and climate) on forage quality of some important range species. Journal of Agricultural Sciences 32:385–397.

Asaadi, A. M. and Khoshnood Yazdi, A., 2011. Phenological stage effects on forage quality of four forbs species. Jour. Food, Agriculture & Environment, 9 (2): 380-384.

Ashrafzadeh, M., Niknahad-Gharmakher, H., Saharkhiz, M.J., Ghorbani-Nahoji, M. Heshmati, Gh., 2019. Breaking seed dormancy of *Clematis ispahanica* and its optimum planting depth and density (Case study: Bavanat, Fars province). Journal of Range and Desert Research, 26 (3): 629-639. (In Persian).

Azarnivand, H., Joneidi, H., Jarari, M. and Nikou, S., 2006. The study of Forage Quality of *Smirnovia iranica* in different phenological stages in sandy areas-case-study: Band-e-Rig-Kashan. Desert Jour., 11(2):1-10. (In Persian).

Bakhshi- Khaniki, G.H., Maroof, E. 2006. Karyotypic study of some species of the genus salsola L. (chenopodiaceae) in Golestan province. Journal of Pajouhesh- va- Sazandegi,72: 66-72. (In Persian).

Ball, D. M., Collins, M., Lacefield, G. D., Martin, N. P., Mertens, D. A., Olson, K. E., Putnam, D. H., Undersander, D. J. and Wolf, M. W., 2001. Understanding Forage Quality. American Farm Bureau Federation Publication 1-01, Park Ridge, IL.

Behnamfar, K., Siadat, S. A. and Salehe, M. H., 2009. Comparison of nutritional values of important range species in semi warm steppe rangeland of Khouzestan. Iranian Jour. Range and Desert Research, 16(1):86-95. (In Persian).

Boufennara, S., Lopez, S., Bousseboua, H., Bodas, R., and Bouazza, L. 2012. Chemical composition and digestibility of some browse plant species collected from Algerian arid rangelands. Span. J. Agric. Res., 10(1): 88-98.

Caballero, R., Alzueta, C., Ortiz, L. Rodriguez, M., Barro, C., Rebole, A. 2001. Carbohydrate and protein fractions of fresh and dried common vetch at three maturity stages. Agron. J., 93 (5): 1006-1013.

Daalkhaijav, D., and Daltanzul, T.S., 2000. Chemical content and rumen degradability of desert steppe pasture, Research institute of animal husbandry, Zaisan, Ulaanbaator 10153. PP: 1-7.

Fonnesbeck, P.V., Clark, D.H., Garret, W.N., and Speth, C.F. 1984. Predicting energy utilization from alfalfa hay from the Western Region. Proc. Am. Anim. Sci. (Western Section) 35: 305-308.

Ghadaki, M. B., Vansoest, P. J., Mcdowel, R. C. and Malekpour, B., 1974. Composition and *in vitro* digestibility of some arid zone forage from Iran. 12th International Grassland Congress. Moscow. *Russia*, 3(1): 542-549.

Ghanbari, A. and Sahraei, M., 2012. Determination of nutritional value in three forage species in three phenological stages in Sabalan Rangelands, Ardebil, Iran. Jour. Rangeland Science, 2(2): 449–457.

Gintzburger G, Toderich KN, Mardonov BK, Mahmudov MM. 2003. Rangelands of the arid and semi -arid zones in Uzbekistan. International Center for Agricultural Research in the Dry Areas (ICARDA). ISBN ICARDA 92-91 27-137-8. PP:434.

Givens, D.I., Everincton, J.M., and Aoamson, A.H. 1990. The nutritive value of spring grown herbage produced on farms throughout England and Wales over four years. II. The prediction of apparent digestibility in vivo from various laboratory measurements. Animal Feed Science and Technology. 27. 173-184.

Goorchi, T., 1995. Determination of chemical composition and dry matter digestibility of dominante species in Isfahan Province, M.Sc. Thesis. Industrial University of Isfahan, Iran. (In Persian).

Harrocks, D. and Valentine, J. F., 1999. Harvested forage. San Diego, CA: Academic Press.

Hanif, Z., Ali, H.H., Rasool, G., Tanveer, A. and Chauhan, B.S., 2018. Genus Salsola: Its Benefits, Uses, Environmental Perspectives and Future Aspects- A Review. Journal of Rangeland Science, 8 (3):315 -328.

Holechek, J.L., Pieper, R.D., Herbel, C.H., 2005. Range management principles and practices, Prentice Hall, Englewood Cliff, 587P.

Jafari, M. (1994) Salt tolerance of some rangeland grasses of Iran. Institute of Forests & Rangelands, pp 54-90. in Persian.

Kashki, M.T., Zandi Esfahan, E., Mohammadi, M., Ranjbar, M. 2016. Effects of growth stages on forage quality of specific halophytes (*Limonium iranicum* and *Reaumuria fruticosa*) in the Bajestan desert of Korasan province, Iran. European Online Journal of Natural and Social Sciences 5(3): 787-794.

Kazemi, M., Valizadeh, R., 2019. Nutritive value of some rangeland plants compared to *Medicago sativa*. Journal of Rangeland Science 9, 136-150.

Linn, J. G. and Martin, N. P., 1999. Forage quality tests and interpretations. The college of Agriculture, food and Environmental Sciences, University of Minnesota, Extension service, USA.

Mcdonald, P., Edvards, R. A., Greenhalgh, J. F. D. and Morgan, C. A., 1995. Animal Nutrition. 5th ed. Longman Scientific & Technical, New York, NY, 597 p.

Niknahad-Gharmakher, H., Jafari Foutami, I., Sharifi, A. 2015. Effects of grazing exclusion on plant productivity and carbon sequestration (Case study: Gomishan rangelands, Golestan province, Iran). Journal of Rangeland Science, 5(2):122-134.

Niknahad-Gharmakher H, Sheidai-Karkaj E, Jafari,I. 2017. Effects of Exclosure on Soil Properties in Winter Rangelands in Golestan Province, Iran. Journal of Rangeland Science **7**(1): 55-66.

Oddy,V.H., Robards, G.E., and Low, S.G. 1983. Prediction of in vivo dry matter digestibility from the fiber and nitrogen content of a feed. Glenfield, New South Wales, Australia: Department of Agriculture, Nutrition and Feeds Evaluation Unit, Veterinary Research Station. p. 395–398.

Panahi, F., Assareh, M., Jafari, M., Jafari, A., Arzani, H., Tavili, A. and Zandi Esfahan, E., 2012. Phenological Effects on Forage Quality of *Salsola arbuscula*, *Salsola orientalis* and *Salsola tomentosa* in Three Habitats in the Central Part of Iran. Middle-East Jour. Scientific Research, 11 (6): 800-807.

Pasandi, M., Hosseini, M.A., Kavian, A. 2017. Forage quality of important halophytes in saline and alkaline rangelands of Golestan province at two phenological stages. Iranian Journal of Range and Desert Research, Vol. 24 No. (3).

Pinkerton, B. 1996. Forage quality. Clemson, SC: Crop and Soil Environment Science Department, College of Agriculture, Forest, and Life Science, Clemson University. 998. p.

Prasad, M. N. V. 2008. Trace Elements as Contaminants and Nutrients: Consequences in Ecosystems and Human Health, John Wiley & Sons, Inc.

Rayburn, E., 2002. Forage management. Sheep symposium, March, 2, 2002, Meadow Landspa.

Schuetz, M., Benske, A., Smith, R.A., Watanabe, Y., Tobimatsu, Y., Ralph, J., Demura, T., Ellis, B., Samuels, A.L. 2014. Laccases direct lignification in the discrete secondary cell wall domains of protoxylem. Plant Physiol. 166:798–807. doi: 10.1104/pp.114.245597.

Squires, V.R., Ayoub, A.T. 1994. Halophytes as a Resource for Livestock and for Rehabilitation of Degraded Lands. Kluwer Academic Publisher, Dordrecht Boston, London, 315 p.

Squires, V.R. 1981. Livestock management in the arid zone. Melbourne, Australia. Inkata press. 269 pp.

Standing Committee on Agriculture (SCA), 1990. Feeding standards for Australian livestock ruminants, CSIRO, Australian.

Torkan, J.1999. Effects of phonological Stages and Ecological Factors on Forage Quality of some Rang Species., MSc thesis. Thehran University.

Van Soest, P. J. (1994) Nutritional Ecology of the Ruminant, 2nd ed. Cornell University Press, Ithaca, NY. 476 p.

Zare, M., Zandi-Esfahan, E., Ghorbani, A. 2019. Forage Quality of *Salsola yazdiana* and *S. tomentosa* in different Growth Stages in Saline Desert of Yazd Province, Iran. Journal of Rangeland Science. 9 (2): 104-113.

کیفیت علوفه *Salsola turcomanica* در منطقه نیمه خشک گمیشان در استان گلستان، ایران

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چکیده. اطلاعات کیفیت علوفه‌ی گیاهان مرتعی به منظور فراهم نمودن رژیم غذایی مناسب برای دام‌های اهلی و تعیین نرخ دامگذاری و ظرفیت چرا مراتع ضروری است. *Salsola turcomanica* یکی از مهمترین گونه‌های گیاهی در مراتع نیمه خشک غرب استان گلستان، ایران است. این پژوهش در تابستان و پاییز ۱۳۹۸، به منظور بررسی ارزش غذایی *Salsola turcomanica* در مراحل مختلف رویشی آن انجام گردید. نمونه‌های گیاهی (در سه تکرار) به صورت تصادفی در چهار مرحله رویشی (رشد رویشی، اوایل گلدهی، اوخر گلدهی و بذردهی) از مراتع شهرستان گمیشان جمع‌آوری شدند. هفت شاخص کیفی شامل: الیاف نامحلول در شوینده اسیدی، پروتِین خام، هضم‌پذیری ماده خشک، انرژی متابولیسمی، مجموع مواد غذایی قابل هضم و خاکستر کل در هر مرحله اندازه‌گیری گردیدند. آنالیز داده‌ها با استفاده از روش تجزیه واریانس یک طرفه و مقایسه میانگین‌ها با استفاده از آزمون دانکن انجام شد. نتایج نشان داد که بین میانگین همه شاخص‌های مطالعه شده در مراحل مختلف فنولوژیکی اختلاف معنی‌داری وجود دارد (P<۰/۰۱). نتایج نشانگر آن است که با پیشرفت مراحل فنولوژیک، محتوی پروتیین خام (از ۲۵/۶۶ به ۸/۳۳ درصد)، هضم‌پذیری ماده خشک (از ۸۴/۴۵ به ۵۶/۳۱ درصد)، انرژی متابولیسمی (از ۱۲/۳۵ به ۷/۵۷ مگا ژول بر کیلوگرم)، خاکستر (از۴۰/۰۳ به ۳۵/۶ درصد)، انرژی قابل هضم (از ۳۶/۷ به۲۴/۱۲ مگا کالری بر کیلوگرم) و مجموع مواد مغذی قابل هضم (از ۸۲/۵۵ به ۵۳/۴۱ درصد) کاهش یافت. باتوجه به فصل رشد این گونه گیاهی و مقادیر بالای پروتئین خام، انرژی متابولیسمی و هضم‌پذیری ماده خشک آن در تمامی مراحل مطالعه شده، نتیجه‌گیری شد که این گونه گیاهی نقش برجسته‌ای در رژیم غذایی دام‌های اهلی چرا کننده از مراتع نیمه خشک دارد. با توجه به فصل رشد این گونه گیاهی و مقادیر بالای پروتئین خام، انرژی متابولیسمی و هضم پذیری ماده خشک در همه مراحل رشدی این گونه گیاهی می‌تواند جایگاه ویژه‌ای در رژیم غذایی دام در مراتع نیمه خشک داشته باشد.

کلمات کلیدی: *Salsola turcomanica*، کیفیت علوفه، مراحل فنولوژیک، مراتع نیمه خشک