Influence of altitude and seasons on forage quality of Prosopis juliflora shrubs

El-Morsy M.H.M., Assiri A.M.A., Osman H.E., Hashemi M.

in

López-Francos A. (ed.), Jouven M. (ed.), Porqueddu C. (ed.), Ben Salem H. (ed.), Keli A. (ed.), Araba A. (ed.), Chentouf M. (ed.).
Efficiency and resilience of forage resources and small ruminant production to cope with global challenges in Mediterranean areas

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 125

2021
pages 531-536

Influence of altitude and seasons on forage quality of *Prosopis juliflora* shrubs

M.H.M. El-Morsy[1,2], A.M.A. Assiri[2], H.E. Osman[3,4] and M. Hashemi[5]

[1]Plant Ecology & Range Management Dept., Desert Research Center, Cairo (Egypt)
[2]Umm Al- Qura University, PB: 7296, Abidiyyah, Makkah 21955 (Saudi Arabia)
[3]Botany and Microbiology Department, Faculty of Science, Al-Azhar University, Cairo (Egypt)
[4]Biology Dept, College of Applied Sciences, Umm Al-Qura Univ., Makkah 21955 (Saudi Arabia)
[5]Stockbridge School of Agriculture, University of Massachusetts, Amherst, 01003 MA (USA)

Abstract. Fodder trees and shrubs in low rainfall areas are considered as an important source of feed adapted to harsh environments and overgrazing. A study was carried out to evaluate the quality indices of *Prosopis juliflora* forage shrub harvested in two growing seasons (spring and autumn 2013-2014) at three locations (Makkah, Jeddah, and Taif) in Kingdom of Saudi Arabia with varied altitudes. Forage harvested in spring had higher crude protein content but low crude fiber. The highest crude protein (CP) was found in forage growing in Taif (14.6%) characterized by high moisture availability and high altitude. In general, the values of ADF and NDF were relatively low and ranged from 26-42%. Forage harvested from Taif, had less NDF and ADF than that harvested from the other two locations. Nitrogen free extract (NFE) which represents the amount of carbohydrates in forage was higher in spring than in autumn. Calcium (Ca), phosphorus (P), potassium (K) and magnesium (Mg), total digestible nutrients (TDN), digestible energy (DE), metabolized energy (ME) and net energy (NE) were not affected by seasons or sites or their interaction?

Keywords. *Prosopis juliflora* – Forage quality – Chemical composition – Seasonal variation – Saudi Arabia.

***Influence de l'altitude et des saisons sur la qualité fourragère des arbustes* Prosopis juliflora**

Résumé. *Les arbres et les arbustes fourragers dans les zones à faible pluviosité sont considérés comme une source d'alimentation importante grâce à leur adaptation aux environnements difficiles et au surpâturage. Une étude a été réalisée pour évaluer la qualité d'arbustes fourragers de* Prosopis juliflora *récoltés à deux saisons de croissance (printemps et automne 2013-2014) dans trois localités d'altitude variable en Arabie saoudite (La Mecque, Djeddah et Taëf). Les fourrages récoltés au printemps ont une teneur élevée en protéines brutes (PB) mais des teneurs faibles en fibres brutes (FB). La plus forte teneur en protéines brutes (PB) a été trouvée dans les fourrages cultivés à Taif (14,6%), un endroit plus humide à altitude élevée. En général, les valeurs d'ADF et de NDF étaient relativement faibles et varient de 26 à 42%. Les fourrages récoltés à Taif, endroit plus humide que Makkah et Jeddah, ont moins de NDF et d'ADF que les fourrages cultivés dans les autres localités. L'extrait sans azote (ESA), qui représente la quantité de glucides dans le fourrage, était plus élevé au printemps qu'en automne. Le calcium (Ca), le phosphore (P), le potassium (K), le magnésium (Mg), les nutriments totaux digestibles (TDN), l'énergie digestible (DE), l'énergie métabolisée (ME) et l'énergie nette (NE) ne sont affectés ni par la saison, ni par la localité ni par leur interaction.*

Mots-clés. Prosopis juliflora – *Qualité fourragère – Composition chimique – Saison – Arabie Saoudite.*

I – Introduction

Kingdom of Saudi Arabia (KSA) (Lat: 32' 34º N – 16' 83º N, long. 34' 36ºE – 56'E) is a vast arid desert with a total area of about 2.25 millions km^2 covering the major part of the Arabian Peninsula. Xerophytic vegetation makes up the prominent features of the plant life in the Kingdom (Zahran, 1982).

Legume fodder trees and shrubs, in the low rainfall areas, especially in arid and hyper arid areas, are adapted to stressful environments which frequently subjected to water shortage, overgrazing, coppicing and rehabilitation of rangelands. In addition, deep-rooted shrubs promote more efficient

water use and year-round ground cover compared with annual crops and pastures and also provide extra shade and shelter for livestock (Harris, 2010; Koech *et al*., 2010). *Prosopis juliflora* (prosopis or mesquite) is a shrub or small tree belonging to Fabaceae family (Leguminosae), and is one of phreatophytes plants, which are supplied with surface water and often have their roots constantly in touch with soil moisture. *Prosopis juliflora* leaves and fruits can be considered as potential source of protein, especially when herbaceous vegetation becomes withered during droughts.

Seasonal forage quality is an important consideration when planning rangelands rehabilitation. Seasonal variations affect the availability of nutrients from the soil to the plant. The nutritional values of forage species are generally low in dry seasons compared with wet season (Onyeonagu and Eze, 2013). Environmental factors such as temperature, precipitation, altitude, etc. may strongly influence forage yield and quality (Kwon *et al*., 2005). Estimates of forage quality constituents, including crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), can be used to predict animals' performance (Jacobs, 2012).

The objective of this study was to investigate the foliage quality (nutritive value) of *Prosopis juliflora* as affected by three growing sites (with different elevations) and two harvesting seasons (spring and autumn) in Kingdom of Saudi Arabia.

II – Materials and methods

Study area, The study was conducted at three selected sites at Kingdom of Saudi Arabia: Holy Makkah (Mecca), located in the south-west of KSA (21° 25' 19'' N, 39° 49' 46'' E) where plant samples were taken from Arafat area at an altitude of f 238m above sea level; Jeddah, located in the west coast of the KSA (21° 32' 36'' N, 39° 10' 22'' E) and plant samples were taken from Jeddah – Makkah road (15 Km from Jeddah) at an elevation of 74 m above sea level and the Taif region, situated in the mountains above Makkah and Jeddah on the eastern slopes of the Al-Sarawat Mountains (21° 26' N, 40° 21' E) and lies south east of Jeddah and Makkah. The plant samples were taken from Al-Hadda -Taif road at an elevation of 1840 m above sea level. The climate of the tested sites is reported in Table 1. Soil samples were collected from the three selected sites at a depth of 0–60 cm. Physical and chemical soil analysis are given in Table 2.

Table 1. Long term climatic data (1980-2015) of Makkah, Jeddah and Taif experimental sites

Site	Avg high temp. (°C)	Avg. low temp. (°C)	Rainfall (mm)	Humidity (%)
Makkah	37.93	24.55	110.1	46.4
Jeddah	33.55	22.98	53.5	62.75
Taif	29.06	15.73	119.0	41.08

Source: National Oceanic and Atmospheric Administration (NOAA), USA.

Table 2. Physical and chemical soil analysis of the experimental sites (Makkah, Jeddah and Taif). (N and P expressed in ppm; anions and cations expressed in mg l^{-1})

Sites	Particle-size distribution (%)				Soil texture
	Coarse Sand (1 - 0.5)	Fine Sand (0.25-0.1)	Silt (0.05-0.002)	Clay (0.002)	
Makkah	46.70	33.85	10.34	9.11	Sandy loam
Jeddah	35.30	60.13	0.90	3.67	Sandy
Taif	12.64	43.42	27.34	16.60	Sandy loam

Sites	pH	N	P	$CaCO_3$	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Makkah	8.30	25.00	10.00	1.00	1.00	0.55	0.27	1.00	0.20	0.42	0.20
Jeddah	8.10	30.00	24.00	2.60	1.60	0.90	0.20	1.60	0.20	0.77	0.13
Taif	7.60	60.00	26.00	0.20	2.60	2.00	2.80	4.60	0.10	2.64	0.16

Plant new growth was collected in autumn (September 2013) and spring (April 2014) in all three sites. Samples were dried in an air oven at 65°C till a constant weight and ground to powder for chemical analysis. Crude protein (CP), crude fiber (CF), ash content (Ash) and ether extract (EE) was determined according to A.O.A.C. (2005). Nitrogen free extract content (NFE) was calculated according to the following equation: NFE (%) = 100 – (Ash% + CP% + CF% + EE% on DM basis)

Potassium (K) and calcium (Ca) were detected by using Flame photometer, while magnesium (Mg) was determined by atomic absorption, and phosphorus (P) by spectrophotometer. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined using the procedure described by Goering and Van Soest (1970). Total digestible nutrients (TDN) were estimated by following equation (Abou El-Naga and El-Shazly, 1971): TDN (% DM) = 0.623 (100 +1.25 EE) - 0.72 CP, where EE is ether extract (%) and CP is crude protein (%).

Gross energy (GE) was calculated by following equation (NRS, 1984): GE (kcal 100 g_{-1}) = 5.72 CP% + 9.5 EE% +4.79 CF% +4.03 NFE%. Digestible energy (DE) was calculated by the equation (NRS, 1984): DE (Mcal kg^{-1}) = 0.0504 CP% + 0.077 EE% + 0.02 CF% + 0.000377 (NFE) ^{2} + 0.011 NFE% - 0.152. Metabolized energy (ME) was calculated by the equation of Garrett (1980): ME (Mcal kg^{-1}) = 0.82 DE. Net energy (NE) was calculated as following: NE (Mcal kg^{-1}) = 0.5 × ME (Le Houerou, 1980).

Statistical Analysis: The experimental design was a randomized complete block in a split plot arrangement. The mean separation among treatment means for locations and seasons was obtained by using the Least Significant Difference (LSD) test (Steel and Torrie, 1980). Effects were considered in all statistical calculations for p-values <0.05.

III – Results and discussion

The variation in nutritional quality of *Prosopis juliflora* between autumn and spring seasons in the three studied sites are presented in Tables 3 and 4. The results indicated that the nutritive values of *P. juliflora* plants were influenced by seasons and sites variation.

Dry matter (DM) content varied among the three locations and was highest in Makkah (22.43%). *P. juliflora* had higher DM content in autumn season than in spring season. The higher percentage of dry matter in Makkah and Jeddah compared to that in Taif should be attributed to the lower precipitations and the higher temperatures in these two sites.

In the present study, the crude protein of *P. juliflora* shrubs was significantly influenced (P<0.05) by seasonality. Lower CP was found in autumn harvest (12.10 %) than in spring one (14.56 %) (Table 3). This was mainly due to wetter conditions in spring compared with those in autumn (Table 1). On average, *P. juliflora* shrubs contained more protein (14.61%) at Taif site followed by Jeddah (13.12 %) and Makkah sites (12.26 %). The variation in the nutritive value of *P. juliflora* shrubs might also be attributed to the site potential in terms of edaphic factors and temperature conditions. The interaction season x site effect for CP was significant (Table 3). It has been shown that higher temperatures accelerate the conversion of photosyntates into structural compounds. Results obtained in current study are in agreement with those of Singh and Todaria (2012) who reported that nitrogen concentration in *Quercus serrata* foliage plants increased with the altitudinal gradient where maximum level of crude protein was found in spring season. Ball *et al*., (2001) also concluded that many forage species tend to have lower quality when grown in warm regions than in cool area. The present findings are also in agreement with those of Akin *et al*., (1987) and Sebetha *et al*., (2015).

Ash content was affected by both season and site; however, plants harvested in fall season had over 16% more ash than plants harvested in spring. Plants in Taif and Jeddah sites had roughly 20% less ash than those harvested from Makkah site. According to Kituku *et al*., (1993), ash content of for-

age crops changes with seasonal variations. Crude fiber (CF) was significantly affected by both season and site ($P<0.05$). As expected, lower CF content of *P. juliflora* shrubs was recorded during spring, (37.01%) compared to that recorded in autumn (40.89%). Moreover, CF content of *P. juliflora* plants grown was higher in Makkah (41.59%) than in Jeddah and Taif (39.53 and 35.73%, respectively) and this may be due to the hotter and dryer weather conditions of the two latest sites. Similarly, The highest CF (43.39%) and lowest one (33.72%) was obtained from plants grown in Makkah and Taif in autumn and spring, respectively. An opposite relationship between crude fiber and crude protein was also detected (Table 3). Similarly, El-Morsy (2009) reported that crude fiber content of domestic plants growing in Egyptian desert was lower in spring than in autumn.

Table 3. Effect of season, site and their interaction on dry matter (DM), crude protein (CP), ash, crude fiber (CF), ether extract (EE), nitrogen free extract (NFE), acid detergent fiber (ADF), neutral detergent fiber (NDF) and lignin of *P. juliflora.* Means are averaged over two growing seasons (autumn and spring) and five replications

Treatment/parameters		DM %	CP %	ASH %	CF%	EE%	NFE%	ADF%	NDF%	Lignin %
					Season					
Autumn		22.19	12.10	11.29	40.89	2.93	32.79	26.34	37.95	9.28
Spring		20.77	14.56	9.46	37.01	2.98	35.99	36.46	39.44	9.51
$L.S.D._{0.05}$		0.33	0.71	1.20	0.75	NS	0.84	1.45	1.14	0.18
					Site					
Makkah		22.46	12.26	9.43	41.59	2.71	34.01	34.45	35.72	9.54
Jeddah		21.73	13.12	9.85	39.53	2.85	34.65	31.32	39.10	9.74
Taif		20.25	14.61	11.86	35.73	3.29	34.51	28.43	41.27	8.90
$L.S.D._{(0.05)}$		0.89	0.87	1.86	0.69	0.16	NS	1.98	1.72	0.61
					Season × site					
Autumn	Makkah	23.45	11.12	9.17	43.38	2.65	33.68	29.15	39.11	9.36
	Jeddah	22.58	12.05	9.59	41.56	2.85	33.95	26.80	36.36	9.04
	Taif	20.53	12.99	9.64	37.73	3.28	36.36	23.08	38.39	9.44
Spring	Makkah	21.46	13.40	9.69	39.80	2.78	34.33	39.76	32.33	9.72
	Jeddah	20.88	14.05	10.12	37.50	2.85	35.48	35.84	41.84	10.45
	Taif	19.97	16.23	14.08	33.72	3.30	32.67	33.79	44.14	8.36
$L.S.D._{(0.05)}$	NS	1.14	2.80	0.94	0.23	1.72	NS	NS	1.21	

NS: not significant, $L.S.D._{0.05}$= least significant difference at 5% level.

There was no significant effect of season on ether extract (EE) content of *P. juliflora*. However, plants grown in Taif had similar EE content (13%) that those in the two other locations (Table 3). These results are in agreement with those of Nasrullah (2004) who reported a significant effect of altitude and altitude × season interaction on ether extract.

Nitrogen free extract (NFE) was higher in spring than in autumn. This may be due to the higher moisture availability in the soil, which increases nutrient uptake by plants in spring. No significant difference in NEF was detected between the three locations. Similar result was reported by Singh and Todaria (2012) on *Quercus serrata* foliage plants while different results was reported by Kim *et al*. (2006) on oat varieties forage where ADF and NDF values were significantly higher in spring than in autumn.

The lignin content is generally considered as an anti-quality component in forage plants since it affects the nutritional availability (digestibility) of plant fiber. Overall lignin content ranged from 8.36 to 9.72% with a mean of 9.4%. The highest lignin content was detected at Makkah site in spring season compared to that in Taif site (8.36%) in the same season (Table 3).

Acid detergent fiber (ADF) and Neutral detergent fiber (NDF) were significantly differents among growing seasons and the locations (Table 3). The ADF and NDF values were significantly higher (P<0.05) in spring than in autumn. This could be attributed to the flowering stage of *P. juliflora* shrubs which begins roughly in late February-March in the studied locations. Also more moisture availability in spring leads to the production of plant cells with thinner cell wall (Singh and Todaria, 2012).

Calcium (Ca), Phosphorus (P), Potassium (K) and Magnesium (Mg) contents in *P. juliflora* were higher in autumn season. Similarly, no significant effect of sites was observed on Ca, P, K and Mg contents in *P. juliflora* (Table 4). It is worth to note that soil of the studied locations is considered unfertile. According to Nasrullah *et al.*, (2004), the desert areas where they conducted their research works were poor in nutrients and mineral contents of forage plants were generally lower in rainy seasons where the leaching of minerals from the soil is higher.

Table 4. Effect of season, site and their interaction on Calcium (Ca %), Phosphorus (P %), Potassium (K %),Magnesium (Mg%), total digestible nutrients (TDN %), digestible energy (DE %), metabolized energy (ME %), net energy (NE MJkg^{-1}) and gross energy (GE Mcal kg^{-1}) of *P. juliflora* shrubs. Means are averaged over two growing seasons (autumn and spring) and five replications

Treatment/parameters		CA	P	K	Mg	TDN	DE	ME	NE	GE
						Season				
Autumn		4.21	0.20	2.67	0.69	55.87	2.27	1.86	0.93	425.05
Spring		3.01	0.17	2.13	0.52	54.14	2.44	2.00	1.00	433.91
L.S.D.$_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	6.13
						Location				
Makkah		3.90	0.22	2.18	0.61	55.58	2.32	1.90	0.95	432.15
Jeddah		3.51	0.18	2.45	0.55	55.07	2.35	1.93	0.96	431.11
Taif		3.40	0.22	2.59	0.64	54.34	2.38	1.95	0.98	425.05
L.S.D.$_{(0.05)}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
						Season × Location				
Autumn	Makkah	4.20	0.29	2.68	0.68	55.69	2.28	1.87	0.85	432.30
	Jeddah	4.21	0.15	2.58	0.67	55.17	2.31	1.90	0.95	431.89
	Taif	4.20	0.17	2.80	0.71	55.21	2.41	1.97	0.99	432.72
Spring	Makkah	3.60	0.15	2.22	0.53	54.35	2.36	1.93	0.97	432.05
	Jeddah	2.84	0.21	1.79	0.43	52.83	2.39	1.96	0.98	430.05
	Taif	2.59	0.17	2.39	0.59	53.18	2.36	1.93	0.97	417.36
L.S.D.$_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	

NS = Not Significant; L.S.D.$_{0.05}$= least significant difference at 5% level.

Total digestible nutrients percentage (TDN %) estimates the feed energy available to the animal after digestion; it was not significantly influenced by either location or season and remained unchanged (Table 5). It ranged between 53 % at Jeddah and 56% at Makkah in spring. Similarly, no significant differences between the treatments and/or their interaction were detected for digestible energy (DE), metabolized energy (ME), net energy (NE MJkg^{-1}), and gross energy (GE Mcal kg^{-1}) (Table 4).

IV – Conclusion

The availability of feed in desert areas due to scarcity of water is a biggest challenge to the agriculture. Local fodder trees and shrubs in these areas are considered as important source of feed. In this study, the performance of *Prosopis juliflora* in two harvest seasons in three locations was evaluated. It was concluded that *P. juliflora* can be considered as acceptable forage with relatively

high crude protein and low crude fiber at higher elevation and wetter conditions. Furthermore, in spring season, the forage quality is relatively superior.

References

Abou El-Naga, M.A. and El-Shazly, K., 1971. *The prediction of nutritive value of animal feeds from chemical analysis*. J. Agri. Sci. 77, 25-37.

Akin, D.E., Fales S.L., Rigsby L.L. and Snook, M.E., 1987. *Temperature effects on leaf anatomy, phenolic acids, and tissue digestibility in tall fescue*. J. Agron. 79, 271-275.

Association of Official Analytical Chemists (A.O.A.C.), 2005. Association of official analytical chemists, official methods of analysis, 18Th ed., Washington, U.S.A.

Ball, D.M., M.Collins, G.D., Lacefield, N.P., Martin, D.A., Mert ens, K.E., Olson, D.H., Putnam, D.J., Undersander, and Wolf, M.W., 2001. Understanding forage quality. American farm bureau federation publication 1-01, Park Ridge, IL.

El-Morsy, M.H.M., 2009. Influence of cutting height and plant spacing on Sesbania (Sesbania aegyptiaca [Poir]) productivity under hyper-arid conditions in El-kharga Oasis, El-Wadi El-Gaded, Egypt. Int. J. Plant Prod. 3 (2), 77-84.

Garrett, W.N., 1980. Factors influencing energetic efficiency of beef production. *Journal of Animal Science*, 51, 1434-1440.

Goering, H.K. and Van Soest, P.J., 1970. Forage Fiber Analysis (apparatus, reagents, procedures and some applications). *USDA Agricultural Handbook* No. 379.

Harris, R., Emms, J., Nalder, K., Beloy, J., Davies, C. and Brady, M., 2010. Forage shrubs for alternative grazing systems. BCG 2010 season research results: part A. p. 188-193. Harris, R. (2010). *A profitable and sustainable feed source*. The Mallee Farmer, 1, 20-21.

Jacobs, J., 2012. Seasonal forage quality of five tame pasture grasses on dryland pastures in Montana. United States Department of Agriculture Natural Resources Onservation Services. *Plant Materials Technical Note* No. MT-81 September 2012.

Jahanzad, E., Jorat, M., Moghadam, M., Sadeghpour, A., Chaichi, M.R. and Dashtaki, M., 2013. Response of a new and a commonly grown forage sorghum cultivar to limited irrigation and planting density. *Agr. Water Manage*. 117, 62-69.

Kim, J.D., Kwon, C.H., Shin, C.N., Kim, C.H. and Kim, D.A., 2006. Effect of location, year and variety on forage yield and quality of winter rye. Asian-Aust. *J. Anim. Sci*. 18, 997-1002.

Kituku, V.M., Powell, J. and Olson, R.A., 1993. Restoring shrub quality in a sagebrush-bitterbrush vegetation type of South-Central Wyoming. Wild Land Shrub and Arid Land Restoration Symposium: Proceedings. Ed. Bruce A. Roundy, E. Durant McArthur, Jennifer S. Hayley, David K. Mann. 229-234.

Koech, O.K., Kinuthia, R.N., Wahome R.G. and Choge, S.K., 2010. Effects of *Prosopis juliflora* seedpod meal supplement on weight gain of weaner Galla goats in Kenya. *Res. J. Anim. Sci.* 4, 58-62.

Kwon, C.N., Shin, C., Kim, H. and Kim, D.A., 2005. Effect of location, year and variety on forage yield and quality of winter rye. Asian-Aust. *J. Anim. Sci.* 18, 997-1002.

Le Houérou, H.N., 1980. Chemical composition and nutritive value of browse in tropical West Africa. In: Browse in Africa, the current state of knowledge. H. N. Le Houérou (ed.), ILCA, Addis Ababa, Ethiopia, 261-289.

Nasrullah, Niimi, M., Akashi, R. and Kawamura, O., 2004. Nutritive evaluation of forage plants grown in South Sulawesi, Indonesia. II. Mineral Composition. Asian-Aust. *J. Anim. Sci*. 17, 63-67.

NRS/Nutrient Requirements of Sheep. 1984. National Research Council. National Academy Press, Washington, DC.

Onyeonagu, C.C. and Eze, S.M., 2013. Proximate compositions of some forage grasses and legumes as influenced by season of harvest. *African Journal of Agricultural Research*. 8, 4033-4037.

Sebetha, E.T., Modi, A.T. and Owoeye, L.G., 2015. Cowpea crude protein as affected by cropping system, *Site and Nitrogen Fertilization Journal of Agricultural Science*. 7, 224-234.

Singh, B. and Todaria N.P., 2012. Nutrients composition changes in leaves of *Quercus semecarpifolia* at different seasons and altitudes. *Ann. For. Res.* 55, 189-196.

Steel, R.G.D. and Torrie, J.H., 1980. Principles and procedures of statistics. *A biometric approach*. McGraw-Hill, New York, NY.

Zahran, M., 1982. Vegetation types of Saudi Arabia. King Abdel Aziz University press, Jeddah, (Saudi Arabia).