Iran J Sci Technol Trans Sci (2017) 41:301–305
DOI 10.1007/s40995-016-0032-9

RESEARCH PAPER

Effect of Phenological Stages on Chemical Composition of *Platychaete aucheri* Boiss. as an Important Endemic Shrub in Iran

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Received: 4 July 2014 / Accepted: 21 October 2014 / Published online: 3 June 2016

Abstract *Platychaete aucheri* Boiss. is a native long-lived, perennial shrub adapted to the arid regions of southern Iran. The objective of this study was to evaluate the nutritive composition of the endemic forage species, *P. aucheri* Boiss., in arid communal grazing area of southern Iran. Aerial parts of plants were harvested at three vegetation stages (prebud, flowering, and maturity) in the natural habitats of Jahrom area. The chemical analysis included were crude protein (CP), ash, metabolizable energy (ME), dry matter digestibility (DMD), neutral detergent fiber (NDF), and acid detergent fiber (ADF). Growth season had a significant effect on the forage quality of *P. aucheri* Boiss. The foliage CP content and ME value ranged from 3.56 to 4.56 % and from 6.11 to 8.07 MJ kg^{-1}, respectively. The DMD and CP declined when plant matured. Phenological stage indicated a significant effect on NDF and ADF values, increasing from flowering to maturity stage. The highest crude protein content was 4.56 %, and it would be concluded that this plant alone could not meet nutritional requirements of grazing animals. In general, the best grazing time is in the flowering stage when the forage has higher nutritive composition.

Keywords *Platychaete aucheri* Boiss. · Forage quality · Arid rangelands · Iran

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1 Introduction

Forage quality has described the degree to which forage meets the nutritional requirements of a specific kind and class of animal (Allen and Segarra 2001). Owensby et al. (1999) stated that matching forage quality with nutritional needs of grazing animals influence management and utilization of rangelands. On the other hand, livestock production is dependent on nutritive value of forage grown naturally in rangelands. Rangelands are the major source of animal feed, fuel, and medicinal herbs in many countries, including arid and semi-arid areas (Gintzburger et al. 2003; Larbi et al. 2011; Safari et al. 2011). The utilization of browse plants as fodder for grazing animals is becoming important in many rangelands of the world (Kamalak 2006). The rangelands of Iran support diverse and dynamic goods and services, including the traditional grazing of livestock (Mesdaghi 2008).

Browse plants have a major role in providing feed for livestock (Tolera et al. 1997), soil conservation, and fuel resource in arid rangelands of Iran (Mesdaghi 2008; Ghanbarian and Khorrami 2005). Then, Browse fodder is a potentially inexpensive locally produced protein supplement for ruminant, particularly during the critical periods of the years when the quality and quantity of herbage are limited (Salem et al. 2006). Most browse species have the advantage of maintaining their greenness and nutritive value through the dry season when grasses and forbs dry up and deterioration occurs both in quality and quantity (Tolera et al. 1997). Understanding of nutritional variation of forage plants will help the rangeland managers in achieving the best grazing period, predicting nutrient deficiencies and estimation of supplementation needs of grazing livestock (Arzani et al. 2006).

Phytochemicals composition and season of growth influence the digestibility of rangeland forage plants (Arzani et al. 2006). Seasonal variation determines the quality and quantity of forages (Kassilly 2002), and quality varies over the growing season declining with forages maturity (Licitra et al. 1997). Nutritive values were significantly different, both, and among plant parts, and phenological stages for each species (Arzani et al. 2004). Maturity had a significant effect on the chemical composition, and NDF and ADF contents increased with increasing maturity, whereas the crude protein and dry matter decreased (Kamalak 2006).

Platychaete aucheri Boiss. is an endemic perennial browse plant, widespread in arid parts of southern Iran phytogeographically called Sahara-Sindian region (Zarrin et al. 2010). This native species grow to a height of 0.5 m, leaves oblong-lanceolate with distinct midrib, flowering branches deeply forked. The plant heads heterogamous, radiate, or disciform, solitaring on the tips of branches. Involucres imbricate in many rows. Florets yellow; ray-florets in one row pistillate, with narrow ligules, three dentate, disciflorets hermaphrodites, tubular, 5-dentale with flowering period in late spring and early summer. Javidnia et al. (2008) reported essential oil constitutes and chemical composition of leaves and juvenile twigs of *P. aucheri* Boiss. as a fragrance plant. Karimi et al. (2007) introduces *P.aucheri* Boiss. as an attractive shrub plant for honeybee. Some local remedies of plant leaves and stems have been documented (Yazdanpanah 2011). The average biomass yield of this plant had been reported from 3800- to 5300-kg dry matter (DM) per hectare depending on plant density and habitat condition (Yazdanpanah 2011).

There were limited studies conducted to assess the nutritional quality of aerial parts of this multipurpose species in Iran. This study was, therefore, carried out to evaluate the effect of season and phenological stages on nutritive value of *P.aucheri* Boiss. as an endemic grown shrub in southern parts of Fars, Iran.

2 Methods and Materials

2.1 Study Site

Browse leaves and twigs of *P. aucheri* Boiss. were collected in Jahrom area (52°41′N–38°57′E) located in 240 km southeast of Shiraz. The area has a mean annual rainfall and temperature of 285.4 mm and 20.5 °C, respectively (Ghanbarian and Khorrami 2005; Yazdanpanah 2011). The altitude of study site ranges between 1105 and 1120 above sea level. The vegetation type is arid open woodlands of *Ziziphus spina-christi* in lowlands, accompanying short shrubs and annual grass and forb with a sandy loam soil. Common plant formation, in the study area, includes xerophylic plants, such as *Platychaete aucheri*, *Artemisia sieberi*, *Gymnocarpus decander*, *Platychaete mucronifloia*, *Convolvulus acanthocladus*, *Anvillea garcini*, *Helianthemum lippii*, *Fagonia acerosa*, *Capparis cartilaginea*, *Stipa capensis*, *Hyparrhenia hirta*, *Cymbopogon olivieri*, *Cenchrus ciliaris*, *Poa bulbosa*, *Onobrychis crista-galli*, *Scabiosa persica*, *Salvia macrosiphon*, *Medicago rigidula*, and *M. orbicularis*.

2.2 Forage Sampling

Leaves and edible twigs of juvenile stems of *P. aucheri* Boiss. were collected in three phenological stages (prebud, flowering, and plant matured). Plant parts were hand-harvested from ten different individual plants, oven dried at 60 °C for 48 h and weighted. The samples were ground to pass a 1-mm sieve for the chemical analysis.

2.3 Chemical Analysis

Nitrogen (N) was determined on the basis of Kjeldahl technique, crude protein (CP) was calculated as $CP = N\% \times 6.25$ (Jones 1981). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed by the method of AOAC (2000). Dry matter digestibility (DMD) was estimated using the formula of $DMD\% = 83.58 - 0.824\ ADF\% + 2.626N\%$, suggested by Oddy et al. (1983) and Arzani et al. (2006). Metabolizable energy (ME) was calculated with the equation of $ME = 0.17\ DMD\% - 2$ reported by AOAC (2000).

2.4 Statistical Analysis

Analysis of variance procedure was applied to determine the existence of differences in forage quality indices (CP, ADF, NDF, DMD, and ME) of different phenological stages. Correlation analysis procedure was used between CP and DMD, ADF, NDF, DMD, and ME using MINITAB ver.16.0 statistical package (Ryan et al. 2012).

3 Results and Discussion

3.1 Chemical Analysis

3.1.1 Crude Protein

The CP value differed among three phenological stages ($P < 0.05$). The highest CP content was in prebud (4.56 %) and lowest (3.56 %) for matured plant stage, respectively (Fig. 1). Holechek et al. (2011) reported considerable variation of forage quality among seasons. They concluded that the CP content has the highest level in vegetative stage

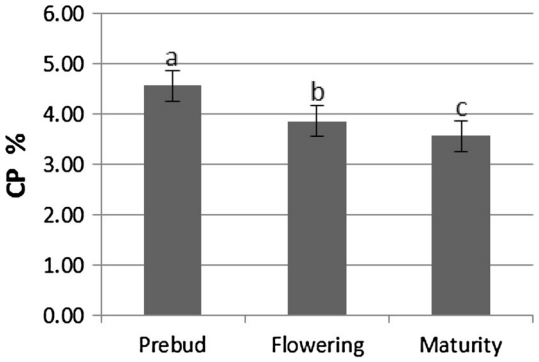

Fig. 1 Variation in CP: crude protein. The differences between the columns with different letters are statistically significant at $P < 0.05$

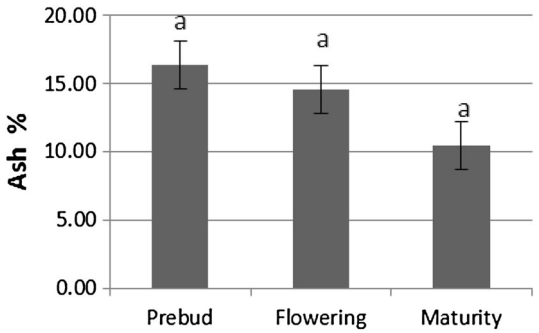

Fig. 2 Variation in Ash. The differences between the columns with different letters are statistically significant at $P < 0.05$

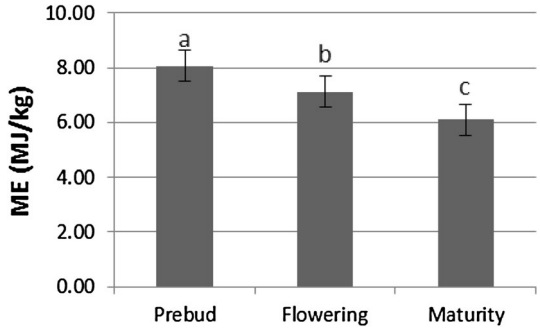

Fig. 3 Variation in ME: metabolizable energy. The differences between the columns with different letters are statistically significant at $P < 0.05$

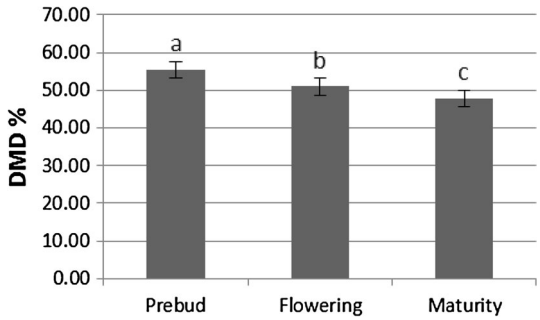

Fig. 4 Variation in DMD: dry matter digestibility. The differences between the columns with different letters are statistically significant at $P < 0.05$

and decreases during the dormancy. According to Alldredge et al. (2002), CP content of shrub plants is higher in early growth season than seed production stage. Our study results are in agreement with Arzani et al. (2006), Khedri et al. (2008), and Kamalak (2006).

3.1.2 Ash

There was no significant difference in ash content of three stages (Fig. 2). Arzani (2009) reported that variations of ash contents of many forage plants are not significant during different seasons.

3.1.3 Metabolizable Energy

Significant differences were obtained between ME of *P.aucheri* Boiss. in maturity and two other growth stages ($P < 0.05$; Fig. 3). Metabolizable energy ranged from 6.11 to 8.07 MJ kg^{-1}. Prebud stage had the highest, while maturity stage had the lowest ME value. Forage requirements of free-grazing animals could be obtained based on ME content of forage plants. Asadi and Khoshnood (2011) reported that ME of forage plants varied among different seasons and showed depletion of ME content when plants matured. Understanding of ME could help estimation of energy deficiency of livestock-feeding forages.

3.1.4 Dry Matter Digestibility

Dry matter digestibility (DMD) of *P.auchri* Boiss. showed declining rate when increasing maturity (Fig. 4). Highest DMD value was recorded for the first (prebud) stage, whereas lowest DMD was found for the third (maturity) stage. A significant difference was obtained among three phenological stages ($P < 0.05$). This agrees with findings reported by Baghestani et al. (2004), Asadi and Khoshnood (2011), and Kamalak (2006). On the other hand, declining of forage shrub digestibility is slower than annual forbs and grasses due to longer growing period (Arzani et al. 2006; Vallentine 1990). Similar to studies conducted by Kamalak (2006), Khedri et al. (2008), and Baghestani et al. (2004) with increasing maturity, the crude protein and dry matter digestibility decreased.

3.1.5 Neutral Detergent Fiber

Neutral detergent fiber (NDF) content was statistically significant ($P < 0.05$) between prebud/flowering and

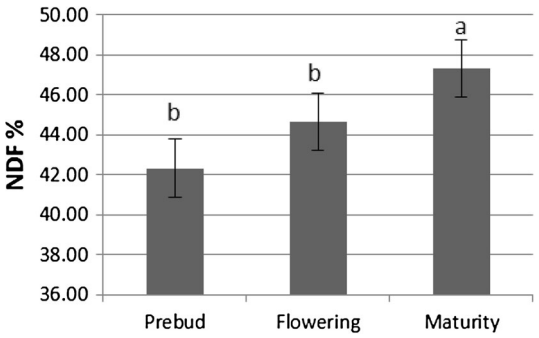

Fig. 5 Variation in NDF: neutral detergent fiber. The differences between the columns with different letters are statistically significant at $P < 0.05$

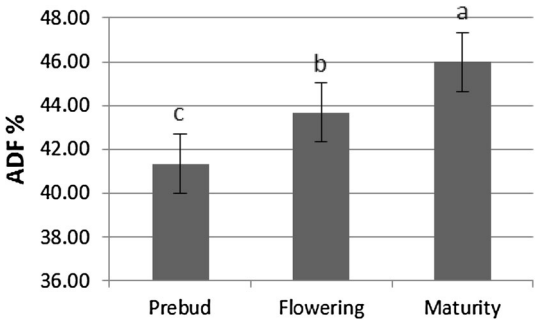

Fig. 6 Variation in ADF: acid detergent fiber. The differences between the columns with different letters are statistically significant at $P < 0.05$

maturity stages, varied between 42.33 and 47.34 % in prebud and maturity stages, respectively (Fig. 5). Shinde et al. (2000) reported a significant difference of ADF content among phenological stages. They concluded that spatial and temporal variations would affect forage quality.

3.1.6 Acid Detergent Fiber

The results of acid detergent fiber (ADF) measurements showed an increase with growth stage completion. ADF value in the first stage was the lowest (41.33 %) and the highest (46.0 %) in the third stage, respectively. ADF was statistically significant ($P < 0.05$) between three phenological stages (Fig. 6). This agrees with findings reported by several authors (Arzani et al. 2006; Baghestani et al. 2004 and Salem et al. 2006).

3.1.7 Correlation Coefficient

The correlation coefficient (r) of the relationship among chemical contents was shown in Table 1. CP showed high positive correlation with DMD ($r = 0.93$) and ME ($r = 0.87$), respectively. This result is in agreement with findings of Arzani et al. (2004, 2006) and Tefera et al. (2008). CP value also had a negative significant correlation with ADF ($r = -0.90$) and NDF ($r = -84$), respectively. Kamalak (2006) showed a strong negative correlation between CP content and ADF ($r = -0.937$), and NDF ($r = -0.963$), respectively. On the other hand, ME was strongly correlated ($r = 0.92$) with DMD. Arzani et al. (2006) reported that due to positive relationship between DMD and ME, higher DMD means higher ME content.

Table 1 Correlation coefficient of the relationship among chemical constitutes of *P.aucheri* Boiss.

	CP	ME	DMD	ADF	NDF
ME	0.87**				
DMD	0.93***	0.92***			
ADF	−0.90***	−0.91***	−0.98***		
NDF	−0.84**	−0.82**	−0.86**	0.87**	
Ash	0.64^{NS}	0.52^{NS}	0.65^{NS}	-0.66^{NS}	-0.43^{NS}

CP crude protein, *ME* metabolizable energy, *DMD* dry matter digestibility, *ADF* acid detergent fiber, *NDF* neutral detergent fiber, *NS* non-significant ($P > 0.05$)

** $P < 0.01$

*** $P < 0.001$

Therefore, it is important to be certain for correct estimation of DMD percentage. Ash content had no correlation with the other forage quality parameters. In general, as the plant matured, the value of fiber, ADF and NDF increased and CP and DMD, and then, ME decreased. Therefore, there is a reciprocal relationship between protein and fiber content of a plant species (McDonald et al. 1995; Arzani et al. 2006).

4 Conclusion

Since rangeland ecosystems are located in arid and semi-arid areas, precipitation is the most important factor that controls plant production in these ecosystems (Koc 2001). The chemical analysis of rangeland forage plants serves as a comparative measure of differences between species and changes with season and phenology (Arzani et al. 2006). The results of this study showed a declining trend of crude protein, dry matter digestibility, and metabolizable energy from vegetative to seed production stages. Then, harvesting stage is an important factor affecting nutritive value of *P. aucheri* Boiss. in arid regions of south Iran. This native plant plays an important role in feeding the livestock of nomads in critical periods but alone could not meet the nutritional needs of grazing animals. Crude protein and dry matter digestibility were negatively affected while plant matured. Decision of proper grazing period is very important when the high forage quality parameters from prebud to flowering and maturity stages are offered.

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