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Seasonal variation of the nutritive value of fourwing saltbush (*Atriplex canescens*)

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Abstract. The objective of this study was to evaluate the effect of season (winter, spring and summer) on the nutritive value of *Atriplex canescens*. The foliage of this shrub species was shade dried and analyzed for chemical composition. Gas and methane production were determined at 24 h incubation time. Season of sampling affected (P<0.05) the chemical composition, gas production, methane production, metabolizable energy and *in vitro* dry matter digestibility. The CP content was lower (P<0.05) in spring (168 g/kg DM) and summer (171 g/kg DM) versus winter (201 g/kg DM). In winter and spring, *Atrilplex canescens* had higher (P<0.05) NDF, ADF, ADL contents than in summer. In all seasons, condensed tannins and EE content were generally low, whereas the ash content was extremely high (P<0.05) with (243.8 g/kg DM) in spring and (197.3 g/kg DM) in winter. The gas and methane production at 24 h incubation ranged from 47 to 67.66 ml and 4.67 to 8.70 ml respectively and decreased (P<0.05) in spring season. It is concluded that season had a significant effect on the nutritive value of *Atriplex canescens*; which is low in spring and relatively high in summer and winter.

Keywords. *Atriplex canescens* – *In vitro* fermentation – Methane production – Nutritive value.

***Variation saisonière de la valeur nutritive d'*Atriplex canescens**

Résumé. *L'objectif de cette étude était d'évaluer l'effet de la saison sur la valeur nutritive d'*Atriplex canescens *prélevé pendant trois saisons (hiver, printemps et été). La saison de prélèvement avait un effet significatif (P<0,05) sur la composition chimique, la production de gaz et de méthane, l'énergie métabolisable et la digestibilité* in vitro *de la matière sèche. La teneur en protéine brutes était inférieure (P<0,05) au printemps (168 g / kg MS) et en été (171 g / kg MS) par rapport à l'hiver (200,89 g / kg MS). En hiver et au printemps, l'*Atrilplex canescens *avait des teneurs plus élevées (P<0,05) en NDF, ADF, et ADL qu'en été. La production de gaz et de méthane à 24 h d'incubation varie de 47 à 67,66 ml et de 4,67 à 8,70 ml, respectivement, et a chuté (P<0,05) au cours du printemps. En conclusion, la saison a un effet significatif sur la valeur nutritive d'*Atrilplex canescens *qui est faible au printemps et relativement élevée en été et en hiver.*

Mots-clés. Atriplex canescens – *Fermentation* in vitro – *Production de méthane – Valeur nutritive.*

I – Introduction

In Algeria, the steppes cover more than 20 million hectares, harbor a human population estimated at 7.2 million, and are grazed by 15 million sheep annually (data from the Algerian Ministry for Agriculture and Rural development, 2009) (Amghar *et al*., 2012). The establishment of farms and the associated increase in the size of the livestock flock have contributed to overgrazing and deterioration of these areas (Aidoud, 1994; Slimani *et al*., 2010). Land degradation and desertification are among the most serious challenges facing the sustainable development of society and human well-being. Drought tolerant plants are widely used in desertification control and degraded land recovery. Four-wing saltbush (*Atriplex canescens*), a C4 shrub native to North America and characterised by its drought and cold tolerance, was introduced for rangeland rehabilitation. The expectation was that *Atriplex canescens* could provide food for livestock during the long dry season (Aouissat *et al*., 2009; Guangyou, 2011; Nedjimi, 2014). However, there is limited information on the nutritive value of this shrub in such environmental conditions.

Plant development is the major factor affecting forage quality. Forage quality generally decreases as plants change from the vegetative stage to the reproductive stage. Our study was undertaken to follow the evolution in the chemical composition, *in vitro* digestibility and gas production of saltbush four-wing (*Atriplex canescens*) through its vegetative cycle.

II – Material and methods

The study was carried out during 2009 in a medium-sized shrub-grassland between El Maader and Bousaada district located in the north central Algeria (N35° 26' 07,9''; E004°20'52,8''), at an altitude of about 398 m above sea. The area is an arid high plateau with steppe like plains and extensive barren soils. It has a continental climate with hot dry summers and very cold winters, with irregular rainfall of between 100 and 250 mm/ year. Under these environmental conditions, the plant species studied show a slow vegetative growth and phenological development throughout most of the year, often lagged in response to the infrequent major rainfalls.

Representative samples from the aerial parts of plants were randomly harvested along a 2 Km transect during mid-January (winter), mid-May (spring) and the end of July (summer) 2009. Leaves, thin twigs (young stem) and some flower and seeds (when existing) were clipped with scissors from the aerial part of the plants, and taken immediately to the laboratory where the samples from different specimens were pooled, oven dried at 50°C (Makkar, 2003), and subsequently ground to a 1 mm screen.

Ash (method ID 942.05), ether extract (EE, method ID 7.045) and crude protein by Kjeldhal (CP, method ID 984.13) in samples were determined by the procedures of the Association of Official Analytical Chemists (AOAC, 2005). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) contents were analysed following the methodology described by (Van Soest *et al*., 1991) using an ANKOM Model 220 Fibre Analyser (Macedon, NY, USA).

Batch cultures of mixed rumen micro-organisms were used to study the ruminal fermentation, gas and methane production. The experimental procedure was based on Theodorou *et al*. (1994) protocol with some modifications. Three identical 48 h incubation runs were carried out in three consecutive weeks. Rumen content from each sheep was obtained before the morning feeding, immediately transported to the laboratory into thermal bottles, mixed and strained through four layers of cheesecloth into a warmed Erlenmeyer flask with an O_2-free headspace. The buffer solution of Goering and Van Soest (1970) was previously prepared into an Erlenmeyer flask under a CO_2 stream and kept one hour with an O_2-free headspace after the resazurine colour turnover showed an O_2-free solution. Particle-free ruminal fluid was mixed with the buffer solution in a proportion 1:4 (vol/vol) at 39ºC under continuous flushing with CO_2. Buffered ruminal fluid (50 mL) was added into each bottle under CO_2 flushing. Bottles were sealed with butyl rubber stoppers and aluminium caps and placed in a water bath at 39ºC.

All data obtained were subjected to analysis of variance (ANOVA) using the randomized completed block design in the SAS software package (SAS, 2002). Significance between individual means was identified using the Tukey's multiple range tests. Mean differences were considered significant at $P<0.05$.

III – Results and discussion

The chemical composition and condensed tannins content of *Atriplex canescens* (ATCA) are shown in Table 1. As expected, there were significant differences ($P<0.05$) between growing seasons in all chemical compounds of ATCA except in free condensed tannins. The CP content was lower ($P<0.05$) in spring (167.7 g/kg DM) and summer (171.1 g/kg DM) than in winter (200.9 g/kg DM). ATCA had higher ($P<0.05$) NDF, ADF, and ADL contents in winter and spring than in summer. In all the seasons, condensed tannins and EE contents were generally low, whereas ash content was extremely high ($P<0.05$) in spring (243.8 g/kg DM) and in winter (197.3 g/kg DM). As shown in Table 2, season had a significant effect on gas production, methane production, IVD.TT and ME. The gas and methane production at 24 h incubation ranged from 47 to 67.7 ml and 4.67 to 8.70 ml respectively and decreased ($P<0.05$) during spring. The IVD.TT and ME of ATCA ranged from 73.05 to 79.34% and from 9.65 to 12.38 MJ/kg DM, respectively.

Table 1. Chemical composition and condensed tannins (g/kg DM) contents of *Atriplex canescens* harvested in three different seasons

	Seasons				
Nutrients	**Winter**	**Spring**	**Summer**	**SEM**	**Significance**
CP	200.89^{a}	167.68^{b}	171.08^{b}	5.553	***
NDF	400.75^{a}	352.49^{b}	282.19^{c}	18.01	***
ADF	172.70^{a}	152.17^{a}	101.19^{b}	11.28	***
ADL	64.06^{a}	63.75^{a}	47.05^{b}	2.834	***
Ash	197.3^{c}	243.8^{a}	212.0^{b}	6.859	***
EE	12.65^{c}	16.64^{a}	14.30^{b}	0.589	***
Free CT	12.56	12.18	12.42	0.119	NS
PCT	2.14^{ab}	4.69^{a}	1.71^{b}	0.625	***
FCT	20.46^{a}	12.23^{b}	12.91^{b}	1.669	***
TCT	35.16^{a}	29.10^{b}	27.04^{b}	1.511	***

$^{a, b, c}$ Row means with common superscripts do not differ (P<0.05); S.E.M.: standard error mean; CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, EE: Ether extract, Free CT: Free condensed tannins, PCT: Protein-bound condensed tannins, FCT: Fiber-bound condensed tannins, TCT: Total condensed tannins, NS: Non-significant, *** P<0.05.

Table 2. Gas and methane production, *in vitro* digestibility and metabolisable energy content

	Seasons				
Nutrients	**Winter**	**Spring**	**Summer**	**SEM**	**Significance**
GP24h (ml/g DM)	60.50^{a}	47.00^{b}	67.66^{a}	3.336	***
CH_4 24h (ml/g DM)	8.70^{a}	4.67^{b}	7.94^{a}	0.6631	***
IVD-TT (%)	73.05^{b}	74.05^{b}	79.34^{a}	0.9246	***
ME (MJ/kg DM)	11.58^{a}	9.65^{b}	12.38^{a}	0.4643	***

$^{a, b, c}$ Row means with common superscripts do not differ (P<0.05); S.E.M.: standard error mean; GP24: gas production after 24 hours of incubation, CH_4: methane production after 24 hours of incubation, IVD-TT: *in vitro* digestibility determined according to Tilley and Terry method, ME: Metabolisable energy.

The reduction in CP content of ATCA in summer *versus* in winter, is consistent with other studies. For example, the level of CP, EE and NFE decreased whereas CF, ash and DM contents increased on passing from the wet season to the dry season (El Shaer, 2010). However, the CP content of ATCA remained relatively high (171.1 g/kg DM) in summer, suggesting the possible use of ATCA as a dry season fodder and /or as feed supplement to low quality diets. In addition, the CP contents obtained in the current study are 7% higher the CP requirement for ruminants that should provide ammonia required by rumen microorganisms to support optimum microbial growth. CP contents obtained in the current study are comparable with the findings of Van Niekerk *et al*. (2009) who reported that CP ranged from 187 g/kg DM in ATCA (Santa Rita) located in Mier to 206 g/kg DM Field reserve 1) in Mier. However, Mellado *et al*. (2012) reported values of 141, 172 and 146 g/kg DM, respectively for spring, summer and fall seasons. The increase in CP levels measured during winter are most likely the result of increased soil moisture levels following the small rain (Johnson *et al*., 1998).

The marked decrease in NDF, ADF and ADL from winter to summer may be explained by the change of maturity stage of ATCA; in which flowering generally occurs between May and September. This period can vary, however, with genotype and location (Hamilton and Hamilton, 2003). The high level of fiber content in ATCA could be explained partly by the environmental conditions prevailing in the area of Bousaada, as high temperatures and low precipitations tend to increase the cell wall fraction and to decrease the soluble content of the plants (Pascual *et al*., 2000). Our values are similar to those reported for other browse forages (Salem *et al*., 2000; Bouazza *et al*., 2012), with some differences among all studies, probably because of the different proportions of foliage and twigs in the samples and the different phonological stage of the plants at sampling. Cell wall concentration in fodder shrubs is negatively correlated with palatability, voluntary dry matter intake and potential dry matter degradability (Larbi *et al*., 1998).

Methane is one of the potent greenhouse gasses, contributing significantly to the environment pollution. The livestock contribute to gas emissions by about 20% (gut microbial and animal waste fermentation). According to Lopez *et al*. (2010) methane reduction potential of any feedstuff can be estimated from the percentage of methane *in vitro* gas production and the feedstuff can be arbitrary divided into three groups, low potential (% methane in gas between 11% and 14%), moderate potential (% methane in the range of 6%-11%), high potential (% methane in gas below 6%) (Kaplan *et al*., 2014).

Therefore, ATCA had low potential since the percentage of methane for all the three seasons is between 11 and 14%. The differences in ATCA among season reflect the observed differences in NDF, ADF, and ADL concentrations. They could be also related to the differences in concentrations of secondary compounds such as tannins in the fodder (Nsahlai *et al*., 1994; Ventura *et al*., 2004); as well as differences in the configuration of cell wall polysaccharides (Cheng *et al*., 1984).

IV – Conclusions

Atriplex canescens is a valuable plant that provides fodder biomass for livestock and wildlife animals. Season had a significant effect on the nutritive value of ATCA. Its nutritive value decreased in spring and increased in summer and winter. ATCA should be grazed or harvested during winter and summer since these seasons are convenient for this shrub species to produce high levels of ME and CP for ruminants. Furthermore, ATCA can be an effective fodder component in mixed diets for livestock mainly during winter and summer.

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