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in

Ben Salem H. (ed.), López-Francos A. (ed.).
Feeding and management strategies to improve livestock productivity, welfare and product quality under climate change

Zaragoza : CIHEAM / INRAT / OEP / IRESA / FAO
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 107

2013
pages 63-68

Nutritive evaluation of foliage from some Acacia trees characteristic of Algerian arid and semi-arid areas

S. Boufennara*', L. Bouazza *'**, R. Bodas*, H. Bousseboua** and S. Lopez***

*Instituto de Ganadería de Montaña (IGM) CSIC-Universidad de León, Departamento de Producción Animal, Universidad de Léon, E-24007 Leon (Spain)
**Faculté des sciences de la Nature et de la Vie, BP 325, route de Ain El-Bey, Université Mentouri de Constantine, 25117 Constantine (Algeria)

Abstract. Chemical composition and digestibility of foliage from five Acacia species (*Acacia nilotica, Acacia horrida, Acacia saligna, Acacia albida and Albizia julibrissin*) from arid and semi-arid areas of Algeria were evaluated. Feed components of proximate analysis were determined, whereas phenolic and tannin compounds were analysed by colorimetric procedures and their activity tested using a biological assay. Digestibility was assessed by conventional gravimetric *in vitro* and *in situ* methods, and rumen fermentation kinetics were measured using the *in vitro* gas production technique. Results showed that all browses contained high levels of CP (157-252 g/kg DM). The content of neutral detergent fiber was highest in *A. horrida* (551 g/kg DM) and lowest in *A. nilotica* (290 g/kg DM). The content of lignin was highest in *A. saligna* (147 g/kg DM). The tannin concentrations varied considerably between species, but in general the plants investigated in this study had high tannin contents. *A. nilotica* had the highest levels of TP and TET (213 and 205 g/kg DM, respectively). The TCT content ranged from 60 g/kg DM in *A. albida* to 726 g/ kg DM in *A. nilotica.* The leguminous fodder tree *A. julibrissin* shows high protein content and its foliage is highly digestible probably due to its low tannin content. It was concluded that foliage from Acacia species is a protein-rich fodder for ruminants, although the high lignin and tannin content of some species represents an important constraint that could limit digestive utilization in the gastro-intestinal tract of these species.

Keywords. Nutritive value – Forage – Acacia – Tannins.

Valeur nutritive du feuillage de quelques Acacia prépondérants des régions arides et semi-arides d'Algérie

Résumé. *La composition chimique et la digestibilité du feuillage de cinq espèces d'Acacia (*Acacia nilotica, Acacia horrida, Acacia saligna, Faidherbia albida *et* Albizia julibrissin), *récoltées de zones arides et semi-arides d'Algérie, sont étudiées. Leurs composants organiques majeurs sont déterminés, tandis que leurs teneurs en polyphénols et tannins sont analysées par colorimétrie. Leur digestibilité est évaluée par les méthodes gravimétriques* in vitro *et* in situ*. La technique dite* in vitro gas production *est utilisée pour le suivi cinétique des fermentations ruminales. Les échantillons étudiés montrent donc des taux élevés en protéines (157-252 g/kg MS), le contenu le plus élevé en FND étant noté chez* A. horrida *(551 g/kg MS) et le plus faible chez* A. nilotica *(290 g/kg MS). La valeur la plus élevée en lignine est enregistrée chez* A. saligna *(147 g/kg MS). Les concentrations en tannins varient considérablement entre les différentes espèces étudiées mais, de manière générale, elles sont élevées. Les taux les plus hauts en polyphénols totaux et en tannins totaux extractibles sont enregistrés chez* A. nilotica *(213 et 205 g/kg MS, respectivement). Pour les tannins condensés totaux, les valeurs varient de 60 g/kg MS chez* F. albida *à 726 g/kg MS chez* A. nilotica*. La légumineuse* A. julibrissin *présente un taux protéique élevé et son feuillage est hautement digestible, probablement en raison de son faible contenu en tannins. En conclusion, les résultats obtenus montrent que le feuillage issu des espèces d'Acacia est un fourrage globalement riche en protéines, alors que des taux élevés en lignine et tannins sont observés, ce qui peut représenter un facteur limitant de leur assimilation dans le tractus gastro-intestinal.*

Mots-clés. *Valeur nutritive – Fourrage – Acacia -– Tannins.*

I – Introduction

Algerian steppe covers more than 30 million ha of land and constitutes a buffer zone between the Sahara Desert and the green belt in the North. Sheep breeding is the main agricultural activity. Sheep has become adapted, showing a particular productive performance. But the steppe rangelands are in a process of degradation and this situation is attributed to several factors, mainly the fragility of the physical environment and changes in nomadic pastoral. This area is very intensively exploited by livestock, and it feeds, approximately, 20 millions of sheep and goat population of Algeria and about 80% of the national herd (FAOSTAT, 2009). The processes of desertification are thus omnipresent and affect vast surfaces primarily confined in the arid, semi-arid and sub-humid dry areas. Acacias and other shrubby plants can be used to combat desertification, mitigating the effects of droughts, allowing soil fixation and enhancing the restoration of the vegetation and the rehabilitation of rangelands. Browsing tree foliage plays an important role in ruminant feeding systems in many tropical and Mediterranean environments around the world (Kumara Mahipala *et al*., 2009). The rational use of fodder and browse requires accurate information about the nutritive value of these fibrous resources and the presence of antinutritional compounds, as high concentrations of tannins may be found in many fodder trees (Reed, 1986; Dube *et al.*, 2001), thus impairing their utilization.

The objective of this study was to investigate the nutritive value of selected browse Acacia species (i.e., *A. albida, A. nilotica*, *A. horrida*, *A. saligna, A. julibrissin*) grown in arid and semi-arid areas of Algeria.

II – Material and methods

Leaves, without twigs, from Acacia species (*Acacia albida, Acacia saligna* [syn. *Acacia cyanophylla], Acacia nilotica, Acacia horrida, Albizia julibrissin)* from Bousaada and Constantine districts were clipped with scissors from the aerial part of the plants, and taken inmediately to the laboratory where the samples from the different specimens were pooled, oven-dried at 50ºC (Makkar, 2003), and subsequently ground to pass a 1 mm screen for chemical analysis and 3 mm for in situ degradability. Dry matter (DM), ash and crude protein (CP) contents were determined following the methods of AOAC (2000). Neutral and acid detergent fibre (NDF and ADF, respectively) and sulphuric acid detergent lignin (ADL) were determined as described by Van Soest *et al.* (1991). Phenolic compounds and total extractable phenols were determined according to Makkar (2003) and Julkunen-Tiitto (1985), respectively. Free condensed tannins (FCT) were measured in the extract using the butanol–HCl assay (Porter *et al.*, 1986), with the modifications of Makkar (2003) and using purified quebracho tannin as standard. Concentration of total condensed tannins (TCT) as calculated as follows: TCT = FCT + BCT (Bound condensed tannins).

Four mature Merino sheep (body weight 49.4 ± 4.23 kg) fitted with a permanent ruminal cannula were used for the extraction of rumen fluid or for *in situ* incubation of nylon bags. Animals were fed lucerne hay *ad libitum* (167 g CP, 502 g NDF, 355 g ADF and 71 g ADL/kg DM). *In vitro* dry matter digestibility was determined using the ANKOM-DAISY procedure (Ammar *et al.*, 1999) following two different approaches, Tilley and Terry (1963) and Van Soest *et al.* (1966), separately in different incubations. Gas production profiles were obtained using an adaptation of the technique described by Theodorou *et al.* (1994). The procedure to measure *in situ* disappearance has been described in detail by López *et al.* (1991, 1999).

One way analysis of variance (Steel and Torrie, 1980) was performed on *in vitro* digestibility, gas production fermentation kinetics and *in situ* degradability data, with browse species as the only source of variation (fixed effect) with source of inoculum for *in vitro* and animal for *in situ* as a blocking factor (random effect). Analysis of variance was performed using the GLM procedure of the SAS software package (SAS Institute, 2008).

III – Results and discussion

The forages used in the present study substantially varied in chemical composition and tannin composition (Table 1). Condensed tannins varied widely among species, being highest in *A. nilotica* (726 g/kg) and lowest for *A. albida* (60 g/kg). Their CP was relatively high and fit with those reported by other authors (Al-Soqeer, 2008) for similar species, which justifies their use to supplement poor quality natural pastures and crop residues such as straw and stover (Osuga *et al.* 2006). The low to moderate fibre content of browse foliage would positively influence their voluntary intake and digestibility by small ruminants (Bakshi and Wadhwa, 2004). However, high lignin in some *Acacia* spp., for example *A. saligna* (148 g/kg DM) and *A. albida* (139 g/kg DM), could be associated with low digestibility (Rubanza *et al.*, 2005).

Table 1. Chemical composition (g/kg DM), phenolic compound contents (g/kg DM, equivalent standard) and tannin biological activity[a] of forages

	Plant species				
	A. nilotica	***A. horrida***	***A. saligna***	***A. albida***	***A. julibrissin***
DM	900	904	913	918	904
OM	920	895	899	936	872
CP	243	217	157	252	186
NDF	290	551	447	430	264
ADF	198	200	255	269	92
ADL	126	74	148	140	50
TEP	213	99	205	31	105
TET	206	92	198	28	101
FCT	609	387	451	26	502
TCT	726	476	631	60	587
Tannin bioassay†					
6h	2.27	0.95	1.55	1.16	1.20
12h	2.18	1.15	1.7	1.12	1.21
24h	1.73	1.08	1.64	1.11	1.17
48h	1.43	1.08	1.58	1.06	1.10

†Tannin bioassay as the ratio between gas production measured at different incubation times adding PEG *vs* control (i.e., Gas PEG / Gas control)

In vitro digestibility and *in situ* DM disappearance were variable (P<0.05) across the examined forages (Table 2). The highest IVD values (*in vitro* and *in situ* DM digestibilities) were observed in *A. julibrissin.* An intermediate value was found for leaves of *A. horrida.* The lowest IVD value was observed for *A. saligna.* Differences among browse species in digestibility and gas production parameters may be partly attributed to the variations in chemical composition.

Kinetic fermentation parameters from gas production curves were variable (P<0.05) across the acacia species examined (Table 3). Asymptotic gas production (A) and G24 were low in *A. albida* (71.6 and 56.2 ml/g DM, respectively). High extent of degradation (E) and fast average fermentation rate were noted in *A. julibrissin* (48.1 % and 6.05 ml/g/h). Values of the fermentation parameters (c, E and L) were lowest for *A. saligna*.

Gas production values indicate large differences in the fermentation parameters for the substrates studied. Cumulative gas production at 24 h of incubation was lowest (P<0.05) in some of the samples with the highest CP content, such as *A. albida*, *A. saligna* and *A. nilotica.* For the last two Acacia spp. this can be attributed to their high TCT concentrations. As for *A.*

albida, its high protein content may have interfered in the gas production results. As protein is degraded, ammonia released will combine with CO_2, so that the amount of gas measured in the headspace is considerably reduced. This effect is more pronounced with protein-rich substrates (Cone and Van Gelder, 1999). Nevertheless, the ranking of the fodder species according to rate and extent of degradation estimated from the gas production curves was similar to that observed for digestibility determined by *in vitro* and *in situ* gravimetric techniques.

For tree foliage from *A. nilotica, A. horrida, and A. saligna,* where total phenolics constitute an appreciable proportion of DM, an overestimation of IVD can be observed, this results is in agreement with that reported by Mlambo *et al.* (2008) with tannin-rich tree fruits from *A. nilotica*, *Acacia erubescens*, *Acacia sieberiana*, and *Acacia erioloba*.

Table 2. *In vitro* dry matter (g g^{-1} DM) digestibility and *in situ* dry matter disappearance (g g^{-1} DM) at different forage incubation times

Species	ivDMloss	TIVD	IVD-TT	*In situ* DM disappearance after incubation times		
				0 h	24 h	96 h
A. nilotica	0.396 ^{c}	0.643 ^{b}	0.497 ^{c}	0.183 ^{c}	0.508 ^{b}	0.696^{b}
A. horrida	0.571 ^{a}	0.703 ^{a}	0.657 ^{a}	0.195 ^{c}	0.536 ^{b}	0.628^{b}
A. saligna	0.307 ^{d}	0.480 ^{d}	0.457 ^{c}	0.205^{c}	0.386 ^{c}	0.639^{b}
A. albida	0.430 ^{b}	0.583 ^{c}	0.567 ^{b}	0.242 ^{b}	0.561 ^{b}	0.661^{b}
A. julibrissin	0.451^{b}	0.723 ^{a}	0.634 ^{a}	0.340 ^{a}	0.741 ^{a}	0.830^{a}
SEM	0.0198	0.0203	0.0183	0.0190	0.0309	0.0210

ivDMloss: *in vitro* dry matter loss; IVD-TT: *in vitro* digestibility of Tilley & Terry; TIVD: true *in vitro* digestibility; $^{a, b, c, d, e, f, g}$ Means in a column with different superscripts are significantly different (P < 0.05); SEM: standard error of the mean.

Table 3. *In vitro* fermentation kinetics (estimated from gas production curves) of Algerian forages

Species	A (ml/g)	c (/h)	L (h)	G24 (ml/g)	E (%)	Average rate (ml/g/h)
A. nilotica	165.9 ^{b}	0.0333 ^{b}	0.05 ^{b}	90.5 ^{b}	33.4^{c}	3.97 ^{b}
A. horrida	200.9 ^{a}	0.0425 ^{b}	1.88 ^{a}	121.9 ^{a}	42.4^{b}	5.56 ^{a}
A. saligna	136.9 ^{c}	0.0313 ^{b}	0.00 ^{b}	71.7 ^{c}	25.9 ^{d}	3.07 ^{b}
A. albida	71.6 ^{d}	0.0690 ^{a}	0.00 ^{b}	56.2 ^{c}	43.1$^{a\ b}$	3.55 ^{b}
A. julibrissin	188.6 ^{a}	0.0431 ^{b}	0.00 ^{b}	124.3 ^{a}	48.1^{a}	6.05 ^{a}
SEM	8.51	0.0030	0.169	5.27	1.56	0.25

A: asymptotic gas production, c: fractional rate of fermentation; G24: gas production at 24 h of incubation; E: extent of degradation for a fractional passage rate of 0.03 h^{-1}; $^{a, b, c, d, e, f, g}$ Means in a column with different superscripts are significantly different (P < 0.05).

In conclusion, foliage from Acacia tree species found in arid areas of Algeria can be considered as protein-rich roughage for ruminants, although their high lignin and tannin contents constitute an important constraint limiting their digestive utilization and likely nutrient absorption in the gastro-intestinal tract. The leguminous fodder tree *A. julibrissin* showed high protein contents and its foliage is more digestible than that from other *Acacia* spp. owing to its lower tannin content. Alternatives and practices to alleviate adverse effects of the studied secondary compounds, mainly condensed tannins, may be investigated.

Acknowledgments

Financial support received from Junta de Castilla y León (Project GR158) is gratefully acknowledged. LB and SB gratefully acknowledge the receipt of a Study and Doctoral Research Abroad Fellowship funded by the Algerian Ministry of Higher Education and Scientific Research to conduct the experimental work of their PhD projects in the University of León (Spain). Raúl Bodas was supported by JAE-Doc contract under the programme under the programme 'Junta para la Ampliación de Estudios' (CSIC-European Social Fund).

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