INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
19–1098/2020/23–1–49–53
DOI: 10.17957/IJAB/15.1256
http://www.fspublishers.org

Full Length Article

Effect of Season on Chemical Composition and *In Vitro* Digestibility of Six Native Forage Shrubs Species Grazed by Goats in Protected Areas in Canary Islands, Spain

María Pastora Flores[1], Ana Belén Robles[2], Raúl Rodríguez[1], Myriam R. Ventura[1] and Francisco P. Caravaca[3*]
[1]*Departamento de Ciencia Animal. Faculty of Veterinary. University of Las Palmas de Gran Canaria. 35416 Arucas, Gran Canaria, Spain*
[2]*Group of Grassland and Mediterranean Silvopastoral. Estación Experimental del Zaidín. Spanish Council for Scientific Research (C.S.I.C.). 18008 Granada, Spain*
[3]*Departamento de Ciencias Agroforestales. Escuela Técnica Superior de Ingeniería Agronómica. Universidad de Sevilla. 41013 Sevilla, Spain*
[*]For correspondence: fp-carava@us.es
Received 05 July 2019; Accepted 29 August 2019; Published 08 January 2020

Abstract

Chemical composition (organic matter, crude protein and fiber fractions), *in vitro* organic matter (OM) digestibility and metabolizable energy (ME) of six native shrubs regularly browsed by goats in a natural protected area in Canary Island has been determined in two seasons (dry and wet) along the year. Means values for each individual species, for wet and dry seasons and for species by season were compared. Chemical composition and *in vitro* digestibility mean values vary significantly among the six species (*Chamaecytisus proliferus* subsp. *meridionalis*, *Teline microphylla*, *Adenocarpus foliolosus*, *Echium onosmifolium*, *Echium decaisnei* and *Dittrichia viscosa*). In general, they have a medium to high crude protein (CP) and high fiber contents. *A. foliolosus* (181 g/kg DM) and *Ch. proliferus* (162 g/kg DM) were the species with highest CP contents. Comparing both seasons' means for the whole of the species, OM, CP and lignin contents showed no significant differences between dry and wet seasons while the rest of fiber fraction and DM values were significantly lower in the wet season. Analyzing the effect of season inside species, differences between dry and wet seasons were no significant for most variables; i.e., in general there was not great variability of analyzed component throughout the year for each individual species. The estimated ME content ranged between 8.4 MJ ME/kg DM for *T. microphilla* (dry season) and 12.1 MJ ME/kg DM for *Ch. proliferus* (wet season). Grazing utilization by goats of these browses in the local conditions guarantees a regular intake of analyzed components along the year.

Keywords: Chemical composition; *In vitro* digestibility; Endemic shrubs; Metabolizable energy

Introduction

Browse plants play an important role in providing fodder for small ruminants in most parts of the world, particularly in areas with dry to semi-dry Mediterranean climates (Papanastasis *et al*. 2008). Most shrubs species have the advantage of maintaining their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate in quality and quantity. In Canary Islands, native shrubs from protected areas have been traditionally used as a source of forage for local goats. However, very few studies have been carried out to know the nutritive value of these species (Ventura *et al*. 2002; 2004; Arévalo *et al*. 2007), probably due to the modest size of this type of shrublands, and in the case of five of the studied species in this work, for its condition of island endemism. Consequently, there is a lack of information on chemical composition and nutritive value of most of spontaneous native forage shrub and herbaceous species grazing by goats for these areas. This study was undertaken to determine the effect of season (wet and dry) on possible variation of the chemical composition and *in vitro* organic matter digestibility of six shrub species present at *El Nublo Rural Park*, a natural protected area (26307 ha) with a warm-summer Mediterranean climate, where goats grazing is permitted along the year.

Materials and Methods

Study area

The present study was conducted at *El Nublo* Rural Park, which is located in the center-western (27°5´N, 15°3´W) of Gran Canaria island (Canary Islands, Spain), with altitudes rangingto 1100–1300 meters from sea level. The precipitations (average of last 50 years) are 319–465 mm, differentiating two periods; from October to March (wet season with 87% of annual rainfall) and from April to September (dry season), being the annual average temperature of 13–15°C. Vegetation cover of the study area is mainly composed of natural communities of shrublands with species of genus *Chamaecytisus*, *Teline*, *Echium* and *Cistus*. In addition, some communities of *Pinus canariensis* and *Amygdalus communis* (almond orchard) are present. The herbaceous layer is represented by *Hirschfeldia incana*, *Erodium malacoides* and *Plantago lagopus* among many others.

Chemical composition

The present trial studied the chemical composition of five of main endemics shrub species of the area: *Chamaecytisus proliferus* subsp. *meridionalis*, *Adenocarpus foliolosus* and *Teline microphylla* from the *Fabaceae* family and *Echium decaisnei* and *Echium onosmifolium* (*Boraginaceae* family), plus an also abundant native Mediterranean weed: *Dittrichia viscosa* (*Astaraceae* family). Four samples of each of the initial five shrub species were collected by season: dry (July 2001) and wet (January 2002). As *Dittrichia viscosa* is a summer flowering seasonal plant, only dry season samples were registered. Each sample consisted of stems (<5 mm of diameter) and their leaves, manually collected and introduced in plastic bags and portable cooler until laboratory. They were weighed and subsequently dried to a constant weight at 65ºC during 48 h in a forced-air oven. Samples were ground to pass a 1 mm screen with *Ciclotec Tecator* mill (AOAC, 1990). Duplicated samples were analyzed for dry matter (DM), ash content and crude protein (CP) following recommendations of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to the methodology described by Goering and Van Soest (1970) with a *220 ANKOM Fiber Analyzer (Ankom Tecnology Corporation).* Lignin was determined by solubilization of cellulose with sulphuric acid.

Digestibility and metabolizable energy

In vitro digestibility of organic matter (IVOMD) was determined using the technique developed by Van Soest *et al*. (1966), following the modification by *Ankom Tecnology Corporation*. Three castrated Majorera male goats fitted with permanent rumen cannulas were used to obtain the ruminal liquid. The animals were fed at maintenance level with alfalfa hay, water *ad libitum* and vitamin-mineral blocks. For all the analysis, a well-known IVOMD cereal straw pattern was included to verify the functionality of ruminal liquid and the rest of the test. Metabolizable energy (ME) was estimated from IVOMD, using the equations described by Agricultural Research Council (1980):

$$\text{ME (MJ/kg DM)} = \text{OM (g/kg DM)} \times \text{IVOMD} (19 \times 0.82 \times 10^{-3})$$

Statistical analysis

Chemical composition (DM, ashes, OM, CP, ADF, NDF and lignin), *in vitro* organic matter digestibility and metabolized energy, as dependent variables, were analyzed using the univariate general linear model (GLM) procedure with species and season as fixed effects. Interaction (species x season) was also analyzed in order to know the seasonality effect for each species. Tukey´s multiple range tests were used to separate means when significant differences were obtained by GLM analysis. A level of $P < 0.05$ was considered as the minimum for acceptable statistical significance. In order to know the possibilities of prediction of IVOMD from chemical composition, a regression equation of IVOMD based on chemical parameter (ADF) has been obtained. All the statistical analyses were undertaken using SPSS 11.0 program (SPSS Inc., 2006).

Results

Chemical composition

Means values for each chemical parameter analyzed according to species, season (wet and dry) and its interaction (species x season) are included in Table 1, as well as SEM (standard error of the mean) and *P*-value for each variable. Only dry season data of *D. viscosa* have been analyzed.

Referring to DM content, the three endemic leguminous species (*Ch. proliferus*, *T. microphylla* and *A. foliolosus)* presented the highest level of it, mainly obtained in the dry season, while *Echium* spp. registered minimum values in wet season. Significant differences were observed among species, seasons and its interaction, being clearly higher the content of DM in the dry season for most of species except for *T. microphylla* and *E. decaisnei* where only a tendency was observed. Organic matter ranged between 741 g/kg DM for *E. decaisnei* and 968 g/kg DM for *Ch. proliferus* and *T. microphylla*, both obtained in the dry season. Significant differences for OM were observed among species but no differences were shown when comparing seasons' means (P=0.1). So, the lowest contents in OM were obtained for *Echium* spp., with the consequent highest ashes content that is more common of halophytes species such as *Atriplex* spp. (Norman *et al*., 2004). The rest of browses had higher OM values with no differences between seasons for each individual species. Crude protein contents ranged between 65 g/kg DM for *E. onosmifolium* (dry season) and 184 g/kg DM for *A. foliolosus* (wet season). When comparing species, two of leguminous (*Ch. proliferus* and *A. foliolosus*) had significant higher CP mean values ($P < 0.001$), while there were no significant differences among the rest of its. However, when comparing both seasons for the whole of the shrubs, differences of CP

Table 1: Chemical composition contents (g/kg DM), *in vitro* organic matter digestibility (g/kg DM) and metabolizable energy (MJ/kg DM) of *Chamaecytisus proliferus* subspp. *meridionalis*, *Adenocarpus foliolosus*, *Teline microphylla*, *Echium decaisnei*, *Echium onosmifolium* and *Dittrichia viscosa* shrubs species[1]

Item	n[2]	DM	Ash	OM	CP	NDF	ADF	Lignin	IVOMD	ME
Species										
Ch. proliferus	8	453^{a}	32^{d}	968^{a}	162^{a}	313^{c}	212^{c}	42^{bc}	739^{bc}	$11,15^{a}$
T. microphylla	8	467^{a}	33^{d}	967^{a}	110^{b}	522^{a}	379^{a}	62^{a}	574^{d}	$8,65^{c}$
A. foliolosus	8	443^{a}	46^{d}	954^{a}	181^{a}	390^{b}	259^{b}	53^{abc}	712^{c}	$10,59^{ab}$
E. onosmifolium	8	268^{b}	205^{b}	795^{c}	89^{b}	306^{c}	196^{c}	35^{c}	854^{a}	$10,58^{ab}$
E. decaisnei	8	187^{c}	241^{a}	759^{d}	105^{b}	341^{bc}	209^{c}	68^{a}	841^{a}	$9,94^{b}$
D. viscosa	4	275^{b}	96^{c}	904^{b}	96^{b}	289^{c}	199^{c}	59^{ab}	767^{b}	$10,8^{a}$
Season										
Wet	20	307^{b}	107	893	135	357^{b}	240^{b}	50	766^{a}	$10,51^{a}$
Dry	24	396^{a}	112	888	120	374^{a}	252^{a}	56	731^{b}	$9,99^{b}$
Species x season										
Ch. proliferus-wet	4	408^{cd}	32^{d}	968^{a}	162^{a}	228^{h}	163^{g}	30^{c}	802^{bcd}	$12,11^{a}$
Ch.proliferus-dry	4	498^{ab}	31^{d}	969^{a}	162^{a}	398^{cd}	261^{cd}	55^{abc}	691^{e}	$10,43^{bc}$
T. microphylla-wet	4	437^{bc}	35^{d}	965^{a}	104^{bc}	482^{ab}	352^{b}	54^{abc}	590^{f}	$8,88^{d}$
T. microphylla-dry	4	498^{ab}	31^{d}	969^{a}	115^{b}	563^{a}	407^{a}	71^{a}	558^{f}	$8,43^{d}$
A. foliolosus-wet	4	363^{cd}	48^{d}	952^{a}	184^{a}	359^{cdef}	240^{cde}	51^{abc}	742^{de}	$11,00^{b}$
A. foliolosus-dry	4	523^{a}	43^{d}	957^{a}	178^{a}	421^{bc}	279^{c}	56^{abc}	683^{e}	$10,18^{bc}$
E. onosmifolium-wet	4	177^{f}	199^{b}	801^{c}	112^{b}	338^{defg}	215^{ef}	42^{bc}	880^{a}	$10,98^{b}$
E. onosmifolium-dry	4	359^{d}	212^{b}	788^{c}	65^{c}	274^{gh}	178^{fg}	29^{c}	829^{abc}	$10,17^{bc}$
E. decaisnei-wet	4	151^{f}	223^{ab}	777^{cd}	111^{b}	381^{cde}	232^{de}	73^{a}	821^{abc}	$9,94^{c}$
E. decaisnei-dry	4	223^{ef}	258^{a}	742^{d}	98^{bc}	301^{efgh}	186^{fg}	64^{ab}	859^{ab}	$9,93^{c}$
D. viscosa-dry	4	275^{e}	96^{c}	904^{b}	96^{bc}	289^{fgh}	199^{efg}	59^{ab}	767^{cd}	$10,79^{bc}$
SEM		19.71	13.59	13.59	6.21	14.872	11.23	2.61	1.61	0.15
P-value										
Species		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Season		<0.001	0.102	0.102	0.060	0.003	0.001	0.138	<0.001	<0.001
Interaction Species x season		0.001	0.039	0.039	0.033	<0.001	<0.001	0.010	<0.001	0.010

[1]Means, standard error of the mean (SME) and *P* value by species, seasons and interaction (species x season); [2]Number of duplicates analyzed samples

[a-h]Values in the same column with different superscripts are significantly different ($P < 0.05$). DM, Dry Matter (g/kg fresh foliage); OM, Organic Matter; CP, CP, Crude Protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; IVOMD, *in vitro* organic matter digestibility; ME, metabolizable energy

between dry and wet season means were not significant (*P*=0.06). Furthermore, none of individual species analyzed had significant differences in content of CP between seasons (with the exception of *E. onosmifolium*).

Related to fibrous fraction, significant differences were obtained when comparing species, being *T. microphylla* that presented the highest NDF and ADF contents (522 and 379 g/kg DM respectively). Respect to lignin content, the highest values were obtained for *E. decaisnei* and again, for *T. microphylla*. Comparing both seasons means for the whole of the species, dry season NDF and ADF contents were significantly higher, while for lignin, the higher summer value was not significantly different (*P*=0.13) when comparing with the wet season one. Analyzing the interaction and only for the leguminous species, higher values for all type of fiber were observed in the dry season. Differences became statistically significant for NDF and ADF in the case of *Ch. proliferus*; and, in the case of *T. microphylla* the difference only was significant for ADF contents. On the other hand, a lower amount of fiber fractions was obtained in the dry season for *Echium* spp., that became statistically significant for ADF content in the case of *E. decaisnei*. Nevertheless, lignin content was nearly the same all through the year for all species with a tendency (not significant) to be higher in summer for leguminous species.

Digestibility and metabolizable energy

Significant differences were observed among species for IVOMD values (Table 1), registering the highest values for *Echium* spp. while de lowest value corresponded to *T. microphylla*. Comparing means between seasons, the wet season IVOMD value was significantly higher than the one in the dry season. Analyzing the interaction, no significant differences between seasons were observed for most individual shrub species with a lower values tendency (but not significant) registered for the dry season; only for *Ch. proliferus* a significant lower value was obtained in the dry season.

A predictive model of IVOMD for these browse species was calculated:

IVOMD = 15.2492 + 9.5217 ADF + 0.04008 ADF^2 + 0.0048 ADF^3 ($R^2 = 0.831$, $P < 0.001$), being ADF (g/kg DM) the best chemical parameter that predicted IVOMD (g/kg OM). However, the use of this equation should have to be strictly limited to the range of variation of analytical variables used to obtain it.

Estimated ME values were significant different among species, with the lowest value registered for *T. microphylla* and the highest for *Ch. proliferus* (Table 1). When comparing both seasons' means, a significant difference was observed in favor of wet season ME value. However, the interaction showed no significant differences between seasons for the most shrubs species where only a tendency (not significant) to lower values in dry season was detected. The exception was for *Ch. proliferus* with a significant higher value registered in the wet season.

Discussion

As could be expected, significant differences among the six species (P < 0.05) were observed for all analyzed variables (chemical composition, IVOMD and ME). However, when analyzing wet and dry season's means for the whole of species, all variables reported significant differences with the exception of ash, OM, CP and lignin (Table 1). Analyzing interaction (specie x season), significant differences (P < 0.05) were detected for all variables once more; however, when comparing the effect of seasonality for each individual species there were not differences between obtained values for wet and dry season for most of them. Then, for OM and lignin contents, none of single species registered significant differences between seasons although differences among species still remained. In the case of CP, NDF, IVOMD and ME contents, no differences between seasons were observed for four of the species (Table 1). For DM and ADF contents, three of species showed differences between seasons. So, the significant *P*-values obtained for the interaction should be explained only for those species that showed differences between seasons.

Obtained DM values are similar to previously described in literature for this type of shrublands. When comparing species there were no significant differences for DM among leguminous which had the highest values. The significant differences obtained for the whole of species between dry a wet season did not were maintain when individual influence of seasonality were analyzed. Therefore, only three of them had significant differences while *T. microphylla* and *E. decaisnei* had not.

Obtained means contents for OM and ashes had no significant differences between dry and wet seasons for individual species (Table 1). This results are unexpected if comparing with the general performance during the summer for most of woody species used by livestock feeding in dry or semi-dry areas, where a higher concentration of ashes are described for this season and lower contents in OM as a consequence (Papanastasis *et al*. 2008). However, obtained values were similar to those described by Ventura (1997), Chinea *et al*. (2000) and Ventura *et al*. (2002) for *Ch. prol. meridionalis* and *A. foliolosus*, as well as data from Paz *et al*. (1986) and Chinea *et al*. (2000) for different species of *Teline* and *Chamaecytisus*.

Respect to protein contents, two of leguminous species had a high CP content while the rest of species had medium values (Table 1). There were no significant differences between dry and wet seasons (P=0.06) when comparing the whole of the species and either when comparing individual seasonal species with the exception of *E. onosmifolium*. Reviewed literature describes for contrast that CP values are in general lower in summer for natural shrub population in dry or semi-dry Mediterranean climates (Papanastasis *et al.* 2008). However, obtained values of CP ranged among those previously described in literature for similar native shrublands or introduced communities (Méndez 1993; Ventura *et al*. 2002; Papanastasis *et al*. 2008; Mahipala *et al*. 2009; Larbi *et al*. 2011). Independently of the intake level, all analyzed species contained enough CP levels along the year to meet goat demands for maintenance; furthermore, leguminous with the highest levels of CP (*Ch. proliferus* and *A. foliolosus*) could meet maintenance and lactation requirements (NRC, 1981).

Besides fibrous fractions differences among different species, obtained results are according with what reviewed literature describes, that in general, a higher concentration of fiber during summer can be expected for this type of shrublands (Papanastasis *et al*. 2008). In contrast, the lignin content was nearly the same all through the year for all species with a tendency (not significant) to be higher in summer for leguminous species which is uncommon because lignin content tends to increase during dry seasons for this species in Mediterranean climate. However, all fibrous fraction values obtained, in general, are according with those described previously in literature for similar types of shrublands (Méndez 1993; Ventura *et al*. 2000; Papanastasis *et al*. 2008; Mahipala *et al*. 2009; Larbi *et al*. 2011).

In general, the obtained IVOMD values are in concordance with those found in the literature, or even can be considered slightly higher if comparing with those registered for similar browslands (Ventura *et al*. 2002, 2004; Papanastasis *et al*. 2008; Mahipala *et al*. 2009; Larbi *et al*. 2011). *Echium* spp. registered the highest values for IVOMD that did not correspond with higher values in ME due to its high content in ashes and its lower contents in OM. Highlight once more that when comparing the season's effect for individual species most of them did not register significant differences with the exception of *Ch. proliferus.* Comparing with ME (or net energy) estimated in literature for different types of shurblands in dry or semi-dry climates (Robles 1990; Patón *et al*. 1999; Ventura *et al*. 2002, 2004; Mahipala *et al*. 2009) ours results are into the average range and obtained values can be compared to medium quality alfalfa hays (INRA, 1988).

Conclusion

It can be concluded that chemical composition and *in vitro* digestibility values vary significantly among the six shrubs species studied and, in general, they have a medium to high CP and high fiber content, highlighting that *Ch. proliferus* and *A. foliolosus* can be considered of good-quality due its higher CP and suitable IVOMD and EM. When comparing seasons for the whole of shrubs, no significant differences were observed for OM, CP and lignin contents. However, differences between seasons for each individual species were no significant for most of variables, highlighting that CP contents, IVOMD and ME do not considerably vary throughout the year for individual species. Therefore, as the effect of season does not affect most of analyzed variables, grazing utilization for the local goat of this type of native shrublands guarantees a regular intake of analyzed components along the year and provides maintenance requirements in protein and energy if browses are consumed in appropriate amount.

Acknowledgements

The authors would like to thank to the Department of Animal Production at Cordoba University (Spain) were protein analysis was done.

References

AOAC (1990). *Official Methods of Analysis*, 15th edition. Association of Official Analytical Chemists, Washington DC, USA

Agricultural Research Council (1980). *The Nutrient Requirements of Ruminant Livestock*. London: Commonwealth Agricultural Bureaux, Slough, UK

Arévalo JR, E Chinea, E Barquın (2007). Pasture management under goat grazing on Canary Islands. *Agric Ecosyst Environ* 118:291–296

Chinea E, E Barquín, C Afonso, B García-Criado (2000). Cambios químicobromatológicos de seis leguminosas arbustivas, endémicas de Canarias, en dos épocas de poda. In: *III Reunión Ibérica de Pastos y Forrajes*, pp: 269–274. Consellería de Agricultura, Gandería e Política Agroalimentaria (Ed.). Bragança-A Coruña-Lugo, Spain

Goering MK, DJ Van Soest (1970). *Forage Fiber Analysis (Apparatus Reagents, Procedures and Some Applications)*. Agriculture and Book no. 379. Department of Agriculture, USA

INRA (1988). *Alimentation Des Bovins, Ovins et Caprins*. Institut National de la Recherche Agronomique, Paris, France

Larbi A, A Khatib-Salkin, B Jammal, S Hassan (2011). Seed and forage yield, and forage quality determinants of nine legume shrubs in a non-tropical dryland environment. *Anim Feed Sci Technol* 163:214–221

Mahipala MBPK, GL Krebs, P McCafferty, LHP Gunaratne (2009). Chemical composition, biological effects of tannin and *in vitro* nutritive value of selected browse species grown in the West Australian Mediterranean environment. *Anim Feed Sci Technol* 153:203–215

Méndez P (1993). Forage potential of Canary Islands legumes. *In*: *Proc. 7th Meeting of the FAO European Sub Network on Mediterranean Pastures and Fodder crops*, pp: 141–144. Creta, Grecia

Norman, HC, C Friend, DG Masters, AJ Rintoul, RA Dynes, IH Williams (2004). Variation within and between two Saltbush species in plant composition and subsequent selection by sheep. *Aust J Agric Res* 55:999–1007

NRC (1981). *Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries*. No. 15. National Academy Press, Washington DC, USA

Papanastasis VP, MD Yiakoulaki, M Decandia, O Dini-Papanastasi (2008). Integrating woody species into livestock feeding in the Mediterranean areas of Europe. *Anim Feed Sci Technol* 140:1–17

Patón D, J Núñez-Trujillo, MA Díaz, A Muñoz (1999). Assessment of browsing biomass, nutritive value and carrying capacity of shrublands for red deer (*Cervus elaphus* L.) management in Monfragüe Natural Park (SW Spain). *J Arid Environ* 42:137–147

Paz PPD, M Arco, JR Acebes, W Wildpret (1986). Leguminosas forrajeras de Canarias. *In: Publicaciones Científicas Del Excmo. Cabildo Insular de Tenerife* (ed). Tenerife, Spain

Robles AB (1990). Evaluación de la Oferta Forrajera y Capacidad Sustentadora de un Agrosistema Semiárido del Sureste Ibérico. *PhD. Thesis*, University of Granada, Spain

SPSS Inc (2006). *Manual del Usuario de SPSS Base 15.0*. SPSS Inc, Chicago, Illinois, USA

Van Soest PJ, RH Wine, LA Moore (1966). Estimation of the true digestibility of forages by the *in vitro* digestion of cell walls. *In: Proceedings 10th International Grasslands Congress*, pp: 438–441. Helsinki, Finland

Ventura M (1997). Valor Nutritivo de Arbustos Forrajeros Canarios. *PhD. Thesis*, University of Las Palmas de Gran Canaria, Spain

Ventura MR, JIR Castañón, MC Pieltain, MP Flores (2004). Nutritive value of forage shrubs: *Bituminaria bituminosa*, *Rumex lunaria*, *Acacia salicina*, *Cassia sturtii* and *Adenocarpus foliosus*. *Small Rumin Res* 52:13–18

Ventura, MR, JIR Castañón, L Rey, MP Flores (2002). Chemical composition and digestibility of Tagasaste (*Chamaecytisus proliferus*) subspecies for goats. *Small Rumin Res* 46:207–210

Ventura MR, JIR Castañón, M Muzquiz, P Mendez, MP Flores (2000). Influence of alkaloid content on intake of subspecies of *Chamaecytisus proliferus*. *Anim Feed Sci Technol* 85:279–282