Tropical and Subtropical Agroecosystems

SHORT NOTE [NOTA CORTA]

NUTRITIVE VALUE OF DATE PALM LEAVES AND *Aristida pungens* ESTIMATED BY CHEMICAL, *IN VITRO* AND *IN SITU* METHODS

[VALOR NUTRITIVO DE LAS HOJAS DE PALMERA Y DE *Aristida pungens* ESTIMADO POR METODOS QUÍMICOS, *IN VITRO* E *IN SITU*]

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SUMMARY

This study was carried out to determine the nutritive value of two forages from the South-East of Algeria. The forages evaluated were date palm leaves and *Aristida pungens* (local name: drinn). Vetch-oat hay was used as reference control. The nutritive value of the feedstuffs was studied on the basis of their chemical composition, *in vitro* fermentation and *in situ* degradation. The two forages were characterized by a lower crude protein content (64.7-70.3 g/kg DM) and a higher mineral concentration (109.5-119.7 g/kg DM) than vetch-oat hay. The highest NDF and ADF contents were recorded for *A. pungens*, 794.7 g/kg DM and 509.4 g/kg DM, respectively. However, date palm leaves were characterized by their high lignin content (97.1 g/kg DM), total phenols (29.83g tannic acid equivalent/kg DM) and condensed tannin (44.47 g leucocyanidin equivalent/kg DM). The *in vitro* experiment using goat and sheep rumen fluid inocula demonstrated a higher digestive capacity in goats than in sheep, despite, fermentation occurring at the same rate. For both animal species, significant differences were recorded for *in vitro* gas production, *in vitro* dry matter digestibility, potential gas production and rate of gas production ($P<0.001$). The *in vitro* fermentation parameters for the two forages were lower than vetch-oat hay. This is probably due to their high lignin content and/or high tannin content. Dry matter degradation did not differ between forages at all incubation times ($P>0.05$). Nevertheless, the degradation rate (c) of date palm leaves (0.0423 h^{-1}) was statistically similar to that of vetch-oat hay (0.0356 h^{-1}) and higher than that of *A. pungens* (0.0123 h^{-1}) ($P < 0.05$). These results indicate that the two arid-zone forages can be use in ruminant rations, taking into account their lignin and tannin content.

Key words: Date palm leaves; *Aristida pungens*; goat; sheep; chemical composition; *in vitro* fermentation; *in situ* degradation.

RESUMEN

Se determinó el valor nutricio de dos forrajes de zonas áridas, los cuales fueron colectados en el sureste de Algeria. Los forrajes evaluados fueron las hojas de palma datilera y *Aristida pungens* (nombre local: drinn). El heno de Veza fue empleado como forraje de referencia. Se analizó su composición química, fermentación *in vitro* y degradación *in situ*. Los dos forrajes tuvieron bajo contenido de proteína cruda (64.7-70.3 g/kg MS) y una alta concentración de minerales (109.5-119.7 g/kg MS) en comparación con la Veza. Los valores más altos de FDN y FDA fueron para *A. pungens*, 794.7 g/kg MS y 509.4 g/kg MS, respectivamente. Sin embargo, las hojas de palma se caracterizaron por su alto contenido de lignina (97.1 g/kg MS), fenoles totales (29.83g equivalentes a ácido tánico/kg MS) y taninos condensados (44.47 g equivalentes a leucocianidina/kg MS). El experimento *in vitro* empleando fluido ruminaal de cabras y ovejas mostró una mayor capacidad de fermentación de las cabras aunque la tasa fue similar. La producción de gas *in vitro*, digestibilidad de la material seca *in vitro*, producción portencial de gas y tasa de producción de gas fueron diferentes entre ovinos y caprinos ($P<0.001$). Los parámetros de fermentación *in vitro* de estos forrajes fueron menores que los obtenidos con la Veza probablemente debido a su alto contenido de lignina y/o taninos. La degradación *in situ* no fue diferente entre los forrajes ($P>0.05$). Sin embargo, la tasa de degradación (c) de las hojas de palma (0.0423 h^{-1}) fue similar a la Veza (0.0356 h^{-1}) pero mayor que *A. pungens* (0.0123 h^{-1}) ($P < 0.05$). Los resultados sugieren que ambos forrajes son bien degradados en el rumen y pueden ser empleados en la alimentación de rumiantes.

Palabras clave: Hoja de palma datilera, *Aristida pungens,* cabra, oveja, composición química, fermentación *in vitro*, degradación *in situ*.

INTRODUCTION

The harsh climatic conditions of arid areas generate low agricultural production and a low availability of forage for ruminants. In these areas, local smallholders can identify some autochthonous plants as been selected and consumed by ruminants. Among these forages, *Aristida pungens* (locally known as drinn) is currently harvested and offered to animals. However, little is known about its nutritive value, thus making it difficult to assess its potential contribution to sustain animal production. Furthermore, the arid zones of North Africa are characterized by the dominance of date palm trees (P*hoenix dactilyfera L.*), which the vegetation represents more than 10 million date palm trees in Algeria Belguedj (1996). The yearly maintenance of date palm trees let considerable quantities of green leaves, roughly 20 kg per tree Bahman et al. (1997); Pascual et al. (2000). This date palm by-product is traditionally used as complementary feeding source for livestock by oasian people.

As far as we know only one study reported the nutritive value of *Aristida pungens* Chehma et al. (2004). Similarly, information concerning the nutritive value of date palm leaves is scarce and inconsistent. The available data have reported the low nutritional quality of this forage Al-Youcef et al. (1994); Khorchani et al. (2001). However, Bahman et al. (1997) and Pascual et al. (2000) have concluded that date palm leaves could be used as an acceptable alternative to barley straw for feeding goats and cows.

The nutritive value of a ruminant feed is determined by the concentration of its chemical components, as well as its rate and extent of digestion. *In vitro* gas production and *in sacco* rumen degradability, both rapid and low-cost methods have been used to assess the degradation and nutritive value of feedstuffs. The present study was carried out to determine the chemical composition, *in vitro* rumen fermentation and *in situ* degradation of date palm leaves and *Aristida pungens* comparatively to vetch-oat hay taken as a reference control.

MATERIAL AND METHODS

Experimental feedstuffs

Three forages were studied: date palm leaves, *Aristida pungens* (local name drinn) and vetch-oat hay taken as control reference. *Aristida pungens* is a perennial grass species which belongs to the graminaceae family (*Poaceae*). The plant was selected based on herdsmen knowledge from four grazing lands in the administrative districts of El-Oued, situated in the South-East of Algeria (longitude 6°53' E and latitude 33°20' N). The area is located at an altitude of 67m above sea level and receives a mean annual rainfall of 75 mm, with mean temperature ranging from 11°C in January to 37.5°C in July. The edible plant samples were harvested at maturity stage (June 2004) from 8 to 10 plants and chopped to 2 cm length. Date palm leaves were sampled during the period of November 2004 from the same region. The samples consisted on leaves removed at senescence stage from date palm trees. The feedstuff was harvested by hand from different date palm trees. Vetch-oat hay was collected from the ITELV (Technical Institute of Breeding, Ain Mlila, Algeria). Feedstuffs and the reference forage were dried at 60°C,except samples for tannins determination were sun-dried, then ground through a 1-mm screen for chemical analysis and the *in vitro* experiment, and a 3-mm screen for the *in situ* experiment.

Chemical analysis

Feedstuffs were analyzed for dry matter (DM) by drying the sample at 105°C for 24 h, and for ash by igniting the samples in a muffle furnace at 550°C for 8 h, and nitrogen content (N) was measured by the Kjeldahl method (AOAC, 1990; ID numbers: 930.15 and 976.05). Crude protein (CP) was calculated as N x 6.25. Contents of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin of forages were determined as described by Van Soest et al. (1991). The feedstuffs were also analyzed for total phenols and condensed tannin. These measurements were determined in the supernatant, which was extracted with 70% acetone solution as described by Makkar (2000). Total phenols were determined by Folin-Ciocalteau reagent and are expressed as tannic acid equivalent using the regression equation of standard. Condensed tannins were measured following the procedure of Porter et al. (1986) and were expressed as leucocyanidin equivalent using the relation proposed by Makkar (2000). The radial diffusion method was used to estimate protein precipitating polyphenolics (PPP). PPP values are expressed as the diameter of the protein-tannin band per gram of dry matter (mm/g DM) Hagerman (1987).

In vitro experiment

Two rams (8-10 months old) and two dry goats (1-2 years old) were used. The Ouled Djellal breed rams weighed 39 and 43 kg. The Arbia breed goats weighed 43 and 45 kg. The animals were fitted with a permanent rumen cannula (60 mm diameter) and received a diet composed of 700 g vetch-oat hay and 300 g concentrate (barley 58%, wheat bran 38%, mineral and vitaminic premix 1%, NaCl 1% and limestone 2%) at 07.00 and 16.00 h each day in two equal parts. Water was available *ad libitum*.

Rumen liquor, used as inoculum, was collected for each trial before morning feeding from the two sheep and the two goats. The *in vitro* experiment was carried out separately for sheep and goats. Rumen fluid was pumped with a manually operated vacuum pump and transported into two pre-warmed thermos flasks to the laboratory. Immediately on arrival, the rumen liquors from the two animals of the same species were pooled, strained through four layers of gauze, flushed with CO_2 and mixed with buffer solution at a ratio of 1:2 v/v. The buffer solutions used were as described by Menke and Steingass (1988).

The samples were incubated *in vitro* with rumen fluid in polypropylene syringes (60 mL) following the procedure of Menke and Steingass (1988). After weighing 200 ± 5 mg of each sample (1-mm screen) in each syringe, the pistons were lubricated with silicone to ease movement and to prevent gas escaping. The syringes were pre-warmed for an evening at 39°C prior to the injection of 30 ± 1 mL of rumen liquor plus buffer mixture. The syringes were incubated at 39°C in an electrically heated, isothermal oven equipped with a rotor which ran continuously at 9 rpm (GFL 3033). Each sample was incubated in triplicate in four separate runs performed on different days. In each series, a blank (rumen fluid + buffer mixture) was run in triplicate. The gas volume was recorded after 3, 6, 9, 24, 48, 72 and 96 h of incubation. Net gas production was calculated as the difference between the recorded volumes minus the mean volume of the blank. The following equation was used to estimate the volume of gas produced:

$$GP\left(mL/200mg\,DM\right)=\frac{(V_t-V_0-GP_b)x\,200}{W}$$

Where: V_t, volume of gas produced at time t; V_0, gas volume at t = 0 h; GP_b, mean gas volume of the blank; W, weight in mg DM of sample in each syringe.

At the end of the incubation period, the pH was recorded and the content of each syringe was centrifuged at 12000 rpm for 20 min. The pellet was dried at 80°C until constant weight. *In vitro* dry matter digestibility (IVD) was calculated as the difference between the DM weight of the sample at the start of the incubation and the weight of the residual DM remaining at the end of the incubation minus the mean residual dry matter of the blank.

In situ experiment

Three Texel sheep weighing 54 kg were used for the *in situ* experiment. They were fitted with a permanent fistula in the rumen, and received daily 700 g of cocksfoot hay (88.2% DM, 8.7% crude ash, 37.4% crude fibre, 9.1% crude protein) and 300 g of concentrate (barley 43%, beet pulp 40%, soybean meal 10%, beet molasses 5% and mineral–vitaminic premix 2%) in equal amounts at 08.00 and 16.00 h. The experimental diets were offered for two weeks prior to data collection for adaptation. Animals were kept in individual pens and water was available *ad libitum* during the experiment.

Determination of *in situ* degradability of experimental feedstuffs was carried out as outlined by Michalet-Doreau et al. (1987). Three g of dry sample (3-mm screen) were weighed in approximately 130 x 50 mm Dacron bags (Ankom Technology Corporation, Fairport, New York) with pore size 40-60 µm. Bags containing each feed were suspended for 3, 6, 12, 24, 48, and 72 h in the rumen. Bags were introduced into the rumen before the morning feeding and were withdrawn according to the schedule times. Six measurements were made for each forage at each time point (3 sheep x 2 replicates). Immediately on removal, the bags were rinsed thoroughly under running tap water to stop fermentation, and were then frozen. After defrosting, they were washed in a semi-automatic washing machine with cold water (T=19.6°C, pH=7.01) until all ruminal color had disappeared. After washing, the bags were oven dried at 80°C until constant weight, incubation residues were determined, and dry matter degradation was calculated from the loss in weight.

Calculations and statistical analyses

The results of gas volume produced *in vitro* and DM disappearance from the Dacron bags were fitted to the exponential model developed by Orskov and McDonald (1979): $Y = a + b\,(1 - e^{-ct})$, where y (mL or %) is gas production or degraded DM at time t, a (mL or %) is amount of gas or proportion of degraded DM corresponding to the rapidly degradable fraction, b (mL or %) is amount of gas or proportion of DM corresponding to the slowly degradable fraction, a+b (mL or %) is potential gas production or proportion of DM corresponding to potential degradable DM, and c ($mL.h^{-1}$ or h^{-1}) is fractional gas production or degradation rate. The estimation of these parameters has been made by the Neway Excel software Chen (1997). Effective degradability (ED) of dry matter was calculated assuming that ruminal outflow rate is 0.03 h^{-1}:

$$\text{ED}\,(\%) = a + \frac{bc}{c + k}$$

Where: k is rumen outflow rate. The nutritive index value (NIV) was calculated from the equation proposed by Orskov and Ryle (1990) using the parameters estimated from the exponential equation of *in sacco* experimental data: $a + 0.4\,b + 200\,c$.

The results were analyzed using the GLM procedure of the SAS software package (1990). For the *in vitro* experiment, the model was: $Y = \mu + Fi + Sj + FSij + e$, where μ is the overall mean, F is the forage effect, S is the animal species effect and FS is the interaction between forage and animal species. Experimental units were the runs, and replicates in a same run were considered as repetitions. For the *in situ* experiment, the model used was: $Y = \mu + Fi + e$. Experimental units were the means of replicates within a same animal, and animals were considered as repetitions. The Student-Newman-Keuls test was used for means comparisons.

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of the feedstuffs is shown in Table 1. There was a wide variation between the chemical components of the forages. *A. pungens* and date palm leaves were characterized by their high ash content comparatively to vetch-oat hay. Forages in arid areas have characteristically high ash content Haddi et al. (2003). For all feeds, crude protein content was low; *A. pungens* had the highest value and date palm leaves had the lowest. This result was in agreement with that reported by Genin et al. (2001). The authors noted low nitrogen content (crude protein content 5.1%) and high ash content (11.6%) for leaves collected from Deglet Nour date palm tree variety. NDF was the lowest in date palm leaves and the highest in *A. pungens*, but ADF was lowest for vetch-oat hay and highest for *A. pungens*. However, lignin content was highest in date palm leaves and lowest in vetch-oat hay. ADF: NDF ratio was higher in date palm leaves (0.72) and *A. pungens* (0.64) than vetch-oat hay. This result indicates the high cellulose content of the two forages. Concentrations of total phenols and condensed tannins were highest for date palm leaves. This was confirmed by the radial diffusion method. Information on the tannin content of North African forages remains scarce. The results obtained in this study are within the range of forages with moderate tannin content previously reported by Ben Salem et al. (2000); Frutos et al. (2002). These values are generally considered too low to affect nutrient digestibility in ruminants Frutos et al. (2002); Makkar (2003).

For *A. pungens*, the results obtained for ADF, NDF and lignin content fit with those noted by Longuo et al. (1989); Harche et al. (1991); Chehma et al. (2004), but higher than those noted by Haddi et al. (2003) for five halophyte plants collected from South-Eastern Algeria in the same environmental conditions as *A. pungens*. Nevertheless, crude protein and ash content were higher than reported by Longuo et al. (1989). These differences may be due to the growth stage and the period at which the plant had been harvested. Date palm leaves composition was similar to that reported by Pascual et al. (2000), but cell wall fraction content was lower than those mentioned by Bahman et al. (1997) and Genin et al. (2001). These differences could be due to characteristics of the soil collection area, the old of date palm trees and/or date palm tree variety. Concerning the vetch-oat hay used as reference, its chemical composition was similar to that reported by Hadjigeorgiou et al. (2003) for high-quality hay. Based on their chemical composition, the two feedstuffs could be classified as highly fibrous feed with low protein content.

Table 1. Dry matter content and chemical composition ($g.kg^{-1}$ dry matter) of the feedstuffs.

Feedstuffs	Date palm leaves	*A. pungens*	Vetch-oat hay
DM ($g.kg^{-1}$ feed)	896.3	797.3	891.1
Organic matter	890.5	880.3	949.2
Ash	109.5	119.7	50.8
Crude protein	64.76	70.33	67.9
NDF	586.1	794.7	616.2
ADF	422.8	509.4	327.7
Lignin	97.1	84.4	43.6
Total phenols^{+}	29.83	7.25	6.42
Condensed tannin^{++}	44.47	2.76	5.04
PPP (mm/g DM)	205.76	99.63	59.22

DM, dry matter; NDF, neutral detergent fibre expressed exclusive of residual ash; ADF, acid detergent fibre expressed exclusive of residual ash; lignin, lignin determined by solubilization of cellulose with sulphuric acid; PPP, protein precipitating polyphenolics.
+, total phenols expressed as g of tannic acid equivalent/kg DM.
++, condensed tannins expressed as g of leucocyanidin equivalent/ kg DM.

In vitro *experiment*

There were significant differences (P<0.001) between *in vitro* fermentation parameters among animal species and feeds (Table 2). Goats exhibited a higher microbial activity in digesting feeds than sheep, despite fermentation occurring at the same rate. This result confirmed earlier findings concerning the ability of goats to adapt to a wide range of conditions, and their greater digestive capacity than sheep Molina-Alcaide et al. (1997); Aregheore (2000). The differences in ruminal microbial activity between sheep and goats mainly resulted in variations in the feed fractions (soluble and insoluble but fermentable fractions), whereas rate of degradation was not affected. Similar observations were reported by Nozière et al. (1996) with low quality forages. Cumulative gas production recorded at 96 hours was significantly higher in vetch-oat hay (37.7 mL/200 mg DM) than in *A. pungens* (27.5 mL/200 mg DM) and date palm leaves (22.6 mL/200 mg DM) (P<0.001). *In vitro* dry matter digestibility was higher in vetch-oat hay than date palm leaves, and higher in date palm leaves than in *A. pungens* (P<0.001). The fermentation parameters deduced from the exponential equation were statistically different among feedstuffs. Potential gas production (a+b) was higher in vetch-oat hay than in *A. pungens*, and higher in *A. pungens* than in date palm leaves (P<0.001). In addition, vetch-oat hay was fermented faster than *A. pungens*, and gas production rate was higher for *A. pungens* than date palm leaves (P<0.001). The high level of cell wall in *A. pungens* and the presence of both lignin and tannins in date palm leaves could account for the limited microbial activity and consequently the low gas production observed. The effect of tannins in the case of date palm leaves can be explained by formation of complexes between phenolics compounds and minerals which mainly occurring at ruminal pH McSweeney et al. (2001). IVD values for *A. pungens* and date palm leaves were slightly higher than recorded *in vitro* by Longuo et al. (1989); Bahman et al. (1997); Genin et al. (2001). The last authors reported a low *in vitro* dry matter digestibility of date palm leaves with tendency of lower values in sheep, compared with goat and dromedary. More specifically, date palm leaves presented low gas production and high *in vitro* dry matter digestibility, hence a degradation of dry matter without gas production. This result, particularly pronounced with sheep, is in agreement with that reported in sheep by Frutos et al. (2002) who recorded a positive correlation between tannin content and the partitioning factor, which indicates that the effect of tannin is more strongly reflected by the reduction of gas production than by the digestibility of organic matter.

Table 2. In vitro experiment parameters of the feedstuffs for goat and sheep.

	Goat			Sheep				Significance		
	Date palm leaves	*A. pungens*	Vetch-oat hay	Date palm leaves	*A. pungens*	Vetch-oat hay	SEM	Species	Forages	F*S
Final pH	6.72^{b}	6.72^{b}	6.72^{b}	6.71^{b}	6.85^{a}	6.83^{a}	0.02	***	**	**
GP_{96} (mL/200 mg DM)	30.06^{c}	28.84^{c}	40.87^{a}	15.24^{e}	26.13^{d}	34.51^{b}	0.43	***	***	***
IVD (%)	47.61^{c}	32.28^{e}	63.30^{a}	35.90^{d}	25.62^{f}	57.46^{b}	1.10	***	***	*
a + b (mL)	28.60^{c}	23.61^{d}	36.17^{a}	14.02^{e}	21.86^{d}	31.03^{b}	0.48	***	***	***
c (h^{-1})	0.0298^{c}	0.0489^{b}	0.0857^{a}	0.0355^{c}	0.0431^{b}	0.0822^{a}	0.003	NS	***	NS

Values are the mean of four runs; GP_{96}, gas production at 96 h ; IVD, in vitro dry matter digestibility; a+b, potential gas production; c, rate of gas production; NS, non significant (P> 0.05); ***, significant (P< 0.001); **, significant (P< 0.01); *, significant (P < 0.05); ; $^{a, b, c, d, e, f}$ means with different superscripts in the same row are significantly different (P < 0.05); F*S, interaction forage-animal species ; SEM, standard error of means

In situ *experiment*

A different trend was observed with *in situ* dry matter degradation. Figure 1 show a time-course for dry matter degradation (DMD). There were no significant differences among the forages in DMD at all incubation times (P>0.05). The DMD values of date palm leaves are similar to those measured *in vivo* by Pascual et al. (2000) in goats and Al-Youcef et al. (1994) in sheep. Compared to literature, the discrepancies between the results of the *in vitro* and *in situ* experiments have been also reported by Vitti et al. (2005) and Apori et al. (1998). These authors have noted differences between *in sacco* degradation and *in vitro* gas production measured in sheep of three Brazilian fodder legumes and *Spondias mombin* leaves. The effect of the anti-nutritive factors, which are unlikely to be detected using an *in sacco* method Apori et al. (1998); El Hassan et al. (2000), could account for the differences between the two methods. In the *in vitro* gas production technique, which is a batch system with limited supply of rumen fluid, these anti-nutritive factors remain in the fermentation media and affect rumen microflora activity. Conversely, in the *in sacco* technique, which is an open system with rumen environment, the inhibition would be transient because of washout of soluble material from the nylon bag.

The degradation parameters of the feedstuffs are presented in Table 3. There were no significant differences between forages with respect to their rapidly degradable fraction (a), slowly degradable fraction (b) and potential degradable fraction of DM (a+b) (P>0.05). However, there was a significant difference in degradation rates between feedstuffs (P<0.05). Degradation rate for date palm leaves was statistically similar to vetch-oat hay and higher than for *A. pungens*. The mean effective degradability of dry matter (ED) calculated assuming a rate outflow of 0.03 h^{-1}, which is generally accepted to be a typical outflow in sheep receiving low quality forages, was not significantly different among the feedstuffs (P>0.05). For all forages under study, nutritive index values (48.3%, 50.0% and 47.7% for date palm leaves, *A. pungens* and vetch-oat hay, respectively) were shown to allow animals to feed at maintenance levels. Orskov and Ryle (1990) have reported that a nutritive index value above 33 would enable an animal to consume sufficient feed to meet its maintenance needs. Comparatively to vetch-oat hay, these results indicate that the two arid forages were degraded by the ruminal microflora at the same level. Therefore, their use in the ration of ruminants can be considered.

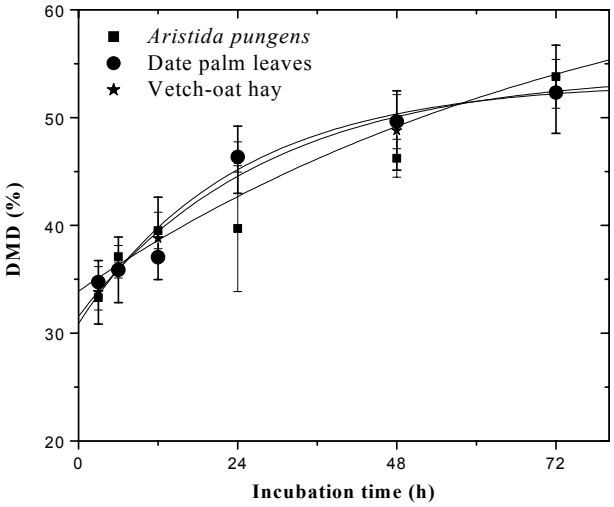

Fig.1. In situ dry matter disappearance curve of the feedstuffs

CONCLUSIONS

This study aimed to estimate the nutritive value of two arid forages. The *in vitro* experiment results revealed that the feedstuffs were weakly fermented by the ruminal microbiota comparatively to vetch-oat hay. On contrary, the *in sacco* experiment showed that the two forages were degraded at the same level as control. The discrepancies between the results of the two experiments may suggest the presence of antinutritive factors that could probably limit the nutritional potential of these forages, particularly, date palm leaves. For this reason, it is imperatively to assess the impact of these factors on nutritive value *in vivo*, and to evaluate the effects of tannins present in this type of forages by conducting bioassays with tannins complexing agents.

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Table 3. Dry matter loss (%) of the forages studied from nylon bag at different times of incubation in the rumen and in situ experiment parameters (%) of the feedstuffs, including nutritive index value (NIV) and effective degradability of dry matter (ED).

	Date palm leaves	*A. pungens*	Vetch-oat hay	SEM	Significance
DM loss					
3h	33.80	33.29	34.73	1.15	NS
6h	35.78	37.10	35.86	1.08	NS
12h	38.80	39.53	37.04	1.39	NS
24h	46.10	43.04	46.35	1.18	NS
48h	48.70	46.23	49.63	1.63	NS
72h	52.63	53.79	52.32	1.54	NS
Constants from fitted model					
a	30.90	33.90	31.57	1.06	NS
b	22.38	34.09	22.61	3.10	NS
a + b	53.28	67.99	54.18	3.54	NS
c (h^{-1})	0.0423^{a}	0.0123^{b}	0.0356^{a}	0.003	**
ED	43.84	43.35	43.79	0.88	NS
NIV	48.32	50.00	47.71	1.44	NS

Values are the means of three sheep; a, rapidly degradable fraction; b, slowly degradable fraction; c, degradation rate; a+b, potential degradable fraction; ED, effective degradabilility of dry matter calculated for an outflow rate of 0.03 h^{-1}; NIV, nutritive index value (Orskov and Ryle, 1990); SEM, standard error of means; NS, non significant (P>0.05); **, significant (P<0.01); $^{a, b}$means with different superscripts on a same row significantly differ (P<0.01).

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