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Ameliorating the Anti-nutritional Factors Effect in *Atriplex halimus* on Sheep and Goats by Ensiling or Polyethylene Glycol Supplementation

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ABSTRACT

Succulent twigs of *Atriplex halimus* naturally grown in Nubaria desert area, Egypt were cut and sun dried (AH), or ensiled (AS). The AH was offered either alone or with daily supplementation of polyethylene glycol (20 g PEG/kg DMI) as a tannin complexing agent to three mature male Rahmany sheep and three mature male baladi goats. Berseem (*Trifolium alexandrinum*) hay (BH) was used as a control. Animals were offered crushed barley grains to cover 50% of maintenance requirements, while tested forages were offered *ad lib*. The nutrients proximate analysis of BH was comparable to that of *A. halimus*. The average daily DM intake by both sheep and goats from BH (32.0 g/kg $w^{0.75}$) was higher ($P < 0.01$) than AH, AS and AH + PEG, which ranged between 20.40 and 22.74 g/kg $w^{0.75}$, due to *A. halimus* high content of total tannins (95.6 g/kg DM) and its high contents of ash and NaCl. Nutrients digestibility coefficients of BH ration were better ($P < 0.01$) than those of AH and AH + PEG rations, meanwhile they were comparable to those AS one. Ensiled *A. halimus* showed better digestibilities than AH alone ($P < 0.01$) or with PEG supplementation, but the differences were only significant ($P < 0.01$) with CF and NFE. Crude protein digestibility of AH was raised ($P < 0.01$) from 49.3% without PEG to 54.19% with PEG. Moreover, N balance ($P < 0.01$) and its % of N intake were also high. Supplementing animals fed *A. halimus* by PEG improved ($P < 0.01$) N balance and its % to N intake, being 9.68% vs 8.03%. It was concluded that ensiling *A. halimus* showed better nutritional results by sheep and goats than PEG supplementation. Moreover, it is easier to be practiced and could be lowered feeding costs.

Key Words: Sheep; *Atriplex halimus*; Anti-nutritional factors; Ensiling; Polyethylene glycol

INTRODUCTION

Browse plants play a significant role in nutrition of ruminant livestock in tropical and sub-tropical regions. Browse species, because of their resistance to heat, drought, salinity, alkalinity, drifting sand, grazing and repeated cutting, are the major feed resources during the dry season (Fagg & Stewart, 1994). In addition, a major advantage of browses over herbaceous legumes and grasses is their higher crude protein content. However, due to the presence of secondary plant metabolites (particularly tannins) in browses, digestibility of protein and organic matter in these feeds is low (Terrill *et al*., 1992; Silanikove *et al*., 1997; Waghorn & Shelton, 1997). This limits the availability of nutrients for ruminant livestock. Tannins have both beneficial and adverse effects. Beneficial effects of tannins include suppression of bloat (Jones *et al*., 1973) and protection of dietary proteins in the rumen (Waghorn *et al*., 1994). The adverse effects of tannins are associated with their ability to bind with dietary proteins, carbohydrates and minerals (McSweeney *et al.,* 2001).

Crude protein in the browses range from 54.0 to 300.0 g/kg. However, the browses contained considerable amounts of secondary plant metabolites, particularly tannins, which ranged from 7.0 to 214 g/kg dry matter as tannic acid equivalent (Getachew *et al*., 2002).

Saltbushes (*Atriplex spp*.) represents an important group of browses. They produce considerable amounts of biomass that can be utilized when herbaceous forage is scare. *Atriplex halimus* is found in semi-arid environments in the Mediterranean basin, where Egypt is located and is valued as livestock forage, when herbage availability is low (Le Houerou, 1993).

Atriplex halimus is characterized by its high ash and crude fiber, moderate crude protein and low crude fat contents (Gihad, 1993). However, it contains up to 10% sodium chloride and secondary plant metabolites one of them is tannin, which considerably affects its palatability and nutritive value.

The objectives of this work were to study the effect either ensiling *A. halimus* or supplementing animals by polyethylene glycol (PEG) as a tannin complexing agent on its palatability and digestion by sheep and goats.

MATERIALS AND METHODS

This study was conducted at Nubaria Experimental Farm, El-Bostan, Behaira Governorate and laboratories of Animal Department, NRC, Giza, Egypt. Succulent twigs of *Atriplex halimus* shrubs naturally grown in Nubaria desert area were cut and either sun dried or ensiled. Dried and ensiled materials were defined as hay (AH) and silage (AS). The AH was fed either alone or with a daily oral supplement of polyethylene glycol (AH + PEG) at the level of 20 g/kg DM intake. Hay was made by chopping and spreading the cut twigs on a thin plastic sheet to avoid mechanical losses and sand contamination.

Silage was made by chopping the cut twigs and adding 10% of its weight sugar cane molasses, which was diluted by fresh water. The mixture was ensiled for 45 days in hard plastic barrels with tight sealed cover.

Three mature male Rahmany sheep (31 kg) and three mature male baladi goats (21 kg) were used to evaluate nutrients digestibility and N utilization of AH, AS, AH + PEG and berseem (*Trifolium alexandrinum*) hay (BH) rations. The BH was used as a control ration. Crushed barley grains were offered to cover 50% of maintenance requirements for sheep (ARC, 1965) and goats (NRC, 1981), while tested forages were offered *ad lib*. Drinking fresh water was available for the experimental animals.

Proximate analysis and Na were determined according to A.O.A.C. (1990) methods. Goering and Van Soest (1970) methods were used to determine cell wall constituents (CWC). Tannin was determined according to Pharmacopoeia Europian (1974, 1975, 1978). Data obtained in this study was statistically analyzed according to SAS (1990). Differences among means were examined using multiple range test according to Duncan (1955).

RESULTS

The data presented in Table I showed that nutrients proximate analyses of *A. halimus* were comparable to those of berseem hay. However, it showed better CP content 13.45% vs. 11.84%. *Atriplex halimus* showed the highest ash (20.05%) compared with berseem hay and Na (3.96%) contents. NaCl content in *A. halimus* was calculated according to Ishihawa *et al*. (2002) to be 10.50%. *Atriplex halimus* contains 9.56% of the total tannins. However, the silage processing showed that a decrease in the total tannins to be 7.84%.

Berseem hay had the lowest fiber fraction (i.e. 35.34%, 19.05% & 8.44%) compared with Atriplex hay, which had the highest fiber compositions (i.e. 48.34%, 32.57% & 11.85%) for NDF, ADF and ADL, respectively. Similarly, Atriplex hay and Atriplex silage had relatively high NDF, ADF and ADL.

The daily DM intake (Table II) by both sheep and goats from barley to cover 50% of their maintenance requirement was 19.44 g/kg $w^{0.75}$. The dry matter intake (DMI) from the experimental forages as shown in Table II was variable. Both animal species consumed higher average amounts from BH (32.56 g/kg $w^{0.75}$) than AH, AS and AH + PEG, being 22.74, 21.22 and 20.40 g/kg $w^{0.75}$, respectively. The variation within DM of the latter three rations was in narrow limits. Differences between sheep and goats were out of the study objectives, therefore the results mean values for the two species were used.

Table I. Chemical analysis of experimental rations ingredients

Item	BH	AH	AS	BG
Moisture, %	12.51	12.30	65.53	10.20
Proximate analysis (DM basis) %				
OM	88.66	79.95	79.65	93.28
CP	11.84	13.45	13.99	8.49
CF	24.97	30.19	26.34	9.59
EE	3.09	4.80	4.17	1.54
NFE	48.76	31.51	35.15	73.66
Ash	11.34	20.05	20.35	6.72
Tannins	--	9.56	7.84	--
Cell wall constituents (DM basis) %				
NDF	35.43	48.34	48.27	28.67
ADF	19.05	32.57	33..04	15.79
ADL	8.44	11.85	11.42	2.17

BH = Berseem hay; AH = Atriplex hay; AS = Atriplex silage, BG = Barley grains.

The BH ration showed better nutrients digestibility than the other three rations *A. halimus* (Table II). The differences were significant (P < 0.01) between those of BH and AH and AH + PEG (except for CP), where there were no significant differences compared with those of AH + PEG. Accordingly, these results are reflected on better (P < 0.01) TDN and DCP values. Ensiling *A. halimus* showed better (P < 0.01) digestibilities for all nutrients than feeding it as hay alone or with PEG, except CP digestibility of AH + PEG, which showed comparable values. Supplementing animals fed AH by PEG improved (P < 0.01) CP digestibility, being 49.31% for AH vs 54.19% for AH + PEG, however it was almost similar to as (54.22%).

The data (Table II) of daily N balance of BH ration showed the highest (P < 0.01) N balance, which was reflected on high N balance/N intake % than rations contained *A. halimus*.

Ensiling *A. halimus* showed better (P < 0.01) N balance and accordingly N balance/N intake % than being fed as AH or AH + PEG.

Supplementing animals by PEG showed better (P < 0.01) nitrogen retention than animals fed AH rations. Meanwhile, PEG supplementation improved (P < 0.01) N retained/N intake %, being 8.03% for AH and 9.68% for AH + PEG rations.

DISCUSSION

Both berseem hay and *Atriplex halimus* showed comparable chemical nutrients contents. Nevertheless, dry matter intake by both sheep and goats from BH was higher (P < 0.01) than AH. In the other words, AH was less palatable than BH. This result might be due to high ash, Na and NaCl contents. Moreover, AH contained considerable amounts of total tannin (9.56% of DM), which seems to be an anti-nutritional factor, which decreased its palatability. Getachew *et al.* (2002) found that total tannin content in browsed plant species were ranged from 7 to 214 g/kg DM.

Table II. Daily intake, digestibility, nutritive value and nitrogen utilization of feeds and experimental rations by sheep and goats

Item	BH		AH		AS		AH+PEG		Mean of treatments			
	Sheep	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**
No. of Animals Av. Body wt:	3	3	3	3	3	3	3	3	6	6	6	6
Kg	34.92	22.53	24.53	19.54	31.26	21.66	33.69	20.98	28.72	22.06	26.46	27.33
Kg $w^{0.75}$	14.36	10.34	11.04	9.29	13.22	10.04	13.98	9.80	12.35	10.16	11.63	11.89
DMI intake g/kg $w^{0.75}$												
Forage	29.86	35.26	24.99	20.50	20.98	21.46	20.81	19.99	32.56^{a}	22.74^{b}	21.22^{b}	20.40^{b}
Barley	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44
Total DMI	49.30	54.70	44.43	39.94	40.42	40.90	40.25	39.43	52.00	42.18	40.66	39.84
Nutrient digestibility (%)												
DM	50.73	67.12	49.21	52.13	54.81	63.34	49.96	56.33	62.92^{a}	50.76^{c}	$59.o7^{ab}$	56.65^{b}
OM	57.68	65.40	50.37	53.08	58.93	58.49	53.85	58.19	61.54^{a}	51.72^{c}	58.71^{ab}	56.02^{b}
CP	51.45	57.25	48.52	50.11	53.39	55.06	50.07	58.31	54.35^{a}	49.31^{c}	54.22^{a}	54.19^{a}
EE	46.18	56.27	49.89	52.19	50.28	52.31	50.10	50.29	51.22	51.04	51.29	50.19
CF	61.26	61.59	53.93	55.23	60.37	60.37	55.73	59.73	61.42^{a}	54.58^{c}	60.37^{a}	57.73^{b}
NFE	62.56	72.00	50.64	56.73	62.34	67.37	52.09	59.45	67.28^{a}	53.68^{b}	64.85^{a}	55.77^{b}
Nutritive value (%)												
TDN	60.52	68.23	45.31	49.45	52.60	56.94	46.86	52.33	64.34^{a}	47.38^{c}	54.77^{b}	49.59^{c}
DCP	5.41	6.18	4.27	4.39	4.84	4.96	4.39	4.83	5.79^{a}	4.33^{c}	4.9^{ab}	4.61^{b}
N utilization, mg/kg $w^{0.75}$												
N intake (NI)	829	931	624	560	644	590	564	552	880^{a}	592^{c}	617^{b}	558^{c}
Fecal N	371	390	301	243	319	273	247	250	380.5^{a}	272^{bc}	296^{b}	248.5^{c}
Urinary N	329	382	281	264	252	241	268	243	355.5^{a}	272.5^{b}	246.5^{c}	255.5^{c}
N balance	129	159	42	53	73	76	49	59	144^{a}	47.5^{d}	74.5^{b}	$54oo^{c}$
N balance/NI, %	15.56	17.08	6.73	9.46	11.33	12.88	8.69	10.69	16.36^{a}	8.03^{d}	12.07^{b}	9.68^{c}

Supplementing both sheep and goats by PEG as a tannin complexing agent did not obviously affect AH palatability measured as DM intake. This result agreed with Decandia *et al.* (2000), who reported that PEG supplementation did not affect DM intake. Nevertheless, it caused higher ($P < 0.01$) increase in organic matter digestibility and crude protein digestion and utilization. They found that the *in vivo* CP digestibility of the diet increased from 37% without PEG to 71% with 50 g PEG supplementation. Moreover, Silanikove *et al.* (1996) reported a significant increase in organic matter digestibility of Mediterranean browses from maintenance level to levels considerably exceeding the maintenance requirements of goats as a result of daily supplementation of PEG. The present results are in line with the above authors findings showing that 20 g PEG daily supplementation enhanced ($P < 0.01$) organic matter and crude protein digestibilities of AH by sheep and goats. Moreover, PEG improved ($P < 0.01$) CP utilization estimated as N balance and N balance/N intake %. Similar trends were obtained by Decandia *et al.* (2000), who found that PEG increased the intake of digestible N and tended to increase N balance.

Ensiling *A. halimus* as a process to ameliorate the anti-nutritional factors effect on both sheep and goats showed better ($P < 0.01$) nutrients digestibility and nutritive value as energy (TDN) or digestible crude protein (DCP) than un-treated one, however, it did not affect its palatability measured as dry matter intake. Atriplex silage showed better ($P < 0.01$) N balance and N balance/N intake % than rations contained *A. halimus* with or without PEG.

CONCLUSIONS

Ensiling *A. halimus* as a browse forage showed comparable results to PEG supplementation. In the mean time this process might be easier and might lower feeding cost than daily PEG supplementation. Therefore, it might be preferable than the later one in developing countries to ameliorate the anti-nutritional factors effect of browsed plant species on ruminant livestock.

REFERENCES

A.O.A.C, 1990. *Official Methods of Analysis (15th Ed.)*, Association of Official Analytical Chemists: Washington, D.C. U.S.A

A.R.C, 1965. *The Nutrient Requirements of Farm Livestock* Ruminants. Agriculture Research Council, London

Decandia, M., M. Sitzia, A. Cabiddu, D. Kababya and G. Molle, 2000. The use of polyethene glycol to reduce the anti-nutritional effects of tannins in goats fed woody species. *Small Rumin. Res.*, 38: 157–64

Duncan, D.B., 1955. Multiple range and multiple F-test. *Biometrics*

Fagg, C.W. and J.L. Stewart, 1994. The value of Acacia and Prosopis in arid and semi-arid environments. *J. Arid Environ.*, 27: 3–25

Getachew, G., H.P.S. Makkar and K. Becker, 2002. Tropical browses: contents of phenolic compounds, *in vitro* gas production and stoichiometric relationship between short chain fatty acid and *in vitro* gas production. *J. Agric. Sci. Camb.*, 139: 341–52

Gihad, E.A., 1993. Utilization of high salinity tolerant plants and saline water by desert animals. *In*: Lieth, H. and A.A. Massoom (eds), *Towards the Rational Use of High Salinity Tolerant Plants*, Pp: 443–7. Kluwer Acad. Publication, The Netherlands

Goering, H.K. and P.J. Van Soest, 1970. *Forage Fiber Analysis U.S.D.A.,* P: 89. Agriculture Handbook No. 379. Washington, DC

Ishikawa, N., K. Shimizu, T. Koizumi, T. Shimizum and O. Enish, 2002. Nutrients value of Saltwort (*Salicornia herbacea L.*) as feed for ruminants. *Asian-Australian J. Anim. Sci.*, 15: 98–100

Jones, W.T., L.B. Anderson and M.D. Ross, 1973. Bloat in cattle: detection of protein precipitants (flavolans) in legumes. *New Zealand J. Agric. Res*., 16: 441–6

Le Houerou, H.N., 1993. Environmental aspects of fodder trees and shrubs plantation in the Mediterranean Basin. *In*: Papanastasis, V. (ed.), *Agriculture A Grimed Research Program: Fodder Trees and Shrubs in the Mediterranean Production Systems: Objectives and Expected Results of the EC Research Contract,* Pp: 11–34. C.E.C

McSweeney, C.S., B. Palmer, D.M. Mcneil and D.O. Krause, 2001. Microbial interactions with tannins: nutritional consequences for ruminants. *J. Anim. Feed Sci. Tech*., 91: 83–93

N.R.C, 1981. *Nutrition Requirements of Goats.* National Academy of Science, Washington, D.C

Pharmacopoeia Europian, 1974, 1957, 1978. Deutscher, Apotheker Verlag, Stutle gart, Gavi Verlag Gmbh Frankfort/M

SAS, 1990. *SAS/STST Guide for Personal Computers*, Vesi

Silanikove, N., A. Giboa, I. Nir, A. Perevolotsky and Z. Nitsan, 1996. Effect of a daily supplementation of polyethelene glycol on in intake and digestion of tannin-containing leaves (Quercus calliprinos, Pistacia lentiscus & Ceratonia siliqua) by goats. *J. Agric. Food Chem*., 44: 199–205

Silanikove, N., N. Giloboa and Z. Nitsan, 1997. Interaction among tannin supplementation and polyethelene glycol in goats fed Oak leaves. *J. Anim. Sci.*, 64: 479–83

Terrill, T.H., G.B. Douglas, A.G. Foote, R.W. Purchas, G.F. Wilson and T.N. Barry, 1992. Effect of condensed tannins upon body growth, wool growth and rumen metabolism in sheep grazing Sulla (Hedysarum coronarlum) and perenial pasture. *J. Agric. Sci. Camb*., 119: 265–73

Waghorn, G.C. and I.D. Shelton, 1997. Effect of condensed tannins in Lotus corniculatus on the nutritive value of pasture for sheep. *J. Agric. Sci. Camb*., 128: 365–72

Waghorn, G.C., I.D. Shelton, W.C. Mcnabb and S.N. Mccutcheon, 1994. Effect of condensed tannins in Lotus pedunculatus on its nutritive value for sheep. 2. Nitrogen aspects. *J. Agric. Sci. Camb*., 123: 109–19

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