Journal of Animal and Veterinary Advances 7 (3): 359-363, 2008
ISSN: 1680-5593

Forage from the Canary Isles (Spain) Adapted to Arid Lands

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Abstract: The diets of Canarian goats are severely deficient in the ratio of long fibre to concentrates; basically this is because the production of forage is very scarce in the Canary Isles. The present study was carried out to determine the nutritive value of 3 different kinds of forage adapted to arid and semi-arid conditions. The first was vinagrera (*Rumex lunaria*), an endemic shrub and the other 2, atriplex and barley (*Atriplex halimus* and *Hordeum vulgare*), are well known as forages adapted to arid land. The vinagrera had a high Crude Protein (CP) content (129 g kg^{-1} DM) with an acceptable intake (33 g kg^{-1} $P^{0.75}$) and energy value (8.4 MJ ME) whilst Atriplex showed a high fibre content (352 g kg^{-1} DM), low intake (17 g kg^{-1} DM) and an energy value of 6.8 MJ ME. Barley hay had 8.2 MJ ME, this being an acceptable value for a cereal-hay.

Key words: Saltbush, *Rumex lunaria*, forage, nutritive value, goat

INTRODUCTION

At least half of the total area of the Canary Isles (Spain) are zones receiving less than 400 mm of annual winter precipitation, as is typical for an arid Mediterranean type climate. There is a higher level of aridity in the eastern islands of the archipelago, Lanzarote and Fuerteventura, where 90% of the surface receives less than 250 mm per annum. Dairy goats are the principal farm animals in the arid and semi-arid areas and are milked for cheese production, as in many other Mediterranean basin regions (Boyazoglu and Morand-Fehr, 2001). However, in spite of the importance of cheese production, the ratio of fibre to concentrated food is 1 of the greatest problems for the goat livestock industry in the Canaries. Forage production in the islands is very scarce, owing to numerous factors such as the main industry of tourism, which takes up a large proportion of land mass, the use of irrigation water for more profitable crops such as bananas and tomatoes for export and the abandonment of farming in the sub-humid middle areas of the occidental islands which have better natural conditions for crop production and had a tradition of growing forage crops as well as fruit and vegetables for the local markets. These conditions make the importation of dietary fibre a necessity. The purchase price of concentrates is similar to that of other regions of Spain and Europe, but the fulfilment of long fibre requirements makes correct feeding too expensive for many goat farmers. These prices create costs of feeding livestock that can reach 86% of the total husbandry costs, resulting in a reduction of the amount of long fibre in the diet. This gives rise to many animal health problems, the half-life of the female milk producers decreasing as well as the percentage of milk fat content. Moreover it is well known that the lack of long fibre is a negative factor with regard to the quality of the milk, as the low fat content leads to a low quantity and quality of cheese (Morand-Fehr, 1997).

In order to produce diets adapted to the arid and semi-arid conditions the following forages have been suggested: Vinagrera (*Rumex lunaria*), Saltbush (*Atriplex halimus*) and Barley (*Hordeum vulgare*). The main advantage of all these species is the fact that they all are resistant to dry conditions. Vinagrera, an endemic Canary Island shrub, is traditionally used as a supplementary feed for livestock and has several interesting forage properties as described by Alvarez (2003), Mendez *et al.* (2003) and Ventura *et al.* (2004). Saltbush is a well known forage shrub and has been planted on more than 1 m ha of arid lands all over the world over the past 35 years (Le Houerou, 1996). It is of proven competence as a forage in areas with similar conditions (Wilson, 1977; Nefzaoui and Chermiti, 1991; Warren *et al.*, 1991; Gómez *et al.*, 1992; Delgado, 2000; Sotomayor and Miloud, 1994) and is usually consumed by ruminants in autumn period (Franclet and L´Houerou, 1971). However, both vinagrera and saltbush have only 50-60% of really edible material (leaves and branches not more than 3 mm thick). Barley

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was grown extensively in some of the Canary Isles until the middle of the 20th century, having being used as an animal feed as well as for human consumption. It has specific characteristics which makes it very useful for feeding livestock; it grows with the rain of winter and can be made into hay in the dry summer, it is tolerant to adverse conditions, can generate large volumes of forage in 1 harvest and it has a high nutritive value (Delgado, 2000).

MATERIALS AND METHODS

All the forages were obtained from the experimental farm belonging to the Canarian Agronomic Research Institute (annual rainfall 350 mm; 19°C mean annual temperature and 6-11°C mean in the coldest month, with some irrigation support being supplied if necessary. Each 1 of the 3 forages was evaluated during the appropriate period for consumption, i.e., Barley Hay in summer, saltbush and vinagrera at the beginning and end of autumn, respectively, coinciding with the season when there is no pasture production due to the dry conditions. The saltbush and vinagrera fed included branches up to 5 mm thick.

Experiment 1

Chemical composition: The 3 forages were ground through a 1 mm screen and analyzed for Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) (Van Soest *et al*., 1991). The mineral contents were determined by atomic absorption spectrophotometry (Ca, P, Mg, Fe, Zn and Mn) and by flame photometry (K and Na).

Experiment 2

Intake, *in vivo* digestibility and energy content: Following Hess and FernAndez-Rivera's (2000) methodology, 6 castrated males weighing 58±3 kg were kept in metabolic cages for 24 days, taking 4 days to change from the usual diet, allowing an adaptation time of 10 days for feeding each fresh experimental forage and using the last 10 days for data collection (72 days for the whole experiment with rest periods in between). The forage was collected and fed daily in the morning. The males had free access to water and a mineral block consisting mostly of common salt. During the last 10 days of the experiment the following samples were collected and weighed: the amount of food offered and rejected and the amount of faeces produced. Samples of feed offered were analysed as in experiment 1 and refusals and faeces were analysed for DM, OM, CP and mineral content. Forage energy was estimated through its digestible organic matter content (DOM) by predicting equations for goats for maintenance requirements: DE = 18.71 (±0.11) DOM and ME = 15.66 (±0.12) DOM (Aguilera, 2001). The voluntary intake and utilization coefficient was measured as being the difference between food offered and rejected. The mean and standard deviations were calculated for each variable (SPSS 11.0.1).

RESULTS AND DISCUSSION

Experiment 1: Table 1 shows the chemical composition of offered forages, Vinagrera, Saltbush and Barley Hay. The OM of Vinagrera was the highest of the 3 forages (870 g kg^{-1} DM), this being close to barley values and clearly different from the saltbush OM content. The CP of the vinagrera was also of a good level (129 g kg^{-1} DM) and as was that for Barley (128.2 g kg^{-1} DM). This high CP content in vinagrera had been already recorded (FernAndez and Mendez, 1989; Ventura, 1997; Ventura *et al*., 2004). The CP content in saltbush (75.6 g kg^{-1} DM) was considerably lower than that indicated by Sancha *et al*. (1994) who found levels of 141 g kg^{-1} DM, or that found by Gómez *et al*. (1992) with samples taken in autumn (127.5 g kg^{-1} DM) and summer (124.5 g kg^{-1} DM), but was relatively close to the 89 g kg^{-1} DM determined in spring by Otal *et al*. (1993). The results obtained for CP content of barley as a forage were within the range indicated by Salcedo (1998) in 5 stages of its growth and clearly higher than the results obtained by Hadjipanayiotou and Economides (1983). Barley was the forage that provided the greatest amount of digestible protein in the intestine (PDIN and PDIE) with very similar values for vinagrera, whilst saltbush showed the least protein content.

The medium-low ADF values in vinagrera coincide with other investigations on the fibrous fractions. (FernAndez and Mendez, 1989; Ventura *et al*., 1997; Ventura *et al*., 2004), this being mainly due to its high water content. Saltbush ADF content (286 g kg^{-1} DM) coincided with that indicated by Sancha *et al*. (1993) (289 g kg^{-1} DM). The ADF content in barley (267.5 g kg^{-1} DM) was between than that has been stated by Salcedo (1998) for barley at the intermediate stages of development (flowering, milky grain and dough grain) and that of the initial and final phases (panicle initiation and mature grain). Furthermore, the percentage of cell wall or NDF reached considerably high values (540 g kg^{-1} DM).

The most abundant mineral in all the samples was K ranging from 12.1 g kg^{-1} DM in vinagrera to 18.2 g kg^{-1}

Table 1: Mean values of chemical composition of offered forages

	Vinagrera	Saltbush	Barley
DM (g kg^{-1})	217.0±4.0	546.0±9.1	814.0±12.0
OM (g kg^{-1} DM)	870.0±44.0	816.0±46.5	825.9±24.1
CP (g kg^{-1} DM)	129.0±24.3	75.5±15.6	128.2±5.0
ADF (g kg^{-1} DM)	248.0±54.0	286.0±27.0	267.5±20.6
NDF (g kg^{-1} DM)	398.0±22.0	530.0±25.4	540.0±14.1
P (g kg^{-1} DM)	3.0±0.0	3.4±0.1	4.5±0.3
Ca (g kg^{-1} DM)	9.9±3.0	11.0±2.4	6.1±0.6
Mg (g kg^{-1} DM)	4.3±1.6	13.0±2.2	2.2±0.1
K (g kg^{-1} DM)	12.1±3.0	18.2±5.8	14.3±1.1

DM= Dry Matter; OM= Organic Matter; CP= Crude Protein; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber

Table 2: Intake, utilisation, digestibility coefficients and energy feeding value of offered

	Vinagrera	Saltbush	Barley
Intake (g kg^{-1} W$^{0.75}$)	33.00	17.00	30.90
Utilisation	0.65	0.61	0.69
DCP (g kg^{-1} DM)	91.00	26.00	81.00
DIN (g kg^{-1} DM)	77.00	46.00	77.00
PDIE (g kg^{-1} DM)	74.00	56.00	82.00
OMD	0.62	0.54	0.64
DMD	0.60	0.38	0.53
CPD	0.71	0.34	0.63
CFD	0.59	0.61	0.68
DE (MJ kg^{-1}DM)	10.00	8.20	9.80
ME (MJ kg^{-1}DM)	8.40	6.80	8.20

DCP= Digestible Crude Protein; PDIN= Intestine digestible protein when forage is included in a diet short of nitrogen; PDIE= Intestine digestible protein when forage is included in a diet short of energy; OMD= Organic Matter Digestibility; DMD= Dry Matter Digestibility; CPD= Crude Protein Digestibility; CFD= Crude Fiber Digestibility; DE= Digestible Energy; ME= Metabolizable Energy

DM in saltbush. The next highest mineral component in both vinagrera and saltbush samples was Ca while Na is the second highest mineral in saltbush (18 g kg^{-1} DM). Even though the values for Na were relatively high in saltbush (18 g kg^{-1} DM), they were below those found by Muñoz *et al.* (1994) and Sotomayor *et al.* (1994). Na and Cl both have an important role in the osmoregulation of this plant, thereby allowing, with their high concentration, an important physiological activity during periods of water deficiency.

Experiment 2: Table 2 shows intake, utilization percentages, digestibility coefficients and energy values. The daily average consumption of vinagrera was found to be 33 g kg^{-1} W$^{0.75}$ with a reasonable Organic Matter Digestibility (OMD) (0.62), which is appreciably larger than the *in vitro* digestibility obtained in other studies (0.44 and 0.56), in which the fiber content was nevertheless similar (Ventura, 1997; Ventura *et al.*, 2004). Saltbush was found to be the least consumed forage with 17g kg^{-1} W$^{0.75}$ daily. The Dry Matter Digestibility (DMD) of saltbush was 0.38 and the Crude Protein Digestibility (CPD) was 0.34. The most digestible fraction of this bush fodder was found to be integrated with the OM, with a coefficient of 0.54. The OMD (0.54) was greater than that indicated by Sancha *et al.* (1994) who determined a digestibility in the Manchego sheep of 0.49 and 0.45, respectively. The DMD (0.38) was considerably lower than registered for saltbush in sheep, not only by Sancha *et al.* (1994) (0.52) and (0.5), but also by Warren *et al.* (1991) for other species of atriplex*: A. undulata* (0.53), *A. lentiformis* (0.62), *A. amnicola* (0.57) and *A. cinerea* (0.60). It is possible that this result could be related to the high proportion of thick stalks in the food offered, which would reduce the nutritional value of *A. halimus*. The average consumption of barley hay was found to be 26.36 g kg^{-1} W$^{0.75}$ daily, with an utilisation level close to 0.7. OMD in cereal forages, as described by Salcedo (1998), decreasing significantly as the stages of maturity progressed. The results for *in vivo* OMD in this case were similar to those obtained by this same author for the initial period of flowering and between those of the other 2 winter cereals (Delgado, 2000).

The saltbush values of Digestible Energy (DE) (8.2 MJ Kg^{-1} DM) and Metabolizable Energy (ME) (6.8 MJ Kg^{-1} DM), despite being moderately low, were slightly greater than those found by Silva *et al.* (1985) in *A. nummularia* for the Granadine goat. The average energy values of vinagrera were estimated to be 10.0 and 8.4 MJ Kg^{-1} DM for DE and ME, slightly higher than those obtained in previous *in vitro* investigations (Mendez and FernAndez, 1992; Ventura *et al.*, 2004). This supports the idea that the *in vitro* methods lead to an underestimation compared to the *in vivo* methods in the calculation of the nutritive value of forage for ruminants. The results referring to energetic values in barley forage were acceptable for this type of hay and similar to those registered in the INRA food database (1990) for the first period of flowering in green barley.

CONCLUSION

Rumex lunaria, *Atriplex halimus* and *Hordeum vulgare* can be used as fibre supplement to improve forage to concentrate ratio in the diets of goats. These results are important for nutritional management of small ruminants fed low quality and quantity forages at intensive exploitations. This could be applied to other areas with similar conditions, mainly in the Mediterranean basin and other little favoured areas. Moreover, they contribute to the improvement and development of a sustainable management system for degraded pasture, reducing land degradation and erosion and adding value to livestock products through an adapted local feed.

ACKNOWLEDGEMENT

This work was supported by Spanish Science Ministry project RTA 01-092.

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