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The *in vitro* digestibility of pastures from semi-arid Spanish lands and its use as a predictor of degradability

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SUMMARY - The *in vitro* digestibility of dry matter (IVDMD), organic matter (IVOMD) and neutral detergent fibre (IVNDFD) of pastures selected by goats or by sheep grazing on semi-arid Spanish lands were determined using rumen liquor either from goats or sheep fed lucerne hay and the effect of the inoculum source was studied. The chemical composition of the pastures varied widely (crude protein, 77.8-125; neutral detergent fibre, 404-558; lignin, 48.2-170 g/kg dry matter). Average values of IVDMD, IVOMD and IVNDFD ranged from 46.7 to 70.5, 43.7 to 70.0 and 20.0 to 47.0%, respectively. Higher hemicellulose content was found in pastures grazed by sheep when comparing with those selected by goats. The phenological state of the available forage was found to be the major determinant of differences between animal species concerning the *in vitro* digestibility of the selected pastures. The source of the rumen inoculum did not significantly ($P>0.05$) affect the *in vitro* digestibility values. Significant linear regression equations were obtained between average IVDMD or IVNDFD and potential (PDMD) or effective (EDMD) degradability of the forages determined at grazing conditions using the nylon bag technique. It is concluded that either goats or sheep fed a standard diet can be used as donors to measure the *in vitro* digestibility of pastures and to predict their nutritive value when consumed by either of these animal species. Accurate prediction of the degradability of the pastures consumed by the grazing animals can be obtained from the *in vitro* digestibility values determined with indoors animals fed a standard diet.

Key words: Digestibility, degradability, pasture, goats, sheep.

RESUME - "La digestibilité *in vitro* des pâturages de terres espagnoles semi-arides et son utilisation comme prédicteur de la dégradabilité". La digestibilité *in vitro* de la matière sèche (IVDMD), de la matière organique (IVOMD) et de la fibre neutro-détergente (IVNDFD) de prairies sélectionnées par des caprins ou par des ovins en pâturage sur des terres espagnoles semi-arides, a été déterminée en utilisant du jus de rumen provenant de caprins ou ovins recevant du foin de luzerne, et l'effet de la source d'inoculum a été étudiée. La composition chimique des pâturages variait fortement (protéine brute, 77,8-125 ; fibre neutro-détergente, 404-558 ; lignine, 48,2-170 g/kg matière sèche). Les valeurs moyennes de IVDMD, IVOMD et IVNDFD ont varié de 46,7 à 70,5, 43,7 à 70,0 et 20,0 à 47,0%, respectivement. Une plus grande teneur en hémicellulose a été trouvée dans les prairies pâturées par des ovins par rapport à celles sélectionnées par les caprins. L'état phénologique du fourrage disponible s'est avéré être le déterminant majeur des différences entre espèces animales en ce qui concerne la digestibilité *in vitro* des pâturages sélectionnés. La source d'inoculum ruminal n'a pas affecté significativement ($P>0,05$) les valeurs de digestibilité *in vitro*. Des équations de régression linéaire significatives ont été obtenues entre les IVDMD ou IVNDFD moyennes et la dégradabilité potentielle (PDMD) ou effective (EDMD) des fourrages, déterminées en conditions de pâturage en utilisant la technique des sachets de nylon. On en a conclu que les caprins ainsi que les ovins recevant un régime standard pouvaient être utilisés comme donneurs pour mesurer la digestibilité *in vitro* des pâturages et pour prédire leur valeur nutritionnelle lorsqu'ils sont consommés par l'une quelconque de ces deux espèces animales. Une prédiction exacte de la dégradabilité des prairies consommées par les animaux en pâturage peut être obtenue à partir des valeurs de digestibilité *in vitro* déterminées sur des animaux en stabulation recevant un régime standard.

Mots-clés : Digestibilité, dégradabilité, pâturage, caprins, ovins.

Introduction

A knowledge of the nutritive value of the available pastures is essential to establish the extent to which the grazing animal can meet its nutrient requirements. Under field conditions the amount of food eaten is the main factor which determines the ability of the pasture to provide nutrients for the potential productivity of the animal. However, there is little information on the voluntary intake and

digestibility of pastures from semi-arid lands. This is due mainly to the lack of reliable field techniques. The accurate measurement of voluntary intake at grazing is still a major technical problem to be overcome, particularly when very heterogeneous pastures are concerned. Indirect methods for the assessment of food intake require the previous determination of the digestibility of the forage consumed (Cordova *et al.*, 1978). In this respect, the *in vitro* method of Tilley and Terry (1963) has proved to be very reliable for estimating the *in vivo* digestibility of pastures with heterogeneous botanical composition (Scales *et al.*, 1974; van Soest, 1982). Furthermore, rumen liquor obtained from stall fed animals provides higher accuracy to predict the *in vivo* digestibility of the forage than inoculum collected from grazing animals (Scales *et al.*, 1974).

There is some controversy regarding the digestive capacity of goats compared with sheep and those factors which determine differences between animal species (Pfister and Malechek, 1986; Domingue *et al.*, 1991; Isac *et al.*, 1994; García *et al.*, 1995). Therefore, a study which aims at comparing the ability of rumen liquor from sheep and from goats as inoculum for *in vitro* determination of digestibility seems to be of interest. On the other hand, the voluntary intake is closely related to the degradation of the forage in the rumen (Ørskov *et al.*, 1988; Shem *et al.*, 1995) but the application of the *in sacco* method normally used to estimate the forage degradability is particularly troublesome under grazing conditions.

The objectives of the present work were to determine the *in vitro* digestibility of pastures from semi-arid Spanish lands consumed by grazing goats and sheep; the effect of the animal species as donor of the rumen liquor on the *in vitro* values; and the reliability of the *in vitro* method using rumen liquor from stall fed animals as predictor of the rumen degradability of these pastures. For that purpose some data from a trial carried out on sheep and goats grazing on a semi-arid area of the province of Granada in the Southeast of Spain (García *et al.*, 1995) have been reanalyzed. Additional data from previous measurements made in the same animals have been incorporated.

Materials and methods

Samples of pastures selected by eight goats or by six wethers cograzing during four periods of the year (Period I, late autumn; Periods II, III and IV, consecutively from early spring to late summer) on a semi-arid land were used to determine IVDMD, IVOMD and IVNDFD following the Tilley and Terry (1963) method. Goats or sheep fed indoors good quality lucerne hay at maintenance level were used as inocula donors (GRL and SRL, respectively) and three internal standards which had been evaluated *in vivo* were used in each series of analyses. The effect of the source of the inoculum on the *in vitro* digestibility was analysed following a 2 (origin of the rumen liquor) x 2 (pasture selected by goats or by sheep) factorial design using the Statgraphics Statistical Program and the LSD test (STSC, 1991). As the factor 'animal species' as donor of rumen liquor failed to have a significant effect, average values were obtained and the effects of the nature of the pasture (pasture selected by goats or by sheep) and of the phenological state of the pasture (period of the year) were analysed following to a 2 x 4 factorial design.

The rumen degradability of dry matter (DMD) was determined as $DMD = a + b(1 - e^{-ct})$ using the nylon bag technique as described by García *et al.* (1995). The effective degradability (EDMD) was calculated as $EDMD = a + (bc/(c + k))$. The k value was determined using chromium-mordanted fibre as described by García *et al.* (1995). Linear and multiple regression equations were established between potential degradability (PDMD, $a + b$) or EDMD and IVDMD or IVNDFD.

Results

The forage selected by the wethers or the goats included grasses, shrubs and leaves from trees in varying relative proportions depending on the botanical composition of the available vegetation at each experimental period. The chemical composition (g/100g dry matter, DM) of the forage changed widely (Organic matter, OM: 86.6-92.9 and 86.2-93.5; crude protein, CP: 8.69-12.5 and 7.78-12.4; neutral detergent fibre, NDF: 40.4-53.1 and 42.9-55.5; acid detergent fibre, ADF: 26.1-39.9 and 25.5-43.1; lignin, ADL: 6.11-15.2 and 4.82-17.0, respectively, for the pastures selected by goats and by sheep).

In Table 1 mean values of IVDMD, IVOMD and IVNDFD of the pastures grazed by goats and by sheep are given. No statistical differences which could be ascribed to the source of the inoculum were found ($P>0.05$). These results suggest that the animal species under study when fed a good quality diet can replace each other as donors of rumen liquor to determine the *in vitro* digestibility of forages from semi-arid lands. The lowest *in vitro* digestibility coefficients were obtained in Period I, when the selected material showed the highest degree of lignification. In this period the digestibility of the forage grazed by the goats was higher than that obtained for the pasture consumed by the wethers, irrespective of the animal species from which the rumen liquor for incubation was taken (on average 6.4, 6.9 and 5.2 percentage units, respectively, for IVDMD, IVOMD and IVNDFD). Correspondingly, the pasture selected by goats contained less lignocellulose and lignin and somewhat more protein than the forage consumed by sheep. For the rest of the periods assayed differences in chemical composition between the material selected by one and the other animal species were negligible, although the pasture selected by sheep had a consistently higher hemicellulose content than that eaten by goats and their digestibility was also higher (on average 3.7, 3.6 and 3.3 percentage units, respectively for IVDMD, IVOMD and IVNDFD). Significant differences in digestibility were found between periods ($P<0.05$) as a result of changes in the chemical composition of the pasture following their phenological state. The interaction of the factors 'animal species' and 'period of the year' was highly significant ($P<0.001$).

Table 1 also shows the data concerning the potential and effective degradabilities of the grazed forage throughout the experiment. The number of incubations did not allow for a statistical analysis of the data. Differences between animal species regarding degradability were irrelevant except in Period I when noticeable differences in PDMD and EDMD favourable to sheep were found. Significant regression equations were obtained between PDMD and IVDMD ($PDMD=1.134IVDMD$, $r=0.995$, $RSD=5.45$, $P<0.001$) and IVNDFD ($PDMD=48.23+0.547IVNDFD$, $r=0.651$, $RSD=6.82$, $P<0.05$) and between EDMD and IVDMD ($EDMD=0.852IVDMD$, $r=0.998$, $RSD=2.65$, $P<0.001$) and IVNDFD ($EDMD=24.18+0.725IVNDFD$, $r=0.931$, $RSD=3.05$, $P<0.001$).

Discussion

An analysis of the changes observed in the forage digestibility and/or degradability according to period of grazing and animal species corroborates earlier observations concerning the effects on these parameters of variations in botanical and physico-chemical composition of the available substrate (Minson, 1982; du Toit *et al.*, 1995). That analysis also corroborates the hypothesis of an enhanced selective capacity of goats in comparison with sheep which would only appear whenever the proportion of cell wall material in the available pasture becomes dominant, as a result of the advanced stage of maturity or increased presence of shrubs or morphological parts of trees, leading to a comparatively greater nutritional value of the selected forage (Pfister and Malechek, 1986; Domingue *et al.*, 1991).

The absence of significant effect of the animal species as donor of rumen liquor agrees with the previous results reported by Pfister and Malechek (1986) and Isac *et al.* (1994), who did not find differences in digestive capacity between goats and sheep fed good or medium quality diets.

Although the rumen environment is likely to be different, one may expect to obtain close relationships between *in vitro* digestibility measurements made with inocula from stall fed animals and *in sacco* degradability values determined with grazing animals, due to the similarities of both degradation techniques. These relationships may be of great interest as potential degradability has been closely related to the voluntary intake of forages (Ørskov *et al.*, 1988; Shem *et al.*, 1995). On the other hand, potential and effective degradabilities describe, respectively, the maximum and effective amounts of degradable material available to the rumen microflora and, therefore, their estimation provides useful simple tool for calculating the requirements of rumen-degradable nitrogen for an efficient substrate breakdown (ARC, 1984).

Table 1. *In vitro* digestibility (%), obtained by incubation in rumen liquor of stall fed goats or sheep, and degradability (%) of the pastures from semi-arid Spanish lands consumed by grazing goats and sheep during different periods of the year^{†††}

Period of the year	Nature of the pasture	<i>In vitro</i> digestibility. Source of the rumen liquor										Degradability								
		GRL					SRL					PDMD	EDMD							
		IVDMD	IVOMD	IVNDFD	IVDMD	IVNDFD	IVDMD	IVOMD	IVNDFD	IVDMD	IVNDFD									
Period I	Pasture consumed by goats	52.5	50.4	27.7	53.6	50.8	22.5	50.5	35.2											
	Pasture consumed by sheep	46.6	42.7	21.9	46.8	44.7	18.0	65.1	39.9											
Period II	Pasture consumed by goats	68.8	67.7	39.5	71.3	70.5	42.2	80.2	58.9											
	Pasture consumed by sheep	69.0	68.3	49.9	71.9	71.6	44.9	80.9	59.8											
Period III	Pasture consumed by goats	58.8	56.2	42.2	60.2	57.0	39.1	67.9	54.8											
	Pasture consumed by sheep	64.2	61.2	47.3	63.5	60.5	46.7	69.5	55.7											
Period IV	Pasture consumed by goats	56.0	53.2	40.6	57.6	57.4	38.7	65.6	49.6											
	Pasture consumed by sheep	62.2	60.0	40.1	64.0	62.0	41.6	66.2	52.8											

[†]IVDMD: *in vitro* dry matter digestibility; IVOMD: *in vitro* organic matter digestibility; IVNDFD: *in vitro* neutral detergent fibre digestibility; GRL: rumen liquor from stall fed goats; SRL: rumen liquor from stall fed sheep

^{††}Level of significance of the statistical treatments of the *in vitro* values: 2 x 2 factorial design: Source of rumen inoculum: P>0.05; Nature of the pasture: P>0.05; 2 x 4 factorial design: Nature of the pasture: P>0.05; Period of the year: P<0.05; Interaction Nature of the pasture x Period of the year: P<0.001 for IVDMD and IVOMD, P>0.05 for IVNDFD
Standard errors: 2 x 2 factorial design; 1.52, 1.68 and 2.02, respectively, for IVDMD, IVOMD and IVNDFD; 2 x 4 factorial design, 0.307, 0.422 and 0.688, respectively for IVDMD, IVOMD and IVNDFD

Conclusion

It is concluded that either goats or sheep fed a standard diet can be used as donors of rumen liquor to measure the *in vitro* digestibility of pastures selected under grazing conditions by either goats or sheep. Accurate prediction of the degradability of the pastures consumed by grazing goats or sheep can be obtained from their *in vitro* digestibility determined with animals fed a standard diet indoors.

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