Relationship between chemical composition and *in vitro* digestibility of rangeland vegetation of northern Greece

Bouris F.[1], Babasis V.[1], Parissi Z.M.[1], Kyriazopoulos A.P.[2], Abraham E.M.[1], Sklavou P. [1]

[1]Laboratory of Range Science (236), Faculty of Forestry and the Natural Environment, AUTh, 54124 Thessaloniki, Greece
[2]Department of Forestry and Management of the Environment and Natural Resources, DUTh, 193 Pantazidou str., 68200 Orestiada, Greece
e-mail: pz@for.auth.gr

Abstract

The relationship between chemical composition and *in vitro* digestibility of some rangeland species in northern Greece was examined in the present study. Samples of herbaceous and ligneous browse species were collected during middle of June and early October. Nutritive value of the above species was evaluated based on chemical composition: crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and the *in vitro* organic matter digestibility (IVOMD). The herbaceous IVOMD did not significant correlated with any of the cell wall fractions in June. However, a significant negative correlation with NDF and a positive one with CP were found in October. Concerning the browse species IVOMD's, it was negatively related with NDF, ADF, and ADL, both in June and October. It seems that, cell walls content is a reliable predictor for both summer and autumn *in vitro* digestibility for browse species but it is not for herbaceous species.

Key words: forage quality, herbage, browse species

Introduction

The estimation of forage digestibility is probably the most useful tool of the pasture quality (Graham et al., 1997), as it is related to energy content of feed and presents a positive correlation to crude protein. It is known, that rangelands species differ in chemical composition and nutritive value, according to their botanical family and stage of maturity (Marinas et al. 2003, Bell 2003). Therefore, digestibility is mainly predicted by chemical and biological methods for each species separately.

In rangeland ecosystems floristic diversity in relation to the soil characteristics, climate, season, and management (Georgiadis and McNaughton 1990) controls the growth and maturity of each species and consequently affects forage digestibility (Arzani et al. 2006). Thus, the nutritive value of grasses and legumes in mixed pastures may be different from that in monocultures (Vazquez-de-Aldana et al. 2000). Moreover, forbs contribute to animal feed when they are in a mixture with grasses

(Cook and Wayne 1983), while they considered as less favorable feed separately.

The digestibility trials are time- consuming, laborious and require expensive facilities. Thus, the use of chemical composition could be an alternative for the indirect estimation of IVOMD. The aim of this study was to evaluate the nutritive value of herbaceous and ligneous species based on the relationship between their chemical composition and *in vitro* digestibility.

Materials and methods

Herbaceous and ligneous species from two different locations in northern Greece were tested in this research. Hand-harvested samples of the herbaceous understory vegetation of a silvopastoral oak system (*Quercus frainetto*) were collected from ten different sites in 2010. The study area was located in Cholomontas, Chalkidiki (40°23'N, 23°28'E) at 800 m a.s.l. The climate of the area is classified as subhumid Mediterranean, with a mean air temperature of 11.1°C and an annual rainfall of 767 mm. Four samples in quadrats (0.50x0.50m) were cut to 2 cm above ground level in each site. The dominant species were representative of different botanical families including grasses, legumes and forbs (*Dactylis glomerata*, *Brachypodium* sp*., Trifolium* sp*., Vicia lathyroides*, *Galium* sp*., Silene* sp*.* etc) which have different forage characteristics (Van Soest 1994). At the meantime hand-plucked samples (i.e. leaves and twigs <2 mm) of four ligneous browse species (the evergreen shrubs *Arbutus unedo* L., *Arbutus andrachne* L. and the deciduous *Robinia pseudoacacia* var. *monophylla* L., and *Morus alba* L.) from the Aristotle University's farm, Thessaloniki (40° 34′ E, 23°43′ N, at sea level) were collected. The climate of the area is semi-arid, with a mean annual temperature of 16.4°C, and a mean annual precipitation of 374 mm. For each species, foliage from four individual plants was collected. Both herbaceous and ligneous samples were collected at two vegetative stages: at reproductive (middle of June) and at regrowth (early October).

The samples were oven-dried at 60°C for 48 hours, ground through a 1 mm screen and analyzed for N using a Kjeldahl procedure (AOAC, 1990). Crude protein (CP) was then calculated by multiplying the N content by 6.25. Additionally, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1991). *In vitro* organic matter digestibility (IVOMD) of the samples was

determined using Tilley and Terry (1963) method as modified by Moore's (Harris, 1970).

The procedures of SPSS 10.0 for Windows statistical software were used for the implementation of Pearson correlation between chemical composition and *in vitro* digestibility (Steel and Torrie,1980).

Results and Discussion

There was a significant positive correlation (Tables 1, 2) between IVOMD and CP in herbaceous vegetation both in June and October, although it was weak. This finding is in agreement with results reported by Getachew et al. (2004).

Table 1. Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for herbaceous species in June

	NDF	ADF	ADL	IVOMD
CP	-0,265	-0,736**	0,187	0,439*
NDF	1	0,358	-0,448*	-0,298
ADF		1	-0,417*	0,377
ADL			1	-0,230

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: *In vitro* organic matter digestibility, *Significant at ** P< 0.01, * P<0.05*

Table 2. Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for herbaceous species in October

	NDF	ADF	ADL	IVOMD
CP	-0,884**	-0,342	0,219	0,386*
NDF	1	0,534**	-0,175	-0,478*
ADF		1	0,392*	-0,273
ADL			1	-0,168

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** P< 0.01, * P<0.05

Moreover, IVOMD was significantly negative correlated (P<0.05) only with NDF (Table 2) in October (r=−0,478), while it was not significantly correlated with any cell walls parameter (NDF, ADF, ADL) in June. Similar negative correlations between NDF and ADF with digestibility have been found by Moreira et al. (2004). On the contrary, Marinas et al. (2003), found strong negative correlation between IVOMD with NDF and ADF in herbage

species, but a weak correlation with ADL in consistent with our findings (Tables 1, 2). These findings indicated that it is very difficult to use indirect methods in order to predict IVOMD for herbaceous species. This may be attributed to high variance of chemical composition among species due to different stage of maturity (Aguiar et.al. 2011).

In the ligneous browse species, IVOMD was significantly positive correlated (P<0.01) with CP only in June (Tables 3, 4). Similar, Arzani et al. (2006), working with forage species of Zagros Mountain, found a significant positive correlation of IVOMD with CP. Concerning the cell wall components, there was a significant negative strong correlation (p<0.01) with IVOMD both in June and October (Tables 3, 4).

Table 3. Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for ligneous species in June

	NDF	ADF	ADL	IVOMD
CP	0,139	-0,307	-0,090	0,230
NDF	1	0,555	0,815**	-0,772*
ADF		1	0,887**	-0,916**
ADL			1	-0,940**

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** P< 0.01, * P<0.05

These results are in agreement with those of Ammar et al. (2004), who found a strong negative correlation between IVOMD and both ADF (r=-0,659) and ADL (r=-0,701), in Spanish browse species, collected at different stage of maturity from spring to autumn. In addition, Papachristou (1990) found higher correlation between *in vitro* digestibility and ligneous species compared to grasses and forbs in shrublands in northern Greece.

Table 4. Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for ligneous species in October

	NDF	ADF	ADL	IVOMD
CP	0,076	-0,617	-0,163	0,370*
NDF	1	0,524	0,907*	-0,880*
ADF		1	0,818*	-0,849*
ADL			1	-0,965**

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** P< 0.01, * P<0.05

Among the cell walls parameters, ADL exhibited the highest correlation with IVODM. The composition and structure of the cell walls may affect digestibility to a greater extent than its content, depending on its degree of lignification (Van Soest, 1994, Ammar et al. 2004), and resulting in higher negative correlations of the in vitro digestibility with ADL than with NDF content.

Conclusions

The prediction of *in vitro* digestibility of herbaceous species based on the chemical composition parameters had weak correlation with cell walls parameters. However, the correlation with CP was good. On the other hand, indirect estimation of *in vitro* digestibility using cell walls parameters is reliable predictor for browse species both in summer and autumn.

References

Aguiar A.D., L.O. Tedeschi, F.M. Rouquette Jr, K. McCuistion, J.A. Ortega-Santos, R. Anderson, D. DeLaney and S. Moore, 2011. Determination of nutritive value of forages in south Texas using an *in vitro* gas production technique. *Grass and Forage Science*, 66: 526–540.

Ammar H., S. López, J.S. González and M.J. Ranilla, 2004. Chemical composition and *in vitro* digestibility of some Spanish browse plant species. *Journal of the Science of Food and Agriculture,* 84(2):197–204.

AOAC, 1990. Official Method of Analysis, 15th edn. AOAC, Washington DC, USA, 746 pp.

Arzani H., M. Basiri, F. Khatibi, and G. Ghorbani, 2006. Nutritive value of some Zagros Mountain rangeland species. *Small Ruminant Research,* 65:128–135.

Bell A., 2003. Pasture assessment and livestock production. Agnote series DPI-428 (1st edition). State of New South Wales.

Cook C., Wayne, 1983. "Forbs" need proper ecological recognition, *Rangelands*, 5: 217–220.

Georgiadis N.J. and S.J. McNaughton, 1990. Elemental and fibre content of savannah grasses. Variation with soil type, season and species. *Journal of Applied Ecology*, 27: 623-634.

Getachew G., P.H. Robinson, E.J. Depeters and S.J. Taylor, 2004. Relationships between chemical composition, dry matter degradation and *in vitro* gas production of several ruminant feeds. *Animal Feed Science and Technology*, 111: 57–71.

Graham P., A. Bell and C. Langford, 1997. How pasture characteristics influence sheep production. Agnote series 4-51 (2nd edition). State of New South Wales.

Harris L.E., 1970. Nutrition Research Techniques for Domestic and Wild Animals. Vol. 1. L.E. Harris, Logan, UT. pp. 5501-5505.

Marinas A., R. García-González and M. Fondevila, 2003. The nutritive value of five pasture species occurring in the summer grazing ranges of the Pyrenees. *Animal Science*, 76:461-469.

Moreira F.B., I.N. Prado, U. Cecato, F.Y. Wada and I.Y. Mizubuti, 2004. Forage evaluation, chemical composition, and *in vitro* digestibility of continuously grazed star grass. *Animal Feed Science and Technology*, 113:239–249.

Papachristou T.G.,1990. Botanical composition and nutritive value of goat diets on shrublands with different proportions of shrubby and herbaceous species. PhD Thesis. Aristotle University of Thessaloniki, Greece. 145 pp.

Steel R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics, 2nd ed. McGraw-Hill, New York, USA, 481 pp.

Tilley J.A. and R.A. Terry, 1963. A two-stage technique for the *in vitro* digestion of forage crop. *Journal of British Grassland Society*, 18:104-111.

Van Soest P.J., 1994. Nutritional Ecology of the Ruminant. (2nd ed.) C. U. Press, Ithaca, NY.

Van Soest P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74: 3583-3597.

Vazquez-de-Aldana B. R., A. Garcia-Ciudad, M. E. Perez-Corona and B. Garcia-Criado, 2000. Nutritional quality of semi-arid grassland in western Spain over a 10-year period: changes in chemical composition of grasses, legumes and forbs. *Grass and Forage Science*, 55: 209-220.