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Chemical Composition, Ruminal Dry Matter, Crude Protein and Cell Wall Degradation Kinetics of Pasture Forages Dominant in the West Provinces of Iran

Research Article

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ABSTRACT

The objectives of this study were to determine and compare the chemical composition and ruminal degradability of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) of ten pasture forage species dominant in the west provinces of Iran. Duplicate nylon bags of pasture samples were suspended in the rumen of four wethers for up to 96 h. The chemical composition of forages varied from 54 to 212 g/kg DM for CP, 239 to 638 g/kg DM for NDF, 190 to 378 g/kg DM for ADF and 60 to 108 g/kg DM for ash. The effective DM degradability at rumen outflow rate of 0.05/h was different ($P<0.05$) between forages and varied from 307 g/kg for *Festuca ovina* to 679 g/kg for *Prangus ferulacea*. The lowest CP degradability was for *Festuca ovina* (402 g/kg) and the highest for *Bromus tomentellus* (760 g/kg). The lowest NDF and the highest ADF degradability were for *Hordeum bulbosum* and *Prangus ferulacea*, respectively. The results of this study showed that the rate and extent of ruminal CP and cell wall degradation were different among forages, therefore must be considered as a main parameter in ration formulation of grazing ruminants.

KEY WORDS chemical composition, pasture species, ruminal degradation.

INTRODUCTION

In the extensive production systems, forage has an important role in ruminant nutrition in terms of providing energy, protein and minerals, as well as fibre for chewing and rumination. Cell wall carbohydrates are the most relevant components of pasture forages (Van Soest, 1994). Determination of ruminal crude protein and cell wall degradation characteristics is valuable in feed evaluation (Allen and Mertens, 1988). Chemical composition, in combination with ruminal degradability of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were widely used to determine the potential nutritive value of forages (Evitayani *et al*. 2004; Fujihara *et al*. 2005; Kamalak *et al*. 2005a; Kamalak *et al*. 2005b; Karabulut *et al*. 2007; Aydin *et al*. 2007; Dongmei *et al*. 2008).

Natural pastures are the most important feed resources for ruminant livestock in the west provinces of Iran. In spite of this, the available information on the chemical composition, crude protein and cell wall degradation characteristic of pasture forages dominant in the west provinces of Iran are scarce (Arzani *et al*. 2001). Therefore, this study was designed to determine and compare chemical composition and ruminal DM, CP, NDF and ADF degradation characteristics of ten pasture forage species.

MATERIALS AND METHODS

Ten forage samples of the following pasture species were tested: hairy vetch (*Vicia villosa*, legume), downy Brome (*Bromus tomentellus*, grass), bulbous barley grass (*Hordeum bulbosum*, grass), sheep fescue (*Festuca ovina*, grass), wheat grass (*Agropyron tauri*), wheat grass (*Agropyron trichophorum*), *Prangus ferulacea* (umbellilerae), Ushak gum (*Ferula orientalis*, umbellilerae), sweet peas (*Lathyrus odoratus*, legume), Medusahead (*Taeniatherum caput-mesusae*).

Forage collection was carried out at the vegetative stage on the same date (30 May 2011) from permanent pastures located in south of the West Azerbaijan and north of Kurdistan provinces of Iran (Figure 1).

Forages were collected by hand from four 1 metre square areas and then were pooled. Three samples (800 g each) were obtained from each pooled material. Forage samples were dried and ground in a Wiley mill through a 1 mm screen, and stored at 4 °C for 5 weeks for furtherchemical analyses. For in situ procedure, forage samples were ground through a 4 mm screen.

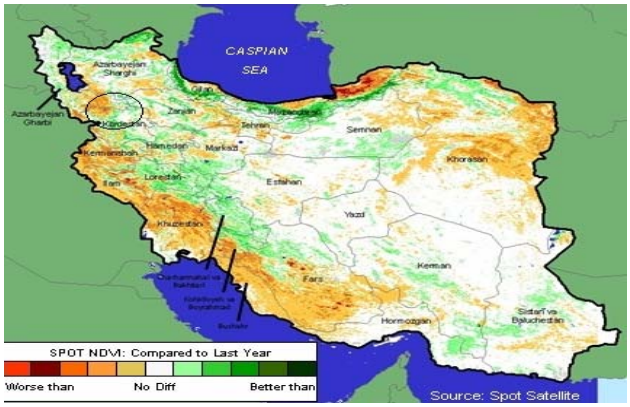

Figure 1 Area of pastures (circle) located in the south of West Azerbaijan and in the north of Kurdistan provinces, Iran

Four castrated male sheep (Zandi breed, weighing approximately 56 kg and 13 months old) fitted with rumen fistulas. The sheep were fed twice daily (08:00 and 16:00 h) on a ration containing 150 g concentrate (barley, soya bean meal, cottonseed meal, wheat bran, salt, dicalcium-phosphate, and vitamin+mineral premix at the level of 510, 150, 100, 210, 10, 10 and 10 g/kg DM, respectively) and 850 g alfalfa hay.

Procedure of ruminal incubation followed the method of Ørskov and McDonald (1979). Nylon bags (10 cm×20 cm; sample surface ratio 25 mg/cm; 46 µm pore size) were filled with 5 g of dried forage that had been ground previ usly through a 4 mm screen. Duplicate bags were prepared for each incubation period for each sheep (8 replicates for each sample). All nylon bags were soaked in tepid (39 °C) water for 20 min prior to insertion into the rumen to remove water soluble components and reduce lag time associated with wetting. Nylon bags were incubated in the rumen for 0, 4, 8, 12, 16, 24, 48, 72 and 96 h. The bags were washed three times for 5 min in a turbine washing machine (Jata, model 582, Spain). Bags were then dried to a constant weight at 60 °C for 48 h and weighed.

Forage samples were analysed for DM (method no. 930.15), CP (method no. 984.13), ether extract (method no. 920.39) and ash (method no. 924.05) by procedures of Association of Official Analytical Chemists (AOAC, 1995). Dry matter and CP content of forage residues after rumen incubation were also determined by the respective methods. NDF and ADF were analyzed according to the method of Van Soest *et al.* (1991) using an automatic fiber analyzer (Fibertec System M, Tecator). All chemical analyses were carried out in triplicate and the averaged value was considered for statistical analysis.

Degradation kinetics parameters of DM, CP, ADF and NDF were determined according to the equation of Ørskov and McDonald (1979). The various degradability parameters for the nylon bags were analyzed as a randomized complete block design (animals as the blocks). Analysis was carried out using the general linear model procedure of SAS (1996). The differences between means were separated at P<0.05 using Tukey test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The chemical composition of forages is given as mean values in Table 1. Among the forages, CP content varied between 54 g/kg DM (*Festuca ovina*) to 212 g/kg DM (*Lathyrus odoratus*). The content of NDF varied between 239 g/kg DM (*Ferula orientalis*) to 638 g/kg DM (*Agropyron trichophorum*).

The dry matter degradation characteristics of forages are shown in Table 2. The results showed that the effective DM degradability and degradation characteristics of these forages in the rumen were differ (P<0.05). The a fraction of DM ranged from 112 g/kg (*Festuca ovina*) to 490 g/kg (*Lathyrus odoratus*).

The washout DM fraction was the highest (P<0.05) for umbellilerae, intermediate for legumes and the lowest for grasses. The b fraction ranged from 329 g/kg (*Festuca ovina*) to 626 g/kg (*Taeniatherum caput-medusae*). Degradation rate of the b fraction of DM was the highest for *Festuca ovina* (0.073/h) and the lowest for *Agropyron trichophorum* (0.038/h). The effective DM degradability at rumen out flow rate 0.05/h varied (P<0.05) from 307 g/kg (*Festuca ovina*) to 679 g/kg (*Prangus ferulacea*). The CP degradation characteristics of forage species are presented

in Table 3. The effective rumen degradation and degradation characteristics of CP were differ (P<0.05) among different species. The fraction of CP ranged from 108 g/kg for *Festuca ovina* to 372 g/kg for *Bromus tomentellus*. For legumes, the fraction was higher (P<0.05) than that of grasses. The b fraction ranged from 433 g/kg (*Ferula orientalis*) to 595 g/kg (*Prangus ferulacea*). Degradation rate of b fraction was the highest for *Prangus ferulacea* (0.12/h) and the lowest for *Agropyron trichophorum* (0.086/h). The effective rumen degradation of CP at rumen outflow rate of 0.05/h was the highest for *Bromus tomentellus* (760 g/kg) and the lowest for *Festuca ovina* (402 g/kg). Results showed that NDF degradation characteristics of these pasture species were different (P<0.05), Table 4. The a fraction was the highest (P<0.05) for *Prangus ferulacea* and the lowest (P<0.05)

Table 1 Chemical composition of pasture forages (n=9, g/kg dry matter)

Forag species	Dry matter	Crude protein	Ether extract	NDF[1]	ADF[2]	Ash
V. villosa	921	197	15	398	357	92
L. odoratus	916	212	21	307	272	102
B. tomentellus	927	143	21	451	273	108
H. bulbosum	934	94	23	611	192	80
F. ovina	941	54	30	626	190	73
A. tauri	934	123	25	604	348	65
A. trichophorum	939	72	38	638	378	73
P. ferulacea	891	122	34	251	244	79
F. orientalis	892	102	47	239	232	91
T. caput-medusae	930	124	38	512	287	60

[1] NDF: neutral detergent fiber.
[2] ADF: acid detergent fiber.

Table 2 Dry matter degradation characteristics of pasture forages (n=8)

Forage pecies	Degradation traits[1] (g/kg)				ERD (g/kg)[2] at outflow rate (/h)		
	a	b	a + b	c (/h)	0.02	0.05	0.08
V. villosa	310^{d}	437^{e}	747^{c}	0.056^{b}	632^{d}	541^{bc}	490^{c}
L. odoratus	490^{a}	376f^{g}	866^{b}	0.044^{cd}	748^{b}	666^{a}	623^{a}
B. tomentellus	291^{d}	563^{b}	854^{b}	0.042^{d}	672^{c}	548^{bc}	485^{c}
H. bulbosum	165^{g}	362^{g}	527^{f}	0.049^{c}	422^{g}	344^{f}	302^{g}
F. ovina	112^{h}	329^{h}	441^{g}	0.073^{a}	370^{h}	307^{g}	269^{h}
A. tauri	192^{f}	515^{c}	707^{d}	0.060^{b}	578^{e}	473^{d}	413^{e}
A. trichophorum	199^{f}	450^{e}	649^{e}	0.038^{d}	494^{f}	393^{e}	344^{f}
P. ferulacea	416^{b}	483^{d}	899^{a}	0.060^{b}	778^{a}	679^{a}	623^{a}
F. orientalis	382^{c}	386^{f}	768^{c}	0.043^{cd}	645^{d}	560^{b}	517^{b}
T. caput-medusae	250^{e}	626^{a}	876^{ab}	0.042^{d}	674^{c}	535^{c}	465^{d}
SEM[3]	22.8	19.1	20.9	0.0053	18.2	17.6	16.3

[1] a: the washout fraction; b: the potentially degradable fraction and c: the rate of degradation.
[2] ERD: effective ruminal degradation.
[3] SEM: standard error of the means.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Table 3 Crude protein degradation characteristics of pasture forages (n=8)

Forage species	Degradation traits[1] (g/kg)				ERD[2] (g/kg)[2] at outflow rate (/h)		
	a	b	a + b	c (/h)	0.02	0.05	0.08
V. villosa	345^{b}	506^{b}	851^{b}	0.096^{bc}	763^{c}	677^{c}	621^{c}
L. odoratus	334^{bc}	512^{b}	846^{b}	0.092^{cd}	754^{c}	665^{c}	608^{c}
B. tomentellus	372^{a}	583^{a}	955^{a}	0.100^{b}	858^{a}	760^{a}	696^{a}
H. bulbosum	128^{f}	445^{c}	427^{c}	0.088^{d}	490^{f}	412^{f}	361^{f}
F. ovina	108^{f}	456^{c}	436^{c}	0.091^{cd}	482^{f}	402^{f}	350^{f}
A. tauri	287^{d}	489^{b}	224^{e}	0.118^{a}	705^{d}	630^{d}	578^{d}
A. trichophorum	223^{e}	435^{c}	342^{d}	0.086^{d}	576^{e}	498^{e}	448^{e}
P. ferulacea	313^{c}	595^{a}	92^{f}	0.120^{a}	823^{b}	733^{b}	670^{b}
F. orientalis	356^{ab}	433^{c}	211^{e}	0.100^{b}	717^{d}	644^{d}	596^{cd}
T. caput-medusae	351^{ab}	589^{a}	940^{a}	0.092^{cd}	835^{b}	732^{b}	666^{b}
SEM[3]	19.4	19.7	20.5	0.0051	18.9	17.8	21.6

[1] a: the washout fraction; b: the potentially degradable fraction and c: the rate of degradation.
[2] ERD: effective ruminal degradation.
[3] SEM: standard error of the means.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

for *Hordeum bulbosum* and *Agropyro tauri* (27 g/kg). The b fraction was the lowest (P<0.05) for *Festuca ovina* (356 g/kg) and the highest for *Taeniatherum caput-medusae* (841 g/kg). The degradation rate was the highest (P<0.05) for *Agropyron tauri* (0.057/h) and the lowest for *Lathyrus odoratus* (0.033/h).

The effective NDF degradability at rumen outflow rate of 0.05/h was the highest for *Prangus ferulacea* (488 g/kg) and lowest for *Hordeum bulbosum* (219 g/kg). Differences (P<0.05) on ADF degradation characteristics were observed in most of the pasture species (Table 5). The a fraction of ADF ranged from 10 g/kg (*Hordeum bulbosum*) to 99 g/kg (*Prangus ferulacea*). The b fraction was the lowest (P<0.05) for *Lathyrus odoratus* (414 g/kg) and the highest for *Prangus ferulacea* (825 g/kg). Degradation rate of b fraction was the highest for *Lathyrus odoratus* (0.038/h) and the lowest for *Agropyron tauri* (0.027/h). The effective rumen degradation of CP at rumen outflow rate of 0.05/h was the highest for *Prangus ferulacea* (408 g/kg) and the lowest for *Hordeum bulbosum* (183 g/kg).

Van Soest *et al*. (1978) reported a trend for higher rates of NDF accumulation in grasses compared with legumes. About NDF degradability, Van Soest *et al*. (1978) noted that extent and nature of lignification of forage cell walls control this parameter, which in turn is a function of various factors, such as forage species, maturity, number of harvest, latitude and climate.

Table 4 Neutral detergent fiber degradation characteristics of pasture forages (n=8)

Forage species	Degradation traits[1] (g/kg)				ERD[2] (g/kg) at outflow rate (/h)[2]		
	a	b	a + b	c (/h)	0.02	0.05	0.08
V. villosa	81^{d}	546^{f}	627^{c}	0.036^{de}	432^{f}	310^{f}	250^{f}
L. odoratus	35^{f}	781^{c}	816^{b}	0.033^{e}	521^{d}	346^{d}	263^{e}
B. tomentellus	106^{b}	723^{d}	829^{b}	0.036^{de}	570^{c}	408^{c}	330^{c}
H. bulbosum	27^{g}	445^{g}	472^{e}	0.038^{d}	318^{h}	219^{h}	170^{g}
F. ovina	108^{b}	356^{h}	464^{e}	0.052^{b}	365^{g}	289^{g}	248^{f}
A. tauri	27^{g}	605^{e}	632^{c}	0.057^{a}	474^{e}	349^{d}	251^{f}
A. trichophorum	49^{e}	525^{f}	574^{d}	0.038^{d}	392^{h}	331^{e}	283^{d}
P. ferulacea	116^{a}	815^{b}	931^{a}	0.042^{c}	668^{a}	488^{a}	396^{a}
F. orientalis	93^{c}	533^{f}	626^{c}	0.035^{de}	432^{f}	312^{f}	255^{e}
T. caput-medusae	94^{c}	841^{a}	935^{a}	0.036^{de}	634^{b}	446^{b}	355^{b}
SEM[3]	6.5	19.6	25.3	0.0041	19.8	17.8	13.6

[1] a: the washout fraction; b: the potentially degradable fraction and c: the rate of degradation.
[2] ERD: effective ruminal degradation.
[3] SEM: standard error of the means.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Table 5 Acid detergent fiber degradation characteristics of pasture forages (n=8)

Forage species	Degradation traits[1] (g/kg)				ERD[2] (g/kg)[2] at outflow rate (/h)		
	a	b	a + b	c (/h)	0.02	0.05	0.08
V. villosa	66^{d}	525^{e}	591^{d}	0.038^{a}	410^{d}	292^{d}	235^{d}
L. odoratus	75^{c}	414^{h}	489^{gh}	0.038^{a}	346^{e}	254^{e}	208^{e}
B. tomentellus	72^{cd}	761^{c}	833^{c}	0.028^{b}	515^{c}	345^{c}	269^{c}
H. bulbosum	10^{g}	461^{g}	471^{h}	0.030^{bc}	286^{f}	183^{h}	135^{h}
F. ovina	73^{cd}	446^{gh}	519^{fg}	0.035^{ab}	356^{e}	256^{e}	208^{e}
A. tauri	12^{g}	589^{d}	601^{d}	0.027^{c}	350^{e}	218^{g}	160^{d}
A. trichophorum	36^{f}	489^{fg}	525^{f}	0.035^{ab}	348^{e}	237^{f}	185^{g}
P. ferulacea	99^{a}	825^{a}	924^{a}	0.030^{bc}	594^{a}	408^{a}	324^{a}
F. orientalis	50^{e}	495^{f}	545^{e}	0.030^{bc}	347^{e}	235^{f}	185^{f}
T. caput-medusae	87^{b}	796^{b}	883^{b}	0.029^{bc}	558^{b}	379^{b}	299^{b}
SEM[3]	5.7	20.5	19.7	0.0052	16.5	14.2	13.8

[1] a: the washout fraction; b: the potentially degradable fraction and c: the rate of degradation.
[2] ERD: effective ruminal degradation.
[3] SEM: standard error of means.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

CONCLUSION

The results of this study showed that the rate and extent of ruminal CP and cell wall degradation are different among pasture forages. The differences of between forage species in the rate and extent of fiber degradation are likely the most major causes of the differences which can be seen in forage intake by grazing ruminants, therefore, these characteristics must be considered as one of the main parameters in ration formulation of these animals.

REFERENCES

Allen M.S. and Mertens D.R. (1988). Evaluating constraints of fibre digestion by rumen microbes. *J. Nutr.* **118,** 261-270.

Arzani H., Torkan J., Jafari M., Jalili A. and Nikkhah A. (2001). Effects of phenological stages and ecological factors on forage quality of some range species. *Iranian J. Agric. Sci.* **32,** 385-397.

AOAC. (1995). Official Methods of Analysis. 16th Ed. Association of Official Analytical Chemists, Arlington, VA, USA.

Aydin R., Kamalak A. and Canbolat O. (2007). Effect of maturity on the potential nutritive value of burr medic (*Medicago polymorha*) hay. *J. Biologic. Sci*. **7,** 300-304.

Dongmei X., Wanapat M., Weidong D., Tianbao H., Zhi-fang Y. and Huaming M. (2008). Comparison of Gayal (*Bos frontalis*) and Yunnan yellow cattle (*Bos taurus*): *in vitro* dry matter digestibility and gas production for a range of forages. *Asian–australas. J. Anim. Sci.* **20,** 1208-1214.

Evitayani L., Warly A., Fariani T. and Fujihara T. (2004). Study on nutritive value of tropical forages in North Sumatra, Indonesia. *Asian–australas. J. Anim. Sci.* **17,** 1518-1523.

Fujihara T., Osuga I.M., Abdulrazak S.A. and Ichinohe T. (2005). Chemical composition, degradation characteristics and effect of tannin on digestibility of some browse species from Kenya harvested during the wet season. *Asian–australas. J. Anim. Sci.* **18,** 54-60.

Kamalak A., Canbolat O., Gurbuz Y., Erol A. and Ozay O. (2005a). Effect of maturity stage on the chemical composition, *in vitro* and in situ degradation of tumbleweed hay (*Gundelia tuonefortii*). *Small Rumin. Res.* ***58,*** 149-156.

Kamalak A., Canbolat O., Gurbuz Y., Ozkan O.O. and Kizilsimsek M. (2005b). Determination of nutritive value of wild mustard, *Sinapsis arvensis*, harvested at different maturity stages using in situ and *in vitro* measurements. *Asian–australas. J. Anim. Sci.* **18,** 1249-1254.

Karabulut A., Canbolat O., Kalkan H., Gurbuzol F., Sucu E. and Filya I. (2007). Comparison of *in vitro* gas production, metabolizable energy, organic matter digestibility and microbial protein production of some legume hays. *Asian–australas. J. Anim. Sci.* **20,** 517-523.

Ørskov E.R. and McDonald I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. Agric. Sci*. **92,** 499-503.

SAS Institute. (1996). SAS®/STAT Software, Release 6.11. SAS Institute, Inc., Cary, NC.

Steel R.G.D. and Torrie J.H. (1980). Principles and Procedures of Statistics: A Biometrical Approach. McGraw Hill, New York, USA.

Van Soest P.J. (1994). Nutritional Ecology of the Ruminant. Cornell University Press, Ithaca, USA.

Van Soest P.J., Mertens D.R. and Deinum B. (1978). Preharvest factors influencing quality of conserved forage. *J. Anim. Sci*. **47,** 712-720.

Van Soest P.J., Robertson J.B. and Lewis B.A. (1991). Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. *J. Dairy Sci*. **74,** 3583-3597.