The Journal of Animal & Plant Sciences, 23(1): 2013, Page: 45-49
ISSN: 1018-7081

CHEMICAL COMPOSITION, MINERAL PROFILE, PALATABILTIY AND *IN VITRO* DIGESTIBILITY OF SHRUBS

I. Rahim, J. I. Sultan, M. Sharif† and M. Q. Bilal*

Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan
*Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan
†Corresponding Author e-mail: drsharifuaf@yahoo.com

ABSTRACT

This study determined the nutritive value of *Indigoferra gerardiana, Marisine affricana, Impashion bicolor* and *Adhatoda vesica* shrubs for ruminants. Chemical analysis revealed that dry matter (DM) content varied from 22.2% (*Dodonia viscosa*) to 33.6% (*Debregeasia salicifolia*). Maximum crude protein (19.8%) was observed for *Anisomoles indica*, while, neutral detergent fiber was greater (67%) in *Dodonia viscosa*. Lower acid detergent fiber (27%) and higher hemicellulose (32%) were observed for *Desmodiem spp.* and *Anisomoles indica*, respectively. Lignin contents varied between 4.9% (*Desmodiem spp.*) to 7.7% (*Dodonia viscosa*). The ash contents were higher (13.2%) in *Debregeasia salicifolia* than other species. The Ca, 0.62-1.3 %; P, 0.031-0.054 %; K, 0.6-1.03 %; Mg 7-41 ppm; Cu, 12.5-23 ppm; Zn, 2.3-48.7 ppm; Mn, 8-18 ppm and Co, 0.025-0.068 ppm were observed among shrub species. The Ca:P ratio in *Debregeasia salicifolia, Anisomoles indica, Desmodiem spp*. and *Dodonia viscosa* was much wider (32.5, 29.03, 13.78 and 17.19, respectively). Potential intake rate and relative preference as indicators of palatability were found higher (67.5 g/sheep/4min and 83.2%, respectively) for *Debregeasia salicifolia,* while, *in vitro* DM digestibility and metabilizable energy values were higher (61.2%, 9.54 MJ/kgDM, respectively) for *Anisomoles indica*. Based on chemical composition, in vitro digestibility and palatability, shrub species were ranked as *Marisine affricana* > *Indigoferra gerardiana* > *Impashion bicolor* > *Adhatoda vesica* for ruminants.

Key words: Shrubs, chemical composition, mineral profile, in vitro digestibility, palatability.

INTRODUCTION

Shrubs, a component of ruminant diet, play an important role in the nutrition of grazing animals (Holechek 1984; Meuret *et al*. 1990; Papachristou and Nastis 1996). At present Pakistan is deficient by 40 and 80% in forage and concentrate feeds, respectively (Pasha 1998). Moreover, the existing feed resources are providing only 62 and 74% of the required crude protein (CP) and total digestible nutrients (TDN), respectively, resulting in low productivity of livestock in the country (Sarwar *et al*. 2009).

Shrubs offer a potential alternative forage source for small ruminants in tropical countries especially during periods of scarcity when both quality and quantity of fodder is scarced. In addition to grasses and legumes, shrubs are widely available and inexpensive source of feed for small ruminants. Therefore, shrubs being valuable supplements providing variety to grasses and have considerable potential in supporting economical animal production in developing conutries (Devendra 1989), moreover, their addition in ruminant diet can help to minimize the wide gap between availability and supply of nutrients, resulting in improved livestock productivity.

Little information regarding the nutritive value of shrubs widely used for small ruminants in hillyareas of the country are available, therefore, present study was conducted to envisage the nutritional evalutation of shrubs by their chemical composition, mineral profile, palatabiltity and *in vitro* digestibility.

MATERIALS AND METHODS

Collection of samples: Leaves of *Indigoferra gerardiana, Marisine affricana, Impashion bicolor* and *Adhatoda vesica* shrubs were collected from valley of Chagharzai, district Bunair, North Trans-Himalayan zone, Malakand Division, North West Frontier Provence, Pakistan. Five shrubs of each species were sampled. Approximately 1 kg leaves sample was harvested from each species as a single sample harvested from a shrub. Thereafter, composite sample of leaves was prepared for each species. The leaf samples were dried in an oven (Mommert, Germany) at 55^{o}C for 48 h and saved in polythene bags.

Chemical analysis: The samples of shrubs species were ground through 2 mm screen in Willey mill and analyzed for dry matter (DM), N, ash (AOAC 1995), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL; Van Soest *et al*. 1991). The CP was calculated as CP= N x 6.25. Hemicellulose was determined by difference of NDF and ADF. Following the wet digestion (nitric acid and perchloric acid), Na was determined by the flame photometer (Jenway PFP7, UK).

The Ca, P, Mg, Cu, Co, Mn and Zn were determined by atom absorption sepectrophotometry (model 4; Perkin-Elmer, Norwalk, CT, USA). All chemical analyses were done in triplicate.

Palatability: Four mature sheep (average body weight 40 kg) were used to determine palatability. The sheep were adapted for 5 weeks to the mixture of dry leaves of selected shrubs and trained in the experimental procedure by offering test samples to them alone or in pairs daily. During preliminary period, animals were fed a mixed diet of 80% dry leaves and 20% concentrate (10% CP and 8.37 MJ/kg ME) along with mineral mixture to meet sheep requirements (NRC, 1985). The potential intake rate and relative preference for different shrub leaves was determined by the procedure of Sultan *et al*. (2007). Leaves of each shrub species were offered to sheep for a set of comparisons consisting of 4 consecutive periods of 1 minute duration at 10 minute intervals. Sufficient feed was offered in plastic containers to ensure that residues remained after one minute of intake. After a delay of 1 h, a new set of comparisons was started with a maximum of 4 sets in a day. Positioning of the containers of forages in a pair were reversed for each successive offering to avoid left- or right-hand bias. The preference for a particular forage was determined by the standard procedure developed by Bell (1959) for 2-choice tests, as the intake of shrub leaves expressed as a percentage of the combined intake of both test and standard forage.

Relative preference = [(amount of test forage eaten) / (amount of test+standard forage eaten)] x 100

***In vitro* dry matter digestibility and metabolizable energy:** Oven-dried ground samples (0.5g) were incubated at 37±1°C for 48 h at pH 6.7-7.0 in an all-glass system using 45 mL of inoculum. The inoculum consisted of 36 mL of McDougal's artificial saliva and 9 mL of strained fresh rumen liquor collected from ruminally fistulated sheep (fed diverse shrubs and grasses and supplemeted with concentrate). After incubation and centrifugation, the residue was treated for 48 h with pepsin in weak acid. All incubations were carried out in triplicate with a blank (without sample). The final residue was composed of undigested plant cell wall and bacterial debris and yield values were supposed to be comparable to *in vivo* apparent digestibility (Tilley and Terry 1963). *In vitro* DM digesibility (IVDMD) was determined by the method described by Sultan *et al*. (2007). The metabolizable energy (ME) was determined by the following equation (Sultan *et al*. 2008):

ME (MJ/kg DM)= 0.15 IVOMD%

whereas, *in vitro* organic dry matter digestibility (IVOMD%) = 0.98 IVDMD% - 4.8

Statistical analysis: The data collected on chemical composition, mineral profile, *in vitro* DM digestibility, ME, potential intake rate and relative preference were analysed using analysis of variance in a completely randomized design and means were compared by least significant difference test (SPSS, 1999).

RESULTS AND DISCUSSION

Chemical composition: Chemical composition of shrubs is presented in Table 1. The DM contents varied from 24.3 (*A. vesica*) to 38.1% (*I. gerardiana, I. bicolor*). Highest CP concentration (23.7%) was observed for *M. affricana*, while, lowest CP concentration (15.6%) was noticed for *I. bicolor* and *A. vesica*. The NDF contents varied from 49 (*M. affricana*) to 64% (*I. bicolor*). Lowest ADF (22%) was observed for *I. bicolor*, whereas highest (37%) for *I. gerardiana*. Hemicellulose ranged from 21 (*A. vesica*) to 42% (*I. bicolor*). Lignin contents varied between 4.6 (*I. gerardiana*) to 7.9% (*I. bicolor*). Highest (14.7%) ash contents were noticed for *M. affricana* and lowest (10.2%) for *A. vesica*. The chemical composition of shrubs species analyzed here provides a good source to be used as the nutrient source of ruminant feed.

Mineral profile: Mineral profile of shrubs is preseneted in Table 2. The Ca contents varied from 1.01 for *A. vesica* to 2.7% for *I. bicolor* and were higher than the dietary requiremenets of dairy cattle (0.43-0.60% of DM of diet) recommended by NRC (2001). However, ruminants can tolerate Ca upto 2 % of diet DM (NRC 1985). The P contents ranged from 0.016 in *I. bicolor* to 0.064% in *M. affricana*. The values of P observed in this study were lower than the maximum value (0.38%) of P examined for most of tree leaves reported earlier (Mandal 1997) and were also lower than the dietary requiremenets of dairy cattle (0.31-0.40% of DM of diet) recommended by NRC (2001). The P in shrubs was low (0.031–0.054 % of DM) in comparison with the required minimum of 0.20% (McDowell *et al*., 1984). The Ca:P ratio in *I. gerardiana, M. affricana, I. bicolor* and *A. vesica* was much wider (30.48, 15.94, 168.75 and 16.56, respectively) compared to those recommended for ruminants (McDowell 1997), however, this factor can be overcome by feeding cereal byproducts supplemented diets containing low Ca and high P (Prakash *et al*. 2009). Ruminant can tolerate Ca:P ratio as wide as 7:1 (NRC 1985). Rogosic *et al*. (2006) observed wide Ca:P ratio among shrub species. Saha and Gupta (1987) reported that tree are rich in Ca and poor in P. High Ca:P ratio reduces absorption of P (NRC 2001). Therefore, P supplementation appears to be essential (Breves and Schroder, 1991). Durand and Komisarczuk (1988) reported that available P should be at least 5 g/kg organic matter digested to optimize degradation of cell walls by microbes. Concentration of Ca >1% have been associated with lower DM intake, and excess Ca can interfere with trace mineral absorption (especially Zn) and lower performance of dairy cattle (NRC 2001). The K value was highest in *I. bicolor* (1.29%) and lowest (0.47%) in *I. gerardiana*. Dietary requirement of K for dairy cattle is 0.80% of diet on DM basis (NRC 2001). Maximum tolerabel level of K is 3% diet DM (NRC 1980). Increasing the level of K from 0.7 to 3% linearly decreased the energy and weight gain in lambs (NRC 1985). The Mg contents varied from 0.012 (*M. affricana*) to 0.032% (*I. bicolor*) and were lower than the required level (0.12-0.18% of diet DM) of Mg for sheep (NRC 1985). The Cu contents ranged from 14 (*A. vesica*) to 25 ppm (*I. bicolor*) and were below the toxic level as Underwood (1981) reported that Cu concentration as low as 40 ppm can cause toxicity in sheep if level of Mo and S are low in the diet, however, cattle are more tolerant. Dietary requiremenets of Cu is 10mg/kg (NRC 1985) and 0.2-7mg/kg (Church 1988). The Cu values determined for shrubs in this study were higher than requried level. Sheep requirement for Zn varied between 20-33 mg/kg of diet DM (NRC 1985). The Zn contents of *I. gerardiana, M. affricana* and *A. vesica* (17.6, 12.4 and 18.4 ppm, respectively) were lower than the required level, whereas, the Zn content (41.3 ppm) of *I. bicolor* was higher than the recommended level, however, this may be controlled by its hgih level of Ca as it affect the Zn utilization (Mills and Dalgarno, 1967). Less variation was observed in Mn contents among *I. gerardiana, M. affricana, I. bicolor* and *A. vesica* shrubs. However, Mn values observed in this study were lower than the recommended level (20mg/kg of diet DM) for sheep (NRC 1985). The Co contents ranged from 0.012 ppm for *I. bicolor* to 0.061 ppm for *I. gerardiana* and were lower than requirement (0.1mg Co/kg diet DM) for sheep (NRC, 1985). Inam-ur-Rahim *et al*. (2008) observed 0.001 to 0.02 ppm Co conenctrations in mature marginal land grasses and reported that the concentrtions were below the recommended requirements for livestock. Vercoe (1987) analyzed mineral contents of 23 tree species used for livestock feeding and reported range of Ca, 0.29-3.52%; P, 0.05-0.18%; K, 0.41-1.78%; Mg, 0.21-062%; Cu, 4-152 ppm; Zn, 22-123 ppm and Mn, 30-917 ppm. In present study, Ca, K and Cu values were within the range as reported by Vercoe (1987), however, Mg and Mn values were below this range.

Palatability: Potential intake rate (g/sheep/4min) was highest (64.5) for *I. gerardiana,* while, lowest (8.8) for *A. vesica* (Table 3). Similar results were observed regarding relative preference. Potential intake rate and relative preference are considered the main indicators for palatability (Rehman 1995; Sultan *et al*. 2007). Potential intake rate is affected by degree of tenderness, while, relative preference is influenced by chemical factors (Sultan *et al*. 2007; Rahim *et al*. 2008). Lower potential intake rate in for *I. bicolor* and *A. vesica* might be due to the presence of any antinutritional factor having particular taste and smell (Rehman, 1995). Sheep prefered diet having faster intake rates when the effects of taste and odor were removed (Kenney and Black 1984).

***In vitro* dry matter digestibility and metabolizable energy:** Highest *in vitro* DM digestibility (69.7%) and ME (9.54 MJ/kgDM) were observed for *I. bicolor* (Table 3). Whereas, lowest *in vitro* DM digestibility (53.5%) and ME (7.16 MJ/kgDM) were examined for *A. vesica*. The higher ME contents of *I. bicolor* than other shrub species might be due to its higher (69.7%) *in vitro* DM digesitblitiy. Lower *in vitro* DM digestibility of *A. vesica* might be due to the presence of any antinutritional factor which inhibit the rumen microbial enzymes (Moore and Jung, 2001; Sultan *et al*., 2007).

Table1. Chemical composition of shrubs (%)

Shrub species	DM	CP	NDF	ADF	HC	Lignin	Ash
I. gerardiana	38.1	16.6	61	37	24	4.6	10.6
M. affricana	36.2	23.7	49	23	26	5	14.7
I. bicolor	38.1	15.6	64	22	42	7.9	12.4
A. vesica	24.3	15.6	56	35	21	5.2	10.2

DM: dry matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, HC: hemicellulose

Table 2. Minerals composition of shrubs

Shrubs	Ca, %	P, %	Ca:P	K, %	Mg, %	Cu, ppm	Zn, ppm	Mn, ppm	Co, ppm
I. gerardiana	1.28	0.042	30.48	0.47	0.014	20	17.6	9	0.061
M. affricana	1.02	0.064	15.94	0.71	0.012	18	12.4	11	0.029
I. bicolor	2.7	0.016	168.75	1.29	0.032	25	41.3	10	0.012
A. vesica	1.01	0.061	16.56	0.56	0.023	14	18.4	12	0.053

Table 3. ***In vitro*** **digestibility and metabolizable energy, potential intake rate and relative preference**

Shrub species	IVDMD	ME	PIR	PR
I. gerardiana	57.8 ^{b}	7.78 ^{b}	64.5 ^{a}	73.18 ^{a}
M. affricana	57.1 ^{b}	7.66 ^{c}	53.0 ^{b}	66.35 ^{b}
I. bicolour	69.7 ^{a}	9.54 ^{a}	34.0 ^{c}	43.8 ^{c}
A. vesica	53.5 ^{c}	7.16 ^{d}	8.8 ^{d}	2.63 ^{d}
Standard error	2.65	0.33	2.29	2.6

IVDMD: in vitro dry matter digestibility (%), ME: metabolizable energy (MJ/kg DM),
PIR: Potential intake rate (g/sheep/4mintues), RP: Relative preference (%)
^{abcd}Means in a row with different superscripts differ significantly (P < 0.05).

Conclusion: The results revealed regarding chemical compostion, high availability of ME, *in vitro* DM digestibility and palatability, shrub species for use as ruminant feed are ranked as *M. affricana* > *I. gerardiana* > *I. bicolor* > *A. vesica*. A wider Ca to P ratio suggests supplementing cereal byproducts having high level of P along with these shrubs when fed to ruminants. The concentration of P, Mg Mn and Co among these shrub species were less than required level. Further research is needed to evaluate these shrubs for any antinutrional factor.

REFERENCES

AOAC. (1995). Official Method of Analysis, 16th ed. Animal Feeds: Association of Official Analytical Chemists, Arlington, VA, USA, pp. 1–18.

Bell, F. R. (1959). Preference thresholds for taste determination in goats. J. Agri. Sci. 52: 25-29.

Breves, G. and B. Schroder (1991). Comparative aspects of gastrointestinal phosphorus metabolism. Nutr. Res. Rev. 4: 125–140.

Church, D. C. (1988). The ruminant animal digestive physiology and nutrition. Prentice Hall, Englewood Cliffts, New Jersey.

Devendra, C. (1989). Shrubs and tree fodders for farm animals. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July, 1989.

Durand, M. and S. Komisarczuk (1988). Influence of major minerals on rumen microbiota. J. Ani. Nutr. 118: 249–260.

Rahim, I., J. I. Sultan, M. Yaqoob, H. Nawaz, I. Javed and M. Hameed (2008). Mineral profile, palatability and digestblity of marginal landgrasses of trans-himalayan grasslands of Pakistan. Pakistan. J. Bot. 40: 237-248.

Kenney, P. A. and J. K. Black (1984). Factors affecting diet selection by sheep I. Potential intake rate and acceptability of feed. Aus. J. Agri. Res. 35: 551-63

Mandal, L. (1997). Nutritive values of tree leaves of some tropical species for goats. Small Rumin. Res. 24: 95-105.

McDowell, L., J. H. Conrad and G. L. Ellis (1984). Mineral deficiencies and imbalances and their diagnosis. In: Gilchrist, F.M.C., Mackie, R.I. (Eds.), Herbivore Nutrition in Subtropics and Tropics, Graighall, South Africa. The Science Press, Johannesburg, pp. 67–88.

McDowell, L. (1997). Minerals for Grazing Ruminants in Tropical Regions. University of Florida. Gainesville.

Mills, C. F. and A. C. Dalgarno (1967). The influence of dietary calcium concentration on epidermal lesions of Zn deficeicny in lambs. Proceeding of Nutrition Society. 26: 19 (Abstr.).

Moore, K. J. and H. G. Jung (2001). Lignin and fiber digestion. J. Range Manag. 54: 420-430.

National Research Council (1980). Mineral toleranec of domestic animals. National Academy of sciences, Washington, DC.

National Research Council (1985). Nutrient Requirements of Sheep: Sixth Revised Edition. National Academy Press, Washington, DC.

National Research Council (2001). Nutrient Requirements of Dairy Cattle. Seventh revised edition. National Academy Press, Washington DC.

Prakash, B., A. Dhali, S. S. Rathore, K. C. Das, I. Walling, K. Vupru, A. Mech, K. K. Baruah and C. Rajkhowa (2009). Chemical composition and nutritional evaluation of various foliages consumed by mithun. Anim. Feed Sci. Tech. 150: 223-229.

Rehman, A. (1995). The potential for the use of saltbush in sheep grazing systems during summer and autumn in a Mediterranean climate. Ph.D. Thesis, University of Western Australia

Rogosic, J., J. A. Pfister, F. D. Provenza and D. Grbesa (2006). Sheep and goat preference for and nutritional value of mediterranean maquis shrubs. Small Rumin. Res. 64: 169–179.

Saha, S. C. and B. N. Gupta (1987). Tree leaves as feed for dairy cattle in India. India Dairyman. 39: 489-492.

Sarwar, M., A. Javaid, M. Nisa and S. A. Bhatti (2009). Food security from exiting resources. Proc.

Agriculture: Challenges, opportunities and options under free trade regime. Organized by WTO and Agriculture policy forum held at new senate hall, University of Agriculture, Faisalabad on May 28-29, 2008.

SPSS. (1999). SPSS Uses guide. Release 10.0.1 edition. SPSS Inc.

Sultan, J. I., I. Rahim, H, Nawaz and M. Yaqoob (2007). Nutritive value of marginal grassess of northern grasslands of Pakistan. Pakistan J. Bot. 39: 1071-1082.

Tilley, J. M. A. and R. A. Terry (1963). A two stage technique for in vitro digestion of forage crops. Grass Forage Sci. 18: 104-111

Underwood, E. J. (1981). The mineral nutrition of livestock. 2nd edition. Common Wealth Agricultural Bureaux, Farnham Royal, UK.

Van Soest, P. J., B. Rebortson, and B. A. Lewis (1991). Method for dietary fiber, neutral detergent fiber and non starch poly saccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597.

Verscoe, T. K. (1987). Australian Acacias in developing countries. In Tumbull, J. W., ed., Fodder potential of selected Australian tree species. Proceding of an international workshop. Forestry training centre, Gympie, Queenland Australia. 4-7 August 1986. Austrlia Centre for International Agricultrual Research, Canberra, Australia.