Pak. J. Bot., 41(6): 2765-2776, 2009.

NUTRITIONAL EVALUATION OF HERBS AS FODDER SOURCE FOR RUMINANTS

JAVED IQBAL SULTAN [1*], INAM-UR-RAHIM[1], MUHAMMAD YAQOOB[2], M.I. MUSTAFA[2], HAQ NAWAZ[1] AND PERVEZ AKHTAR[3]

[1]*Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad-38040, Pakistan*
[2]*Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan*
[3]*Department of Animal Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.*

Abstract

This study augmented the evaluation of herbs as fodder source for ruminants. Eleven herbs species viz., *Denothera vosea, Athyrium acrotiochoides, Chenopodium album, Polygonum amplexicaule, Atrimisia maritima, Oriosma lispidum, Cynoglossum lanceolatum, Plantago ovata, Hackalia macrophyla, Lespedeza spp., Urtica dioka* were selected and analyzed for dry matter (DM), organic matter (OM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose, and lignin contents. The average values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin were 27.5±1.66, 24.2±1.33, 11.6±0.96, 12.3±1.42, 56.7±1.87, 30.9±1.24, 25.8±1.42 and 4.4±0.42, respectively. The average values for Ca, P, K and Mg at were 0.62±0.066, 0.033±0.003, 0.85±0.118, and 0.012±0.002, respectively and average values for Cu, Zn, Mn and Co were 24.59±5.439, 22.64±3.314, 12.18±1.757 and 0.049±0.008, respectively. In species, the highest ($p<0.05$) potential intake rate (PIR) was observed for *Denothera vosea* (59.00±11.70 g/4 minute) and lowest for *Urtica dioka* (36.30±11.03 g/4 minute). However, the highest ($p<0.05$) relative preference (RP) was noted for *Denothera vosea* (81.55±1.61%) and lowest for *Urtica dioka* (10.28±4.38%). The average *in vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME) of fodder herbs species were 52.4±3.02% and 1.67±3.021 MJ/kg DM, respectively. The IVDMD, RP and PIR values are indicative that fodder herbs be fed to livestock with some supplementation for different levels of production and types of livestock.

Introduction

Livestock grazing in rangelands is the most effective lands use in rangeland system (Jones & Martin, 1994). Good pastures are being converted into cropland leaving increasingly poorer lands for livestock production (Pratt *et al*., 1997). According to recent statistics rangelands support 30 million herds of livestock, which contribute about 400 million USD to Pakistan's annual export earnings (Anon., 2006). In the northern areas of Pakistan, livestock shares about 55% to the gross provincial income of the agriculture sector. Mostly the hilly terrain (73%) of the province has little land for crop agriculture; hence, dependence on livestock is relatively high, particularly for rural subsistence (Anon., 1998).

Goats browsed on 104 species, which include 60% herbs, whereas, sheep consumed 98 species that included 54% herbs (Hussain. and Durrani 2009) .To fulfill the maintenance requirements of livestock, there is a need of 13.5 and 110.3 million tons of crude protein (CP) and total digestible nutrients (TDN), respectively (Anon., 2006). However, present feed resources provide 40% CP and 75% TDN to the livestock (Younas & Yaqoob, 2005). In the present scenario the acute deficiency of nutrients leads to under nourishment, low productivity and predisposes the livestock to parasitism, epidemics and breeding problems (Humphreys, 1984). The misuse of rangelands has deteriorated the rangeland ecosystem.

[*]E-mail address: drjisultan@gmail.com

Herbs leaves are an alternative source of livestock feeding in scarcity period, specially in prolonged winter. The herbs leaves are harvested from protected hillside rangelands and are stored as hay. Herbs from ranges and uneven areas are also harvested several times during summer and are fed to livestock. Rangeland grasses are, although the main way of procuring feed, yet herbs play an important role in livestock raising (Qureshi *et al.*, 1993). As there is little information regarding the nutritive value of locally available herbs so the study was conducted to establish the nutritive value of the different species of herbs of northern grasslands of Pakistan.

Materials and Methods

Study site: This study was conducted in North Trans-Himalayan moist zone occupying Malakand Division, North Western Frontier Province (NWFP), Pakistan. The study area has a humid subtropical to temperate environment. It extends from “Budhal” foothills (up to 800 meters altitude) in the south to “Burha Banr” in the north and northeast (more than 2000 meters altitude). Total surface area is approximately 209 square kilometer, with north and south parts divided by a mountain ridge known as “Sar Qala”. The annual precipitation varies from 600 to 1000 mm, mainly during summer and spring. In general the irrigated agriculture in the area is confined to the narrow valley bottom and adjoining gentle slopes. The gentle slopes on mid hills are mainly used for rain fed (Barani) agriculture. The medium to steep hill slopes near the residences and gentle to medium hill slopes away from the residences are protected during wet summer season for forage harvest. The forage is harvested at a mature stage during early autumn and fed as hay to the wintering livestock. The steeper hill slopes near the residences are generally used for free grazing by settled livestock throughout the year. The steeper slopes away from residences are generally scrub/bush lands and natural forest mostly grazed by nomadic sheep and goat flocks. The lower elevation rangelands are grazed during winter season and by nomadic flocks, while tracking to and fro of alpine pastures graze the upper elevation rangelands.

Identification and sampling of fodder herbs species: To achieve this aspect, a questionnaire was prepared and the farmers of various social groups at three elevations i.e., upper, middle and lower elevations were interviewed. They were asked about the names of herbs in local language (Pashtu), their season of use, location, elevations and aspects of their availability, species of animal fed and trends in their frequency. Ninety farmers (30 x 3, at each elevation) were interviewed in 9 villages (3 x 3, villages at each elevation). Based on the information generated by the farmers through the questionnaire, the samples of different herbs species were collected and their specimens were sent to Pakistan Forest Institute, Peshawar, Pakistan for botanical identification. Eleven commonly available herbs species were harvested and air-dried and stored in polythene bags for further analysis.

Chemical analysis: The air-dried herbs leaves samples were further dried in a hot air oven at 60°C and were analyzed for dry matter (DM), organic matter (OM), ash and nitrogen (Anon., 1990). Samples of herbs leaves were also analyzed for neutral detergent fiber, (NDF) acid detergent fiber (ADF), hemi-cellulose and lignin (Van Soest & Robertson, 1990).

Palatability of herbs leaves: Four mature local sheep of average body weight 40 kg were procured from the local market and they were drenched for internal parasites. The sheep were adapted for five week to the dry leaves, trained in the experimental procedure by offering the test samples to them alone or in pairs daily. During preliminary periods animal were fed a diet consisted of 80% mixed dry leaves and 20% concentrate mixture. This diet had 10% crude protein (CP) and 8.37 MJ/kg metabolizable energy (ME). The mineral mixture was also added in the diet to meet the sheep requirement (Anon., 1985). The potential intake rate (PIR) for different herbs leaves was determined through the procedure adopted by Rehman (1995). The leaves of each herb species was offered to sheep for a set of comparisons consisting of four consecutive periods of one minute duration each at ten minutes interval. Sheep were offered herbs leaves in plastic containers ensuring that part of forage was left over after one minute of intake. Relative preference (RP) was also evaluated in 95 days through the procedure used by Sultan *et al.,* (2008). The preference ranking of herbs leaves within each group was determined by offering fodder of herbs leaves in pairs, initially with the forage having highest PIR and then with other forages, until all possible combinations within a group was studied and similarly all herbs leaves were studied. Like PIR, RP test also consisted of a set of four consecutive period of one-minute duration each at ten minutes interval. There was one-hour gap before a new set of comparisons was started with a maximum of four sets in a day. The containers of both forages in a pair were reversed for each successive comparison to avoid left or right hand bias. The preference for particular forage was determined by the standard procedure for two choice tests (Bell, 1959), as the intake of herbs leaves expressed as a percentage of the combined intake of both test and standard forage.

$$\text{Relative preference (RP) \%} = \frac{\text{Amount of test forage eaten}}{\text{Amount of test + standard forage eaten}} \text{ X100}$$

***In vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME) MJ/kg DM:** For the IVDMD determination, oven dried ground samples were incubated at 37±1°C for 48 hours between pH 6.7-7.0 in an all glass system using 45 ml of inoculums. The inoculums comprised of 36 ml of McDougal’s artificial saliva and 9.0 ml of strained fresh rumen liquor collected from ruminally fistulated buffaloes. After incubation and centrifugation the residue was then treated for 48 hours with pepsin in weak acid (pH 2.0). 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 & Terry, 1963). The IVDMD was used for calculating the metabolizable energy (ME) of herbs leaves species by the following equation (Anon., 1984):

$$\text{ME (MJ/kg DM)} = 0.15 \text{ IVDMD\%}$$

$$\text{IVDMD\%} = 0.98 \text{ IVDMD\%} - 4.8$$

The average values for chemical composition, structural constituents, IVDMD and ME were integrated to develop a matrix of correlation (Steel *et al.*, 1997).

Results and Discussion

Chemical and structural constituents: The chemical fractions of fodder herbs are depicted in Table 1. The DM contents of various herbs used for feeding livestock in the study area varied from 20.1 to 34.8% and the mean was 27.5±1.66%. The highest DM value was observed for *Urtica dioka* followed by *Cynoglossum lanceolatum* and *Oriosma lispidum,* respectively. The lowest value was observed for *Chenopodium album (*Table 1). The OM contents ranged from 18.4 to 31.7% and the mean was 24.2±1.33%. The highest OM value was observed for *Urtica dioka* followed by *Cynoglossum lanceolatum* and *Lespedeza* spp., respectively, and the lowest value was observed for *Chenopodium album.*

The ash contents varied from 7.5 to 16.2% and the mean was 11.6 ± 0.96%. The highest ash value was for *Oriosma lispidum* followed by *Cynoglossum lanceolatum* and *Artimisia maritina,* respectively. The lowest value was observed for *Denothera vosea.*

The CP contents of fodder herbs varied from 8.9 to 24.9% and the mean was 12.3±1.42%. The highest CP value was observed for *Chenopodium album* followed by *Polygonum amplexicaule* and *Denothera vosea,* respectively. The lowest value was observed for *Urtica dioka.* Distel *et al*., (2005) reported that CP contents in different forrage species declined with time. Similar findings were reported by Verma *et al.,* (1982) who reported a decline in CP contents of tree leaves from 6.9 to 28.8% on DM basis in mature leaves of forage plants.

Structural constituents in fodder herbs are presented in Table 2, the NDF contents of 11 commonly found fodder herbs varied between 49 to 67% and the mean was 56.7±1.87%. The highest value was observed for *Urtica dioka* followed by *Hackalia macrophyla* and *Cynoglossum lanceolatum,* respectively. The lowest value was observed for *Alhyrium acrotichoides.*The ADF contents varied between 24 to 38% and the mean was 30.9±1.24%. The highest value was observed for *Urtica dioka* followed by *Hackalia macrophyla* and *Cynaglossum lanceolatum*, respectively. The lowest value was observed for *Denothera vosea.*

The hemi-cellulose concentration varied between 20 to 33% and the mean was 25.8±1.42%. The highest hemi cellulose value was observed for *Atrimisia marilina* followed by *Denothera vosea* and *Hackalia macrophyla,* respectively. The lowest hemi cellulose value was observed for *Polygonum amplexicaule* and *Alhyrium acrotichoides.* The lignin concentration was in the range of 2.8 to 7.5% and the mean was 4.4±0.42%. The highest value was observed for *Urtica dioka* followed by *Hackalia macrophyla* and *Lespedeza* spp., respectively. The lowest value was observed for *Chenopodium album*.

The NDF, ADF and lignin contents were lower in vegetative leaves than mature leaves, indicating relatively smaller stem proportion in the anatomy of vegetative leaves. All the structural constituents (NDF, ADF, hemi-cellulose and lignin) increased in mature leaves. According to Cherney *et al*., (1993), the tropical forages generally showed an increase in structural constituents with increasing maturity. Bourquin *et al.*, (1994) reported 72.4% NDF and 43.8% ADF in the orchard grass on DM basis. Sanderson *et al*., (1989) observed a difference of 3l.4 to 66.8% in NDF contents of alfalfa in two different years. In stem of alfalfa, the NDF concentration ranged from 21 to 68%. According to Cherney *et al*., (1990) NDF and ADF tended to be lower in inflorescence than in other morphological components. They also reported higher ADF in stem than in blade and sheath of leaves.

The findings of this study were in line with those of Cherney *et al*., (1993) who also reported an increase in all fiber constituents with increasing maturity. They reported that lignin was proportionately higher in stem than other parts of the plants. Brown *et al.,* (1984) reported that the soil fertility also influenced grass lignin concentration.

Table l. Chemical fractions of herbs found in Northern grasslands of Pakistan.

Name of herb	DM %	OM %	ASH %	CP %
Denothera vosea	21.1	19.5	7.5	13.2
Athyrium acrotichoides	22.5	20.3	9.8	9.3
Chenopodium album	20.1	18.4	8.4	24.9
Polygonum amplexicaule	26.2	22.7	13.4	16.4
Atrimisia maritima	30.4	26.0	14.6	10.5
Oriosma lispidum	32.2	27.0	16.2	9.5
Cynoglossum lanceolatum	34.5	29.0	15.9	11.7
Plantago ovata	22.6	20.7	8.3	9.6
Hackalia macrophyla	26.6	23.2	12.6	12.5
Lespedeza spp.	31.8	28.0	11.9	9.3
Urtica dioka	34.8	31.7	9.0	8.9
Mean ± SE	27.5 ± 1.66	24.2 ± 1.33	11.6 ± 0.96	12.3 ± 1.42

Table 2. Structural constituents in herbs found in Northern grasslands of Pakistan.

Name of herb	NDF %	ADF %	Hemi cellulose %	Lignin %
Denothera vosea	56	24	32.0	3.5
Athyrium acrotichoides	49	29	20.0	3.2
Chenopodium album	51	29	22.0	2.8
Polygonum amplexicaule	53	33	20.0	3.4
Atrimisia maritima	60	27	33.0	4.6
Oriosma lispidum	51	28	23.0	2.9
Cynoglossum lanceolatum	62	34	28.0	4.5
Plantago ovata	53	30	23.0	3.8
Hackalia macrophyla	66	36	30.0	5.9
Lespedeza spp.	56	32	24.0	4.8
Urtica dioka	67	38	29	*7.5*
Mean ± SE	56.7± 1.87	30.9 ± 1.24	25.8 ± 1.42	4.4 ± 0.42

Table 3. Mineral composition of herbs found in Northern grasslands of Pakistan.

Name of herb	Ca %	P %	K %	Mg %	Cu ppm	Zn ppm	Mn ppm	Co ppm
Denothera vosea	0.46	0.044	1.01	0.01	30.0	9.6	6.0	0.068
Athyrium acrotichoides	0.64	0.036	0.62	0.011	20.0	25.2	6.00	0.061
Chenopodium album	0.49	0.018	0.98	0.009	23.5	18.4	13.0	0.026
Polygonum amplexicaule	1.08	0.040	0.31	0.016	12.5	16.9	24.0	0.049
Atrimisia maritima	0.74	0.032	0.37	0.03	15.0	38.9	17.0	0.035
Oriosma lispidum	0.74	0.018	1.27	0.11	32.5	38.3	16.0	0.087
Cynoglossum lanceolatum	0.82	0.020	0.47	0.009	14.5	14.4	12.0	0.023
Plantago ovata	0.42	0.041	0.99	0.013	75.0	31.1	17.0	0.093
Hackalia macrophyla	0.36	0.034	0.85	0.005	15.0	14.5	8.0	0.014
Lespedeza spp.	0.36	0.047	1.62	0.007	20.0	32.2	7.0	0.053
Urtica dioka	0.70	0.029	0.86	0.007	12.5	9.5	8.0	0.025
Mean ± SE	0.62 ±0.066	0.033 ±0.003	0.85 ±0.118	0.012 ±0.002	24.59 ±5.439	22.64 ±3.314	12.18 ±1.757	0.049 ±0.008

Mineral composition of herbs: The mineral composition of herbs is presented in Table 3. The Ca concentration in herbs varied from 0.36% (*Hackalia macrophyla, Lespedeza* spp.) to 1.08% (*Polygonum amplexicaule*) and mean was 0.62±0.066%. The findings of present study revealed that Ca content in herbs generally increased with maturity. Optimum level of Ca in plants ranged from 0.40 to 0.60% and its level above 1.0% is considered high (Georgievskii, 1982, Khan *et al.*, 2005, Khan *et al.*, 2007), whereas, Minison (1990) reported Ca level from 0.31 to 1.98% and the mean as 0.63%. On the other hand Ca level in the diet of livestock to fulfill its maintenance and production requirements should remain within the range of 0.17 to 0.42% (Anon., 1975). The variation noted within the present grasses was in line with previous studies (Skerman & Riveros 1990; Gohl, 1981).

Phosphorus concentration in herbs varied from 0.018% (*Chenopodium album, Oriosma lispidum*) to 0.047% (*Lespedeza* spp.) and the mean was 0.033±0.003%. The P content increased with age in herbs. The consistent low phosphorus content across all vegetation might be due to low P content in the soil or high Ca in the soil. These results differed from those of Minson (1990) who reported declined P content with advancing age of the plants. The P content in tropical grasses varied from 0.02 to 0.06% of plant dry matter and this variation might be due to available P in the soil (Skerman & Riveros, 1990). These results revealed that P concentration in various forages was below the minimum requirement (0.082%) of livestock (Anon., 1975). These results also supported the findings of Sprague (1979) who reported that P was widely deficient in soils of rangelands in semi-arid and sub humid regions and consequently in the grasses grown in these areas. The P deficiency in the soil may hamper the growth of legumes, since high soil pH and higher Ca content caused formation of insoluble Ca phosphate that depress availability of P (Kinzel, 1983). Forages of semi desert and savanna regions were reported to be widely deficient in P content due to low P content in the soil. Phosphorus deficiency in animals is most prevalent when forages are low in P and high in Ca. The temperate forages contained more P than the tropical forages i.e. 0.35% vs. 0.23% of the DM (Minson, 1990). They further reported that within each species, P concentration varied with cultivars, stage of growth, soil fertility and climate. They also reported that in tropical forages only 49% legumes and 35% grasses contained P above the critical level. The P concentration declines as plant increases in size and advances towards maturity. The rate of decline is higher in stem fraction as compared to other parts of the plants. The application of nitrogen fertilizers stimulates plant growth and depresses P concentration.

The K concentration in these herbs varied from 0.31% (*Polygonum amplexicaule*) to 1.62% (*Lespedeza spp*) and the mean was 0.85 ±0.118%. Minson (1990) reported that K concentration was lower in all rangeland grasses than the value noted in pasture (2.75%). However, application of K fertilizer resulted in improved productivity of legumes. Humphreys (1984) reported that K concentration varied in tropical grasses from 0.6% to 1.2%. The K content in temperate legumes were higher than for tropical legumes. The lower K content observed in the present study might be due to increased availability of Ca. Kinzel (1983) reported that high supply of lime with insufficient supply of K caused decreased in K intake from the soil, leading to considerable variation of growth. Potassium activates many enzyme systems in the plant (Humphreys, 1984) which affect the plant growth.

The Mg concentration varied from 0.005% (*Hackalia macrophyla)* to 0.11% (*Oriosma lispidum*) and the mean was 0.012±0.002%. These results supported the findings of Skerman & Riveros (1990) who reported that Mg content of tropical vegetation varied from 0.04 to 0.90% with a mean of 0.36%. In present study it was noted that Mg content decreased in both leaf and stem with increasing plant age. Whereas Georgieviskii (1982) observed equal Mg content in leaf and stem. The Mg deficiency was most common on acid, sandy soil or soil deficient in Mg. The highest Mg concentration in forage plants was observed in early vegetative stage. Minson (1990) reported higher values for tropical grasses (0.36%) than temperate grasses (0.18%) and legumes (0.26 to 0.28%). He did not find interaction among fertilizer, Na, P and K, except in situations where soil Mg was depleted by more frequent forage harvesting. The Mg uptake from the soil was generally low at low temperature and in water logged soils. The proportion of Ca and Mg in the soil not only affected the uptake of Mg by the plant, but also affect the concentration of other cat-ions and soil pH (Skerman & Riveros, 1990).

The Cu concentration varied from 12.5 ppm (*Urtica dioka*) to 75.0 ppm (*Plantago ovata*) and the mean was 24.59±5.439ppm. Anon., (1975) reported that Cu content in all grasses were higher than the livestock requirements (6-12ppm of diet DM). Minson (1990) reported that increasing Molybdenum intake prevented Cu toxicity in livestock. They also reported that increasing soil temperature from 12 to 20°C raised Cu concentration in plants. Temperate legumes generally contained more Cu than temperate grasses (7.8 vs. 4.70ppm). Tropical legumes contained low Cu than tropical grasses (3.9 vs 7.8ppm). Skerman & Riveros (1990) stated that Cu concentration of tropical grasses varied from 3 to 10ppm on dry matter basis. Shah *et al*., (1986) reported an increase in Cu concentration in forages with increasing maturity. The Cu concentration in the present study were in line with those of Gohl (1981) who reported decreased Cu concentration with age of the plant.

The Zn concentration varied from 9.5ppm (*Urtica dioka*) to 38.9ppm (*Atrimesia maritima*) and the mean was 22.64±3.314ppm. The temperate forages contain less Zn content than tropical forages. Grasses contain less Zn than legumes (25 vs. 47ppm) and Zn deficiency rarely occur in ruminant fed such forages. Zinc concentration in such grasses was not affected by grass maturity or change in climate, however was affected with the application of fertilizer.

The Mn concentration varied from 6.0 ppm (*Denothera vosea, Athyrium acrotichoides*) to 24.0ppm (*Dichanthium annulatum*) and the mean was 12.18 ±1.757ppm. These results were in agreement with those of Gohl (1981) who reported gradual increase of Mn content with plant maturity. The Mn content in free rangeland grasses were adequate to meet the livestock requirements (Perveen, 1998).

The Co concentration varied from 0.014 ppm (*Hackalia macrophyla*) to 0.093 ppm (*Plantago ovata*) and the mean was 0.049±0.008ppm. In most of the forage species in the study area, Co concentration was below the recommended requirement of livestock, hence supplementation to livestock rations was recommended (Anon., 1975). The Co concentration in tropical grasses varied from 0.02 to 0.91ppm in the DM with a mean 0.16ppm (Skerman & Riveros, 1990). The Co is essential for legume rhizobial symbiosis and affects the synthesis of vitamin B (Humphreys, 1984). Variation in the Co concentration of forages were reported to be less than 0.01 to 1.26ppm of the DM, associated with differences in soil Co. Forages grown on poorly drained soils contained about 7 times high Co as those of well drained soil. High soil moisture increased the concentration of Co in the soil and doubled the uptake of Co. Applying dolomite lime depresses the Co concentration in the forages. Fertilizer nitrogen, phosphorus and K had no effect on Co concentration (Minson, 1990).

Palatability of fodder herbs leaves: Palatability refers to the relish with which feed is consumed as stimulated by the sensory impulses (Heath *et al.,* 1985). The potential intake rate (PIR) and relative preference (RP) are considered the main indicators for palatability (Rehman, 1995). The PIR and RP of 8 herbs species leaves are presented in Table 5. The average PIR (grams consumed during 4 minutes per sheep) was the highest for *Denothera vosea* (59.00±11.70 g/4 minute) followed by *Athyrium acrotichoides* (53.30±14.35 g/4 minute) and *Chenopodium album* (53.00±15.77 g/4 minute). The lowest PIR value was for *Urtica dioka* (36.30±11.03 g/4 minute). The RP was the highest for *Denothera vosea* (81.55±1.61 %) followed by *Chenopodium album* (80.53±1.72%) and *Athyrium acrotichoides* (68.60±3.24%). The lowest RP was observed for *Urtica dioka* (10.28±4.38%). The fodder herbs leaves having higher PIR values showed relatively higher RP.

The lower RP noted in the leaves of some herbs and grasses might be due to the presence of some essential oils that made these forages less palatable. These essential oils are responsible for the peculiar smell and taste of the grass (Rehman, 1995) and might decrease their relative preference despite of their higher PIR. The higher PIR and RP noted in fodder herbs leaves might be due to lower concentration of essential oil (piperitone) commonly present in herbs and grasses which makes the vegetative parts less palatable for livestock. The PIR was more strongly affected by the degree of tenderness and stage of growth while the RP seemed to be more affected by the intrinsic chemical factors, hence when the leaves were offered in pair with other forages having no such repellent essential oil, the other forage showed higher RP value despite of their lower PIR.

Correlation of palatability with chemical constituents, structural constituents and IVDMD is presented in Table 5. The RP and PIR were positively correlated (r=0.92) with each other across all fodder herbs studied. These results supported the findings of Rehman (1995) who suggested PIR as a useful indicator of preference. The results of present study revealed that although the PIR and RP were correlated with each other, their major determinant affects both the parameters differently. The PIR was influenced by the degree of tenderness, while RP was influenced by chemical factors. The present study suggests that more precise prediction equations can be developed if concentrations of sugars and chemical factors were integrated. Kenney & Black (1984) reported that when effects of taste and odor are removed, sheep preferred diet having faster intake rates. The IVDMD showed positive correlation with both RP (r= 0.75) and PIR (r= 0.74) across all the fodder herbs. The CP contents had positive correlation with RP (r= 0.59) and with PIR (r= 0.39). These results supported the findings of Provenza *et al.*, (1996) who reported that lambs preferred food having higher CP contents. The NDF showed negative correlation with RP (r= -0.63) whereas; it showed negative correlation with PIR (r= -0.58). The ADF, hemi-cellulose and lignin showed negative correlation with both RP and PIR (Table 4). The results of present study were partially in agreement with Rehman (1995) who reported that lignin had negative correlation with both RP and PIR across all the forage species. The rapid accumulation of cell wall contents, fast lignification of cell wall and rapid reduction in CP levels may allow the unpalatable grass to avoid grazing since an early stage of re-growth. Fibrousness reduced intake rate because of the associated reduction in bite size to properly sever forage and the associated increase in chewing time necessary to adequately process the forage (Laca *et al.*, 2001). Lignin and CP contents interfered with the digestion of structural carbohydrates, the former by acting as a physical barrier to rumen microbial enzymes (Moore & Jung, 2001) and the later by limiting rumen microbial growth (Orskov, 1982). However, Pratt *et al.*, 1997 reported that the factors affecting palatability need more investigation.

Table 4. Digestibility and metabolizable energy of herbs found in Northern grasslands of Pakistan.

Name of herb	IVDMD %	ME Mcal/kg DM
Denothera vosea	65.1	2.11
Athyrium acrotichoides	57.4	1.84
Chenopodium album	68.8	2.24
Polygonum amplexicaule	59.6	1.92
Atrimisia maritima	46.4	1.46
Oriosma lispidum	44.5	1.39
Cynoglossum lanceolatum	39.6	1.22
Plantago ovata	58.6	1.89
Hackalia macrophyla	42.7	1.33
Lespedeza spp.	55.7	1.78
Urtica dioka	37.6	1.15
Mean±	52.4 ± 3.02	1.67 ± 3.021

Table 5. Potential intake rate (PIR) and relative preference (RP) of Herbs found in Northern grasslands of Pakistan.

Name of herb	PIR (gm/4min) ± SE*	(%) RP ± SE**
Denothera vosea	59.00 ± 11.70[a]	81.55 ± 1.61 [a]
Athyrium acrotichoides	53.30 ± 14.35[ab]	68.60 ± 3.24[bc]
Chenopodium album	53.00 ± 15.77[abc]	80.53 ± 1.72[a]
Polygonum amplexicaule	52.00 ± 11.50[abcd]	73.35 ± 1.80[ab]
Atrimisia maritima	47.30 ± 10.25[abcde]	62.63 ± 1.46[c]
Oriosma lispidum	43.00 + 13. 72[bcde]	40.72 ± 2.56[de]
Cynoglossum lanceolatum	39.50 113.50[cde]	41.75 ± 3.05[d]
Plantago ovata	39.30 ± 4.96[de]	33.60 ± 2. 13 [de]
Hackalia macrophyla	38.50 ± 14.57 [de]	24.15 ± 3.08[f]
Lespedeza spp.	36.80 ± 10.99[e]	32.88 ± 2. 14[e]
Urtica dioka	36.30 ± 11.03	10.28 ± 4.38

Each figure represent mean (±1 standard error of the mean) of 4 samples. Figures having different letters are significant (p<0.05) within the same forage grass.

**Each figure represent mean (± standard error of the mean) of 40 comparisons. Figures having different letters are significant (p<0.05PO.05) within the group.

Table 6. Correlation matrix among relative preference, potential intake rate, digestibility, crude protein and structural constituents of Herbs found in Northern grasslands of Pakistan.

.	PIR	IVDMD	CP	NDF	ADF	Hemi-cellulose	Lignin
RP %	+0.92	+0.75	+0.59	-0.63	-0.72	-0.19	-0.76
PIR	-	+0.74	+0.39	-0.58	-0.70	-0.12	-0.66
IVDMD	-	-	+0.58	-0.72	-0.60	-0.43	-0.69

***In vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME):** The mean IVDMD and derived ME values for all fodder herbs are presented in Table 4. The IVDMD value for fodder herbs ranged from 37.6% (*Urtica dioka)* and 68.8%

(*Chenopodium album)* and the mean was 52.4±3.02%. The derived ME value had a range from 1.15 Mcal/kg DM (*Urtica dioka*) to 2.24 Mcal/kg DM *(Chenopodium album)* with a mean of 1.67±3.021 Mcal/kg DM. The 1VDMD had a positive correlation with CP (*r*= -0.58), whereas a negative correlation with NDF (*r*= -0.72), ADF(*r*= -0.60), hemi-cellulose (*r*=- 0.43) and lignin (*r*= -0.69) in fodder herbs. The IVDMD decreased with increasing maturity of the plants and similar findings were reported by Skerman & Riveros (1990) who found a fall of 0.1 to 0.2% DM digestibilities per day with maturity of pasture grasses. Buxton (1989) reported that the proportion of stem in a grass approaching maturity was the main morphological factor determining the digestibility. Gabrielsen *et al*., (1990) and Van Soest (1965) reported that NDF, ADF and lignin concentration increased with maturity while IVDMD and CP declined. In contrast to this study Revell *et al*., (1994) reported a positive correlation between CP and digestibility, whereas, Cherney *et al*., (1990) observed negative correlation of IVDMD with NDF, ADF and lignin. The results of our study were in line with those of Van Soest (1978) who reported poor relationship of NDF with digestibility. Lichtenberg & Hemken (1985) also reported that per unit increase in lignin often resulted in a three to four unit decrease in DM digestibility. It had been reported that cell wall component NDF, ADF and lignin were negatively correlated with IVDMD in tree leaves (Mowatt *et at.*, 1969, Kundu & Sharma, 1988; Perveen, 1998). The chemical and structural composition, IVDMD, RP and PIR values of fodder herbs leaves suggest that these can be fed to ruminants with some supplementation for different levels of production.

References

Anonymous. 1975. *Nutrient requirements of domestic animals-Nutrient requirements of sheep*. (5th revised edition) National Research Council (NRC). National Academy of Sci. Washington, DC.

Anonymous. 1984 Ministry of Agriculture, Fisheries, and Food (MAFF), *Energy Allowances and Feeding Systems for Ruminants*. Her Majesty's Stationery Office, London.

Anonymous. 1985. *Nutrient Requirements of Sheep*: Sixth Revised Edition. National Academy Press, Washington, DC.

Anonymous. 1990. *Official Methods of Analysis*. 13th Ed. Association of Official Analytical Chemists (AOAC), Washington, DC.

Anonymous. 1998. Background Paper on the Sustainable Management of Grazing Lands in the NWFP. IUCN, The World Conservation Union, Sarhad Program Office Pakistan.

Anonymous. 2006. Economic Survey, Government of Pakistan (GOP), Finance Division, Islamabad, Pakistan.

Bell, F.R. 1959. Preference thresholds for taste determination in goats. *J. Agric. Sci*., 52:125-29

Bourquin, L.D., E.C. Tibgemeyer, J.V. Milgen and J.C. Fahey Jr. 1994. Forage level and particle size effects on orchard grass digestion by steers: II. Ruminal digestion kinetics of cell wall components. *J. Anim Sci*., 72: 759-67.

Brown, P.H., R.D. Graham and D.G.D. Nicholas. 1984. The effect of manganese and nitrate supply on the level of phenolics and lignin in young wheat plant. *Plant Soil*, 81: 437-440.

Buxton, D.R. 1989. *In vitro* digestion kinetics of temperate perennial forage legume and grass stems. *Crop Sci*., 29: 213-219.

Cherney, D.J.R., D.R. Mertens and J.E. Moore. 1990. Intake and digestibility by withers as influenced by forage morphology at three levels of forage offering. *J. Anim. Sci*., 68: 4387-4399.

Cherney, D.J.R., J.H. Cherney and R.F. Lucey. 1993. *In Vitro* digestion kinetics and quality of perennial grasses as influenced by forage maturity *J. Dairy Sci*., 76: 790-797.

Distel, R.A., N.G. Didoné and A.S. Moretto. 2005. Variations in chemical composition associated with tissue aging in palatable and unpalatable grasses native to central Argentina. *J. Arid Environ*., 62: 351-357.

Gabrielsen B.C., K.P. Vogel, B.E. Anderson and J.K. Ward. 1990. Alkali labile cell wall phenolics and forage quality in switch grasses selected for different digestibility. *Crop Sci*., 30: 1313-1320.

Georgievskii, V. I. 1982. Biochemical regions. Mineral composition of feeds. In: *Mineral Nutrition of Animals*. (Eds.): V.I. Georgievskii. B.N. Annenkov and V.I. Samokhin. Butterworths London

Gohl Bo. 1981. *Tropical Feeds. Feed information summaries and nutritive values*. FAO, Animal Health and Production Series No. 12. FAO, Rome, Italy.

Heath, M.E., R.F. Barnes and D.S. Metcalfe. 1985. *Forages: The Science of Grassland Agriculture.* Iowa State University Press. Ames, Iowa, USA.

Humphreys, L.R. 1984. *Tropical pastures and fodder crops*. Longman Group U.K. Ltd. Longman House, Burnt Mill, Harlow Essex CM 20 2J. E. England.

Hussain, F. and M.J. Durrani 2009. Seasonal availability, palatability and animal preferences of forage plants in Harboi Arid Range Land, Kalat, Pakistan *Pak. J. Bot*., 41(2): 539-554.

Jones, G.E. and Martin. 1994. Eco Zone Suite of Model, for FAO Training Service. Eco Zone Gough SAC Edinburgh Policy Analysis Division, Rome.

Kenney, P.A. and J.L. Black. 1984. Factors affecting diet selection by sheep I. Potential intake rate and acceptability of feed. *Aust. J. Agric. Res*., 35: 551-63.

Khan, Z.I., A. Hussain, M. Ashraf, E.E. Valeem and I. Javed. 2005. Evaluation of variation of soil and forage minerals in pasture in a semiarid region of Pakistan. *Pak. J. Bot*., 37: 921-931.

Khan, Z.I., M. Ashraf, E.E. Valeem, K. Ahmad and M. Danish. 2007. Pasture concentration of minerals in relation to the nutrient requirements of farm livestock. *Pak. J. Bot*., 39(6): 2183-2191.

Kinzel, H. 1983. Influence of limestone silicates and soil pH on vegetation. III. Physiological plant ecology. In: Encyclopedia of Plant Physiology (Eds.): O.L. Lang, P.S. Nobel C.B. Osmond and H. Zieglers. Spriger-Verlag, Berlin.

Kundu, S.S. and V. Sharma. 1988. Chemical composition and *In vitro* dry matter digestibility of certain tree leaves. *Ind. J. Anim. Nutrition*., 5(1): 23-27.

Laca, E.A., L.A. Shipley and E.D. Reid. 2001. Structural anti-quality characteristics of range and pasture plants. *J. Range Manage*., 54: 413-419.

Lichtenberg, V.L. and R.W. Hemken. 1985. Hay Quality. In: *Grazing Management: An Ecological Perspective*. Timber Press, Portland, Oregon USA.

Minson, D.J. 1990. The chemical composition and nutritive value of tropical grasses. In: Tropical grasses FAO Plant Production and Protection Series, No: 23. (Eds.): P.J. Skerman and F. Riveros. FAO Rome.

Moore, K.J. and H.G. Jung. 2001. Lignin and fiber digestion. *J. Range Manage*. 54: 420-430.

Mowatt, D.N., M.L. Kwain and J.E. Wind. 1969. Lignification and *In vitro* cell wall digestibility of plant parts. *Can. J. Plant Sci*., 49: 499-504.

Orskov, E.R. 1982. *Protein Nutrition in Ruminants*. Academic Press, London.

Perveen S. 1998. Nutritive evaluation of some fodder tree leaves through *In vitro* digestibility techniques. Technical Paper, NWFP Agricultural University, Peshawar.

Pratt, D.J., F.L. Gall and C.D. Haan. 1997. Investing in Pastoralism. The International Bank of Reconstruction and Development. The World Bank 1818 H Street, NW Washington, D.C. 20433, USA.

Provenza, F.D., C.B. Scott, T.S. Phy and J.J. Lynch. 1996. Preference of sheep for foods varying in flavor and nutrients. *J. Anim. Sci*., 74(10): 2355-61.

Qureshi, M.A., A.G.S. Khan and M.S. Yaqoob. 1993. *Range management in Pakistan,* University of Agriculture, Pakistan.

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.

Revell, D.K., S.K. Baker and B.B. Purser. 1994. Estimates of the intake and digestion of nitrogen by sheep grazing a Mediterranean pasture as it matures senesces. *Proc. Aust. Soc. Anim. Prod*., 20: 217-20.

Sanderson, M.A., J.S. Hornstein and W.F. Wedin. 1989. Alfalfa morphological stage and its relation to *In-situ* digestibility of detergent fiber fractions of stem. *Crop Sci*., *2*9(13): 15-19.

Shah, S.M., W. Mohammed and M.M. Iqbal 1986. Micro-nutrient status of the soils of the Frontier Regions. *Pak. J. Sci. Ind. Res*., 29 : 288-90

Skerman, P.J. and F. Riveros. 1990. *Tropical grasses*. FAO Plant Production and Protection Series, No. 23. FAO Rome.

Sprague, H.B. 1979. *Management of rangelands and other grazing lands of the Tropics and subtropics for support of livestock production*. Technical Series Bulletin No. 23, Agriculture Technology for Developing Countries, Office of Agriculture Development Support Bureau. Agency fir International Development, Washington DC, 20523

Steel, R.G.D., J.H. Torrie and J.H. Dicky. 1997. *Principles and Procedures of Statistics a Biometrical Approach*. 3rd Ed. McGraw Hill Book Co. Inc., New York, USA.

Sultan, J.I., I. Rahim, H. Nawaz, M. Yaqoob and I. Javed. 2008. Nutritional evaluation of fodder tree leaves of northern grasslands of Pakistan *Pak. J. Bot*., 40(6): 2503-2512.

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.

Van Soest, P.J. 1965. Voluntary intake in relation to intake and digestibility. Symposium on factors influencing the voluntary intake by ruminants. *J. Anim. Sci*., 24: 834-43.

Van Soest, P.J. 1978. Evaluation of forages and feed stuffs in the laboratory. Paper presented at the 6th International Veterinary Congress, Buenos Aires, Argentina.

Van Soest, P.J. and J.B. Robertson. 1990. Methods of Dietary Fiber, NDF and Non-starch poly saccarides. Symposium paper ADSA June 1990. Cornell University, Dept. of Animal Science. Ithaca N.Y.

Verma, A.B., P.S. Yadav, K.T. Sampath and D.J. Roy. 1982. Chemical composition of common fodder tree leaves, shrubs and epiphytes in North-East hill region. *Ind. J. Anim. Sci*., 52: 859-865.

Younas, M. and M. Yaqoob. 2005. Feed resources of livestock in the Punjab, Pakistan. *Livest. Res. Rural Devel. http://www.cipav.org.co/lrrd/lrrd17/2/youn17018.htm*

(Received for publication 1 June 2009)