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Research Article

Nutritive values of fodders at different seasons and altitudes in Gandaki River Basin of Nepal

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ABSTRACT

This study aimed to assess the seasonal and ecological variation of chemical and nutritional values of locally preferred fodders in Gandaki River Basin (GRB) areas. The study was conducted in four altitudinal gradients viz. <400m, 400-800m, 800-1200m and 1200–1600m altitude above sea level in different looping seasons: rainy, spring and winter seasons. The most important five species of fodder trees *Artocarpus lakoocha*, *Ficus roxburghii*, *Thysanolaena maxima*, *Ficus semicordata* and *Bauhinia purpurea* were selected based on farmers' preferences in nutritional values. Fodder samples comprised young leaves, old leaves and young twigs that were taken in July, September and December. It was revealed that nutritive value is not very much influenced by altitude but it is strongly influenced by lopping seasons. Among *Thysanolaena maxima*, *Artocarpus lakoocha*, *Ficus roxburghii* and *Bauhinia purpurea* the cellulose contents were significantly different ($p<0.001$) with seasons but there was no significant variation with altitudes. Similarly, Acid Detergent Fibre (ADF) contents in *Thysanolaena maxima*, *Ficus roxburghii* and *Bauhinia purpurea* were found significantly different with seasons. *Ficus roxburghii* fodder tree was found significantly different in Neutral Detergent Fibre (NDF), ADF, Cellulose and Potassium content with seasons. Similarly, fodder tree *Bauhinia purpurea* was found significant on Dry matter (DM), Crude fibre (CF), NDF, ADF, cellulose, tannin and potassium with seasons. The study hinted how careful planning of species selection and prudent decision in scheduling looping and feeding fodder trees can help improve animal metabolism, health, growth and productivity.

Keywords: Fodders, nutrition, season, altitudes, Nepal

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INTRODUCTION

Fodder trees and shrubs are indicated as the main feeding stuff for livestock in the mid-hill and the mountain regions since farmers follow the open and semi-open grazing practices. The Feeding stage of fodder is highly important to feed the ruminants for attaining major nutrients from fodders. Mostly, farmers in the hilly areas depend on the government forests for collecting fodders and grazing their livestock. In the mid-hills and mountains, many species of fodder and shrubs are available for fulfilling nutrients to the ruminants and farmers rely more on them during the dry periods, especially in winter season since there are enough feeding materials available as forages, crop residues and byproducts in other seasons for feeding ruminants. Mainly in winter, tree fodders are important sources of high-quality feed for ruminants and serve as a supplement to crop residues or byproducts of low-quality feeds. Although livestock is a key mechanism for managing the risk, increased human population leading to land fragmentation is increasingly constraining access to fodders (Thornton, 2010).

Fodders and shrubs growing in arid and semi-arid ecosystems are endurable to extreme drought occurring in winter season owing to the strong root system and vigorous sprouts from the stump and the roots and play an important role in supplying the fodder for animals at the absence of grass-pasture (Papachristou & Papanastasis, 1994). In the same context, tree fodders form part of the complex interactions between plants, animals and crops, the positive aspects of which help to balance a plant-animal-soil ecosystem and from which there is a sustainable source of feeds (Aganga & Tshwenyane, 2003; Devendra, 1994). The nutrients content in soil is one of the good determining factors for the growth of fodders and forages (Adams & Rieske, 2003). The species of tree fodders and shrubs also vary according to ecological amplitudes but some species can grow in wide ranges of ecological belts from 200m to 1700m above sea level. The chemical composition, nutritive values and biomass production in natural conditions are affected by factors such as the region's topography (Oberhuber & Kofler, 2000; Burke et al., 1997).

During the lean period, the quality and limited amount of forages available results in the shortage of diet for the ruminants (Shelton, 2004). Due to the shortage of forages, only feeding crop residues or by-products results in reduced livestock productivity in tropical countries (Babayemi et al., 2004a; Odenyo et al., 1997). Small farmers or landless farmers, keeping the small herds of goats, sheep, buffaloes and cattle mostly depend on the feed resources from tree fodders nearby forest. Farmers grow some species of fodder trees such as *Artocarpus lakoocha*, *Ficus roxburghii*, *Thysanolaena maxima*, *Ficus semicordata* and *Bauhinia purpurea* in their farmland as a silvi-pastoral agroforestry system. Singh (1982), Singh (2004) and Bhatt and Verma (2002) have reported that fodders provide quality feeds during the dry season when protein and nutrient deficiency are likely to occur to the livestock population.

Farmers may not be looping and feeding fodder at the right time or fodder may not be available for feeding animals when farmers like to have it. Or is likely that farmers' preferences don't match with growing stages and the time when the nutritive value is high. We assessed nutritive values of five species of fodder trees and shrubs that were selected

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from plain land to mid-hills of Gandaki River Basin of Nepal based on local preferences to understand the spatial and seasonal variations in nutritive values of selected fodder trees.

MATERIALS AND METHODS

Study area

This study was conducted in plain land and hilly regions of Gondaki River Basin in central and western Nepal to assess the nutritional variation in different seasons and altitudes. The tree foliage was collected from different altitudinal ranges, from low land to mid hills ranging from <400m to 1600m above the sea level in the Gandaki River Basin using a purposive sampling method. The average annual rainfall in the study area range from 1500mm to 3000mm and the temperature between 4°C and 38°C. The coldest months are December and January. The period between June to July is the hottest months, with the temperature reaching 40°C in the Terai.

Soil sample collection and analysis

Soil samples were collected from each study site for observing the soil nutrient status. The sample was taken from 0-15cm and 15-30cm soil depths for further analysis. The soil samples were analyzed for soil pH, Organic Matter (OM), Nitrogen (N), available phosphorus (P), available potassium (K) and texture for observing soil chemical and physical properties. Soil pH was determined by distilled water with 1:2.5 weight by volume, organic matter was determined by Walkley-Black method, nitrogen was determined by sulfuric selenium digestion mixture, available phosphorus was determined by Bray-P1 method and potassium was determined by ammonium extraction method.

Fodder sample collection techniques

More than 60 species of potential tree fodders and shrubs species were found in both low and mid-hills ecological belts. Among them, available five species of fodders were selected for comparative study under different altitudes presented in Table 1. Similar age group of tree fodders and fodders were selected for collecting plant tissue samples. The foliage was harvested from the middle part of the tree in June, September and December.

Table 1. Geographical description of collected fodder samples in Gandaki River Basin

Regions	Location	Altitude ranges
Terai	Chitwan (Gardi VDC)	<400 masl
Mid hills	Kaski (Pumdibhumdi VDC)	400-800 masl
Mid hills	Kaski (Mijure VDC)	800-1200 masl
Mid hills	Lamjung (Ghanpokhara VDC)	1200-1600 masl

The foliage samples were taken from five trees of same species of tree fodder. Six to ten years old tree fodders were selected for collecting foliage sample. Leaves and young twigs were harvested for the laboratory analysis as presented in Table 2. Firstly, 1kg of leaves and young twigs were harvested from each fodder tree and the samples were mixed thoroughly the produce a whole bulk sample. Finally, half kg of the sample was taken as a composite sample for drying and further investigation.

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Table 2. Description of five fodder tree species in the Gandaki River Basin

Scientific name	Family	Local name	English name	Distribution
Artocarpus lakoocha	Moraceae	Badahar	Monkey's Jackfuit	Terai and mid hills
Thysanolaena maxima	Poaceae	Amriso	Broom grass	Terai and mid hills
Ficus roxburghii	Moraceae	Nevaro	Nevaro	Terai and mid hills
Ficus semicordata/cunia	Moraceae	Rai Khanyu	Rai Khaynu	Mid hills
Bauhinia purpurea	Fabaceae	Tanki	Camel's Foot Tree	Terai and mid hills

Chemical analysis of fodders

The clean fresh fodder leaves taken from each study site were collected and weighed. The air-dried fodder leave samples were further dried in a hot air oven at 60°C for 24 hours. Samples were ground and sieved through 2mm mesh sieve. The dry matter (DM) content of plants was determined by drying to constant weight at 105°C, and total ash after heating at 550°C until a constant weight was prepared. Nitrogen (N) content was measured by using the modified semi micro-Kjeldahl method. The Crude Protein (CP) was calculated as N% x 6.25, Ether Extract (EE), Neutral Detergent Fiber (NDF), Acid detergent fiber (ADF), hemi cellulose, lignin were also assessed (Van Soest et al., 1991). The phosphorus, potassium and tannin content in leave samples were also analyzed by using the Association of Official Analytical Chemists method (AOAC, 1990).

Relative feed value (RFV) was calculated from the estimates of dry matter digestibility (DDM) and dry matter intake (DMI) (Rohweder et al., 1978):

$DDM\ \% = 88.9 - (0.779 \times \%ADF)$,

$DMI\ \%\ of\ BW = 120 / \%NDF$,

$RFV = (\%DDM \times \%DMI) / 1.29$,

ADF: acid detergent fibre (% of DM),

DMI: Dry matter intake (% of body weight).

Data analysis

The data obtained from the study were analyzed using the analysis of variances (ANOVA) with the help of SPSS Version 20 (Shrestha & Shrestha, 2017). The treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez & Gomez, 1984; Baral et al., 2016; Shrestha, 2019; Kandel & Shrestha, 2019).

RESULTS

Chemical composition of soil

The chemical and physical properties of soils collected from two different depths are presented in Table 3. Pumdibhumdi site has very acidic soil with the good amount of organic matter and nitrogen. Soil pH is also slightly acidic in Mijure and Ghanpokhara sites. Soils in Madi has good soil pH but very low in organic matter and nitrogen content. Available

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phosphorus and potassium are found higher in Mijure and Ghanpokhara sites and very low in Madi and Pumdibhumdi. Soil texture is sandy loam type to loamy sand in the study sites.

Table 3. Chemical properties of soil in Gandaki River Basin

Soil Parameters	Soil depth (0-15cm)				Soil depth (15-30cm)			
	Madi	Pumdi-bhumdi	Mijure	Ghan-pokhara	Madi	Pumdi-bhumdi	Mijure	Ghan-pokhara
pH (1:2.5)	6.10	4.71	5.49	5.55	6.47	4.95	5.48	5.49
OM (%)	1.25	4.97	3.83	2.85	0.91	4.43	2.37	1.62
Total N (%)	0.02	0.23	0.12	0.11	0.13	0.24	0.12	0.09
Av. P (ppm)	8.75	1.25	157.00	108.12	6.33	3.95	142.00	65.03
Av. K (ppm)	58.40	56.30	132.00	396.53	60.65	58.20	104.40	212.50
Texture (%)	LS	SL	SL	SL	LS	SL	SL	SL

Note: LS – loamy sand; SL – Sandy loam, OM=Organic matter, N=Nitrogen, Av. P=Available Phosphorus; Av. K= Available Potassium; ppm= parts per million.

Chemical composition of fodders

The overall results of the chemical composition of fodders of Gandaki River Basin are presented in Table 4. DM content (g/100g) varied from 27.8 to 42.84 in *Thysanolaena maxima*, 28.0-41.0 in *Artocarpus lakoocha*, 18.31-41.78 in *Ficus roxburghii*, 26.70-38.48 in *Ficus semicordata* and 26.69-42.18 in *Bauhinia purpurea*. Similarly, the maximum values of crude protein, crude fat, and crude fiber content were 21.25%, 4.13%, and 35.01% respectively in *Bauhinia purpurea*. The highest total ash content was found in *Ficus roxburghii* (20.04%) and lowest in *Thysanolaena maxima* (10.50%). The NFE content was highest in *Ficus roxburghii* (64.79%) and lowest in *Bauhinia purpurea* (51.51%). Dry matter digestibility was highest in *Ficus semicordata* (69.67%), followed by *Bauhinia purpurea* (69.60%), *Ficus roxburghii* (66.4%), *Artocarpus lakoocha* (64.54%) and *Thysanolaena maxima* (61.11%). The NDF contents were higher in *Thysanolaena maxima* (79.22 %) and lowest in *Ficus semicordata* (53.21%). The ADF contents were observed highest in *Ficus roxburghii* (57.61%) and lowest in *Bauhinia purpurea* (37.94%).

Seasonal variation in chemical composition of fodders

The seasonal variation in the chemical composition of fodders in the Gandaki River Basin has been presented in Table 5. The dry matter content of fodder leaves is higher between July and Dec during maturity in leaves but its difference by season is not significant. Crude protein and crude fat content in all species are not significantly different with the seasons. Crude fiber content shows a significant difference in *Bauhinia purpurea* (22.99±2.22 to 30.85±2.88) and *Thysanolaena maxima* (26.39±1.76 to 30.47±2.00). There is no significant difference in total ash and carbohydrate content in all species by season. There is no significant difference in phosphorus content but it is significant in potassium content in *Ficus semicordata*, *Ficus roxburghii* and *Bauhinia purpurea*. Tannin content in *Thysanolaena maxima* and *Bauhinia purpurea* are significantly different than other species.

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The gradual increase was found in dry matter from rainy to spring and winter seasons in four species (*Thysanolaena maxima*, *Artocarpus lakoocha*, *Ficus roxburghii* and *Bauhinia purpurea*) except *Ficus semicordata*. Similarly, crude protein also increases in *Thysanolaena maxima* (10.53±1.00 to 13.03±3.82) and *Ficus semicordata* (9.96±0.59 to 12.4±2.14) with seasonal change (rainy to spring to winter). Crude fiber content decreases in all five species with the season. Total ash content increases in *Artocarpus lakoocha* and *Ficus roxburghii*. Similarly, nitrogen free extracts increase in *Ficus semicordata* and *Bauhinia purpurea*. Tannin content increase but phosphorus & potassium content decrease with the season in all species.

Seasonal nutritional factors variation in fodders

The seasonal nutritional factors variation in fodders in Gandaki River Basin has been presented in Table 6. There was a significant difference in nutritional composition of fodders by seasons. *Thysanolaena maxima*, *Ficus roxburghii* and *Bauhinia purpurea* have exhibited a significant difference in seasonal variation at least one variable but other two varieties (*Artocarpus lakoocha* and *Ficus semicordata*) do not significantly differ with seasons. There is no significant seasonal variation in the crude protein of fodders. Neutral Detergent Fiber content varies significantly in *Ficus roxburghii* and *Bauhinia purpurea*. The acid Detergent Fiber content and DDM varied in *Thysanolaena maxima*, *Ficus roxburghii* and *Bauhinia purpurea* while dry matter intake differed in *Ficus roxburghii* and *Bauhinia purpurea*.

Hemicellulose and cellulose were also found significantly different by season but lignin content does not show any significant difference with seasons in all species. NDF and ADF content also seem in decreasing trend but in the case of *Thysanolaena maxima* it is increasing trend by seasonal change (rainy to spring to winter). Digestibility and dry matter intake showed an increasing trend in *Thysanolaena maxima*. Cellulose and lignin content also seem deceasing in all except *Thysanolaena maxima*. *Ficus semicordata* and *Ficus roxburghii* had higher lignin content as compared to other fodders species. Cellulose content is in decreasing trend in *Ficus roxburghii* and *Bauhinia purpurea* with season. RFV value was also increasing trend in all fodders but low RFV in *Thysanolaena maxima* and the result showed high RFV in *Bauhinia purpurea*.

Variation in chemical composition of fodders with altitude

The variation in the chemical composition of fodders with altitude in Gandaki River Basin is presented in Table 7. A significant difference (<0.05) was found in fat content (EE), phosphorus (P) and potassium (K) content in *Thysanolaena maxima*. Nitrogen free extract showed significant difference (<0.05) with altitude but there is no significant difference with altitude in other chemical parameters of fodders trees in *Artocarpus lakoocha*. The crude protein content decreased from 16.15±3.86 to 11.42±1.39 in *Artocarpus lakoocha* but found increasing trend from (8.96±0.35 to 11.45±3.12) in *Ficus roxburghii* between rainy and winter seasons. There is no significant difference in lignin content of fodders along altitudes. Tannin content increased with altitude in *Thysanolaena maxima* and *Artocarpus lakoocha* but among the five fodders *Ficus semicordata* has the highest tannin content and *Thysanolaena maxima* had the lowest. *Thysanolaena maxima* and *Bauhinia purpurea* have high crude fiber

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content and *Ficus roxburghii* has lowest. Tannin is found in increasing trend in *Thysanolaena maxima* and *Artocarpus lakoocha* but it decreased with altitude in *Ficus semicordata*.

Variation in nutritional factors of fodders with altitude

The variation in nutritional factors of fodders with altitude in GRB is presented in Table 8. Lignin content increased from 12.52±1.62 to 14.92±1.96 with altitude variation in *Thysanolaena maxima* while ADF, NDF, DDM, DMI, RFV and Hemi cellulose decreased. Cellulose and lignin content increased in *Ficus semicordata*. Overall ash content in fodders was decreased with altitude gradient from low to high. CP contents showed a decreasing trend in four species of fodders as *Thysanolaena maxima*, *Artocarpus lakoocha*, *Ficus semicordata* and *Bauhinia purpurea* except *Ficus roxburghii*. Other nutrient composition of fodder species did not show a linear change in any direction with altitude and elevation.

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Table 4. Overall constituents of fodders collected from Terai and mid hills area of Gandaki River Basin

	Amriso (*Thysanolaena maxima*)			Badahar (*Artocarpus lakoocha*)			Nevaro (*Ficus roxburgii*)			Raikhanyu (*Ficus semicordata/ cunia*)			Tanki (*Bauhinia purpurea*)		
Parameters	Max.	Min.	$\bar{X}\pm\sigma$	Max.	Min.	$\bar{X}\pm\sigma$	Max.	Min.	$\bar{X}\pm\sigma$	Max.	Min.	$\bar{X}\pm\sigma$	Max.	Min	$\bar{X}\pm\sigma$
% DM	42.84	27.80	33.6±5.03	41.00	28.00	35.41±4.18	41.78	18.31	32.88±7.10	38.48	26.70	32.93±4.47	42.18	26.69	34.88±5.15
% CP	17.94	8.69	11.86±2.85	20.19	10.38	13.32±2.85	15.00	7.81	9.62±1.82	14.25	7.69	10.95±2.07	21.25	10.50	15.68±3.22
% EE	4.04	1.67	2.98±0.72	3.17	2.03	2.48±0.36	3.93	1.79	2.84±0.64	2.98	1.32	2.05±0.49	4.13	2.34	3.19±0.56
% CF	33.17	23.74	28.67±2.51	26.12	13.48	20.41±3.72	23.01	11.41	17.03±3.44	21.17	13.26	18.00±3.02	35.01	20.07	27.19±4.31
% TA	10.54	5.16	8.50±1.57	14.99	8.55	11.57±2.11	20.04	7.89	14.75±3.83	14.45	6.40	10.28±2.51	11.14	5.52	8.45±1.66
% NFE	54.68	43.32	48.28±3.62	62.46	42.36	52.22±5.73	64.79	51.06	55.91±3.97	63.54	54.04	58.72±3.14	51.51	38.19	45.40±4.02
% NDF	79.22	52.73	72.17±6.8	54.83	40.33	45.63±5.17	63.13	35.13	48.45±8.84	53.21	40.32	45.19±4.73	56.90	35.71	45.42±6.67
% ADF	45.91	35.68	41.18±3.11	45.11	31.28	37.63±4.2	57.61	29.31	40.28±8.87	45.88	24.68	36.20±6.61	37.94	24.77	30.80±4.02
%DDM	61.11	53.14	56.82±2.42	64.54	53.76	59.58±3.27	66.06	44.02	57.52±6.91	69.67	53.16	60.70±5.15	69.60	59.34	64.91±3.13
% DMI	2.28	1.51	1.68±0.2	2.98	2.19	2.66±0.29	3.42	1.90	2.56±0.47	2.98	2.26	2.68±0.27	3.36	2.11	2.70±0.4
RFV	93.74	66.59	73.88±7.83	147.14	92.05	123.44±19.2	174.92	64.86	116.01±33.65	160.22	93.39	126.97±22.36	177.58	101.84	136.42±26.26
% HeCel	40.47	6.82	30.99±8.28	11.15	4.01	8.00±2.11	15.27	5.36	8.17±3.08	15.77	5.87	9.00±3.03	22.75	9.09	14.62±3.61
% Cel	35.23	19.42	27.09±4.38	26.34	19.67	23.78±2.08	26.47	16.20	22.23±3.33	30.73	7.29	20.85±6.66	28.04	15.76	20.35±3.69
% Lignin	17.11	10.68	14.09±1.77	18.77	8.69	13.85±3.7	33.18	8.91	18.04±7.61	25.71	6.47	15.35±6.52	13.07	7.77	10.44±1.71
% Tannin	3.49	1.75	2.47±0.63	4.37	1.75	2.88±0.84	6.99	1.75	3.71±1.75	10.05	3.93	7.09±1.9	5.24	1.75	3.16±1.21
%P	0.24	0.07	0.16±0.06	0.26	0.10	0.19±0.05	0.27	0.10	0.17±0.05	0.21	0.13	0.17±0.03	0.34	0.10	0.20±0.07
%K	3.28	0.24	1.39±1.01	1.99	0.17	1.13±0.64	2.30	0.17	1.49±0.79	1.46	0.14	0.92±0.59	1.92	0.16	0.98±0.73

DM: Dry matter, CP: Crude protein, EE: Ether Extract, CF: Crude Fiber, TA: Total ash, NFE: Nitrogen free extract, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, DDM: Dry matter digestibility, DMI: Dry matter Intake, RFV: Relative feed value, HeCel: Hemicellulose, Cel: Cellulose, P: Phosphorus, K: Potassium, mean $\bar{X}$, *standard deviation* (σ).

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Table 5. Seasonal variation in chemical composition of available fodders in Gandaki River Basin

Species	Season	% DM	% CP	% CF	% EE	% NFE	% TA	% P	% K	% Tannin
Amriso (*T. maxima*)	Rainy	29.58±0.94	10.53±1.00	30.47±2.00	3.03±0.27	47.16±2.49	8.55±2.34	0.15±0.04	1.22±0.61	1.97±0.44
	Spring	33.91±2.74	12.00±3.16	29.15±2.09	3.03±0.92	46.84±1.57	8.98±0.91	0.19±0.07	1.61±1.16	2.29±0.22
	Winter	37.30±6.67	13.03±3.82	26.39±1.76	2.86±0.99	50.82±5.13	7.99±1.44	0.13±0.06	1.34±1.38	3.16±0.42
		NS	NS	*	NS	NS	NS	NS	NS	**
Badahar (*A.lakoocha*)	Rainy	32.04±3.48	13.97±2.68	20.88±5.31	2.30±0.26	52.82±8.39	10.02±1.60	0.22±0.04	1.44±0.41	2.95±0.75
	Spring	35.46±4.34	13.74±4.39	22.77±1.82	2.54±0.46	49.42±5.14	11.54±2.04	0.20±0.05	1.31±0.55	2.29±0.82
	Winter	38.74±1.81	12.25±0.98	17.58±0.86	2.60±0.38	54.43±2.45	13.15±1.73	0.17±0.05	0.64±0.74	3.38±0.75
		NS	NS	NS	NS	NS	NS	NS	NS	NS
Nevaro (*F. roxburghii*)	Rainy	25.69±5.89	9.24±0.67	17.85±4.81	2.73±0.64	56.82±4.72	13.36±1.45	0.21±0.07	1.91±0.23	2.73±1.69
	Spring	34.18±5.26	8.66±0.63	18.61±2.60	2.44±0.42	56.51±5.61	14.24±5.06	0.17±0.04	1.86±0.36	3.71±2.38
	Winter	38.79±2.17	10.97±2.73	14.63±1.26	3.34±0.59	54.41±1.89	16.66±4.3	0.13±0.03	0.72±0.94	4.69±0.42
		NS	NS	NS	NS	NS	NS	NS	*	NS
Raikhanyu (*F. cunia*)	Rainy	34.13±2.97	9.96±0.59	20.46±1.04	1.82±0.19	57.6±3.43	10.16±4.05	0.17±0.02	1.29±0.29	5.97±2.49
	Spring	27.8±0.97	10.48±2.69	17.76±4.06	1.94±0.59	58.17±3.58	11.64±1.67	0.17±0.03	1.28±0.3	6.84±0.67
	Winter	36.85±2.38	12.4±2.14	15.79±1.56	2.38±0.57	60.38±2.89	9.06±1.02	0.17±0.04	0.19±0.08	8.45±1.77
		NS	NS	NS	NS	NS	NS	NS	**	NS
Tanki (*B. purpurea*)	Rainy	29.97±3.77	16.72±4.32	30.85±2.88	3.10±0.48	41.68±3.78	7.65±2.2	0.23±0.1	1.4±0.7	2.08±0.66
	Spring	36.18±4.45	14.24±3.35	27.74±3.61	3.00±0.54	45.76±2.52	9.01±1.09	0.19±0.02	1.31±0.56	2.84±0.56
	Winter	38.49±3.37	16.10±1.92	22.99±2.22	3.46±0.69	48.77±2.22	8.70±1.63	0.17±0.05	0.22±0.05	4.56±0.58
		*	NS	*		*	NS	NS	*	**

*DM: Dry matter, CP: Crude protein, EE: Ether Extract, CF: Crude Fiber, TA: Total ash, NFE: Nitrogen free extract, P: Phosphorus, K: Potassium, *Significant at 5% (P<0.05), ** Significant at 1% (P<0.01) and ^{NS} Not-significantly different (P>0.05).*

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Table 6. Seasonal nutritional factors variation for available fodders in Gandaki River Basin

Species	Season	% CP	% ADF	% NDF	% DDM	% DMI	% ADL	% Hem Cel	% Cel	RFV
Amriso (*T. maxima*)	Rainy	10.53±1.00	43.45±1.99	68.25±10.52	55.06±1.55	1.80±0.32	13.02±1.76	24.8±12.05	30.43±3.23	76.4±11.88
	Spring	12.00±3.16	42.03±1.94	75.52±2.6	56.16±1.51	1.59±0.06	14.2±1.39	33.5±3.14	27.83±3.18	69.24±3.15
	Winter	13.03±3.82	38.06±2.63	72.73±4.06	59.26±2.05	1.65±0.09	15.04±1.94	34.68±4.34	23.01±3.45	76.00±5.51
		NS	*	NS	*	NS	NS	*	*	NS
Badahar (*A. lakoocha*)	Rainy	13.97±2.68	37.66±4.81	46.07±7.02	59.56±3.75	2.65±0.39	12.47±4.30	8.41±2.62	25.19±0.93	123.13±25.14
	Spring	13.74±4.39	39.85±4.14	48.46±4.38	57.86±3,23	2.49±0.22	15.22±3.53	8.61±1.41	24.63±1.70	112.11±15.69
	Winter	12.25±0.98	35.39±3.31	42.36±2.06	61.33±2.58	2.84±0.13	13.86±3.77	6.97±2.31	21.52±1.27	135.07±11.5
		NS	NS	NS	NS	NS	NS	NS	*	NS
Nevaro (*F.roxburghii*)	Rainy	9.24±0.67	46.93±9.94	54.05±9.49	52.34±7.74	2.28±0.45	22.08±10.01	7.12±1.14	24.85±1.27	94.42±33.14
	Spring	8.66±0.63	41.34±6.23	51.56±5.28	56.70±4.85	2.35±0.24	18.08±7.90	10.22±4.40	23.26±2.53	103.62±18.15
	Winter	10.97±2.73	32.56±3.3	39.73±3.51	63.54±2.57	3.04±0.28	13.97±2.44	7.18±2.37	18.59±2.08	149.98±18.93
		NS	*	*	*	*	NS	NS	**	*
Raikhanyu (*F. cunia*)	Rainy	9.96±0.59	39.13±6.46	46.31±5.56	58.42±5.03	2.62±0.32	20.36±4.76	7.17±1.14	18.77±10.27	119.32±24.59
	Spring	10.48±2.69	37.68±6.81	47.3±5.18	59.55±5.31	2.56±0.26	15.7±6.83	9.63±1.99	21.98±0.95	118.72±22.02
	Winter	12.4±2.14	31.78±6.43	41.98±2.76	64.14±5.01	2.87±0.18	10.0±4.47	10.2±4.86	21.78±7.83	142.87±18.48
		NS	NS	NS	NS	NS	NS	NS	NS	NS
Tanki (*B. purpurea*)	Rainy	16.72±4.32	34.75±2.93	50.60±2.25	61.83±2.29	2.38±0.11	10.03±1.4	15.85±2.36	24.71±2.43	113.94±8.36
	Spring	14.24±3.35	30.24±3.0	46.43±7.1	65.34±2.34	2.63±0.36	10.94±2.31	16.18±4.41	19.30±1.25	133.43±22.15
	Winter	16.10±1.92	27.40±2.27	39.23±4.41	67.56±1.77	3.09±0.32	10.36±1.7	11.83±2.65	17.04±1.02	161.89±20.42
		NS	*	*	*	*	NS	NS	**	*

*CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid Detergent lignin, DDM: Dry matter digestibility, DMI: Dry matter Intake, RFV: Relative feed value, HeCel: Hemicellulose, Cel: Cellulose, *Significant at 5% (P<0.05), ** Significant at 1% (P<0.01) and [NS] Not-significantly different (P>0.05).*

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Table 7. Altitudinal variation effects on chemical composition of available fodders in Gandaki River Basin

Species	Altitude (m)	% DM	% CP	% EE	% CF	% TA	% NFE	% P	% K	% Tannin
	<400	30.37±3.55	14.15±3.72	2.13±0.75	29.61±3.18	8.44±2.84	45.67±2.42	0.2±0.02	2.79±0.67	2.18±0.44
Amriso	400-800	36.86±6.06	10.46±1.59	3.67±0.38	29.00±1.61	8.57±0.96	49.76±4.63	0.09±0.02	0.71±0.56	2.48±0.67
(*T. maxima*)	800-1200	33.84±3.87	9.94±0.66	3.28±0.16	29.77±2.17	8.47±1.99	48.22±4.59	0.16±0.07	0.89±0.57	2.47±0.91
	1200-1600	33.31±6.57	12.87±3.15	2.83±0.44	26.31±2.36	8.54±0.79	49.45±2.86	0.18±0.02	1.16±0.66	2.76±0.67
		NS	NS	*	NS	NS	NS	*	*	NS
	<400	35.88±3.45	16.15±3.86	2.34±0.26	21.87±3.9	13.56±1.3	46.08±5.5	0.19±0.08	1.86±0.13	2.33±0.67
Badahar	400-800	35.66±6.72	13.86±2.41	2.82±0.59	21.30±2.93	11.10±0.53	50.92±3.15	0.16±0.02	0.77±0.68	2.48±0.67
(*A. lakoocha*)	800-1200	32.75±3.4	11.86±0.94	2.43±0.05	17.36±3.99	10.09±1.53	58.26±4.00	0.20±0.02	0.83±0.57	3.20±0.5
	1200-1600	37.35±3.31	11.42±1.39	2.33±0.26	21.11±4.16	11.52±3.25	53.63±2.7	0.24±0.02	1.06±0.57	3.49±1.16
		NS	NS	NS	NS	NS	*	NS	NS	NS
	<400	29.16±9.5	8.96±0.35	2.85±0.33	13.85±2.15	17.70±2.61	56.65±4.21	0.20±0.06	1.37±1.05	3.35±1.4
Nevaro	400-800	38.14±4.8	8.99±1.26	3.09±0.82	19.28±3.61	13.41±5.24	55.83±7.77	0.12±0.01	1.14±0.77	5.82±1.01
(*F. roxburghii*)	800-1200	31.44±6.13	9.09±0.32	2.93±0.11	17.89±4.56	14.9±4.37	55.2±2.5	0.14±0.04	1.28±0.87	3.05±1.51
	1200-1600	32.79±7.8	11.45±3.12	2.48±1.08	17.11±1.66	13.00±2.68	55.97±0.95	0.21±0.05	2.18±0.11	2.62±1.51
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400									
Raikhanyu	400-800	33.27±5.00	10.02±0.69	2.33±0.56	18.16±3.43	10.72±2.47	59.76±3.27	0.16±0.03	0.89±0.59	8.16±1.01
(*F. cunia*)	800-1200	30.96±3.83	12.59±1.94	2.20±0.36	19.29±1.82	11.15±3.2	55.56±2.04	0.17±0.04	0.85±0.67	6.40±1.10
	1200-1600	34.55±5.52	10.23±2.6	1.60±0.26	16.56±3.95	8.98±2.24	60.83±1.09	0.17±0.02	1.02±0.75	6.70±3.1
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400	35.85±2.67	17.13±0.92	2.85±0.33	26.96±6.97	8.33±0.96	44.74±5.79	0.23±0.04	1.09±0.74	3.17±1.29
Tanki	400-800	38.67±4.47	12.36±1.28	3.44±0.41	26.37±2.71	10.62±0.55	47.22±0.89	0.14±0.06	0.37±0.21	3.49±1.15
(*B. purpurea*)	800-1200	31.21±3.92	17.71±3.09	3.57±0.53	26.94±5.95	7.00±1.3	44.46±6.2	0.21±0.01	1.21±0.86	3.06±1.9
	1200-1600	33.79±7.63	15.54±4.37	2.89±0.74	28.51±2.66	7.87±1.19	45.19±3.04	0.22±0.11	1.24±0.91	2.91±1.1
		NS	NS	NS	NS	NS	NS	NS	NS	NS

*DM: Dry matter, CP: Crude protein, EE: Ether Extract, CF: Crude Fiber, TA: Total ash, NFE: Nitrogen free extract, P: Phosphorus, K: Potassium , *Significant at 5% (P<0.05), ** Significant at 1% (P<0.01) and ^{NS} Not-significantly different (P>0.05). The Ficus semicordata is not found in <400 altitude.*

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Table 8. Altitude variation effects on nutritional factors of available fodders in Gandaki River Basin

Species	Altitude (m)	CP (%)	NDF(%)	% ADF	% DDM	% DMI	% HemCel	% Cell	% ADL	RFV
	<400	14.15±3.72	69.31±14.45	42.69±2.8	55.64±2.18	1.79±0.43	26.62±17.21	30.17±4.38	12.52±1.62	76.74±14.82
Amriso	400-800	10.46±1.59	74.60±1.88	40.68±4.11	57.21±3.2	1.61±0.04	33.92±5.81	26.39±3.57	14.29±0.55	71.32±2.57
(*T. maxima*)	800-1200	9.94±0.66	73.68±3.2	42.52±2.42	55.78±1.89	1.63±0.07	31.16±1.11	27.9±4.7	14.62±2.31	70.57±5.52
	1200-1600	12.87±3.15	71.08±2.38	38.82±2.79	58.66±2.18	1.69±0.06	32.26±1.5	23.9±4.48	14.92±1.96	76.88±5.31
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400	16.15±3.86	47.95±7.02	38.69±6.55	58.76±5.10	2.54±0.38	9.25±2.04	23.91±2.00	14.78±4.57	116.65±27.68
Badahar	400-800	13.86±2.41	42.08±1.64	35.20±0.83	61.48±0.65	2.86±0.12	6.89±1.59	24.56±1.91	10.63±1.18	136.05±5.83
(*A. lakoocha*)	800-1200	11.86±0.94	45.82±3.99	37.85±1.00	59.41±0.78	2.63±0.24	7.97±3.44	22.49±2.88	15.36±2.03	121.33±12.13
	1200-1600	11.42±1.39	46.67±7.09	38.79±6.3	58.68±4.91	2.61±0.39	7.88±1.31	24.17±2.02	14.62±5.27	119.7±27.29
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400	8.96±0.35	50.35±11.14	43.99±11.79	54.63±9.19	2.45±0.49	6.36±1.42	22.25±1.89	21.74±9.91	106.23±36.02
Nevaro	400-800	8.99±1.26	41.85±7.06	33.42±3.86	62.87±3.00	2.92±0.49	8.43±3.37	22.97±4.56	10.44±1.38	143.17±30.71
(*F.roxburghii*)	800-1200	9.09±0.32	49.23±9.07	42.72±9.4	55.62±7.32	2.50±0.51	6.51±1.09	20.2±3.68	22.52±6.67	109.71±37.62
	1200-1600	11.45±3.12	52.36±8.86	40.97±9.47	56.98±7.38	2.34±0.44	11.38±3.58	23.51±3.67	17.46±6.03	104.92±32.81
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400									
Raikhanyu	400-800	10.02±0.69	43.50±3.04	32.40±7.06	63.66±5.49	2.77±0.2	11.10±4.11	19.70±3.08	12.70±4.05	137.11±21.47

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(*F. cunia*)	800-1200	12.59±1.94	43.65±2.61	34.56±2.3	61.97±1.79	2.76±0.17	9.09±2.23	20.30±11.93	14.26±10.13	132.50±10.94
	1200-1600	10.23±2.6	48.43±7.06	41.63±7.07	56.47±5.51	2.52±0.4	6.80±0.91	22.53±4.35	19.09±4.22	111.30±29.17
		NS	NS	NS	NS	NS	NS	NS	NS	NS
	<400	17.13±0.92	47.35±5.03	32.79±4.46	63.36±3.48	2.55±0.26	14.56±1.19	21.40±5.75	11.39±1.29	125.81±19.05
Tanki	400-800	12.36±1.28	42.13±6.97	29.96±5.58	65.56±4.35	2.90±0.47	12.17±2.73	19.92±4.63	10.04±1.99	148.31±32.28
(*B. purpurea*)	800-1200	17.71±3.09	48.48±10.49	30.65±5.13	65.02±3.99	2.57±0.62	17.82±5.46	20.09±3.02	10.57±2.5	130.51±40.05
	1200-1600	15.54±4.37	43.71±4.55	29.79±1.76	65.70±1.37	2.77±0.29	13.93±2.81	20.01±3.02	9.78±1.41	141.04±17.86
		NS	NS	NS	NS	NS	NS	NS	NS	NS

*CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid Detergent lignin, DDM: Dry matter digestibility, DMI: Dry matter Intake, RFV: Relative feed value, HeCel: Hemicellulose, Cel: Cellulose , *Significant at 5% (P<0.05), ** Significant at 1% (P<0.01) and* ^{NS} *Not-significantly different (P>0.05). The Ficus semicordata is not found in <400 altitude.*

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DISCUSSION

Chemical constituents of fodders change significantly with the season, which is affected by different environmental factors but they do not vary significantly for most of the fodder species with the altitude. Crude protein, potassium, and phosphorus contents of fodder were found declined with maturity in *Artocarpus lakoocha* as they mature. Aganga & Tshwenyane (2003) reported that tree fodders maintain higher protein and mineral contents during growth, which decline rapidly in quality with progress to maturity. In this study crude protein in all five fodders found in increasing trend especially in *Ficus semicordata* and *Thysanolaena maxima* because these species produced new shoots and leaves each month.

All the fodders and shrubs are indigenous fodders used by local farmers from the earlier days. These indigenous fodder plants have an important role to play in both small and large ruminants. Roothaert & Paterson (1997) reported that because of their adaptation to the local environment attributable to their pest and drought tolerance, palatability, high nutrient value and biomass production indigenous fodder plants are desirable over the exotic plants.

The fodders and shrubs have varied nutrient content and chemical composition as per the available environment, topography, soil nutrients, seasons, aspect, climatic condition and stages of cut (Mislevy et al., 1989). The chemical composition especially fiber contents such as cellulose and hemicelluloses in fodders vary with the stage of the cut, season and available nutrient in soil (Knettle et al., 1991). The average crude fiber content in five fodders is decreased in three different seasons of cut and there is varied in hemicelluloses and cellulose content among them. Hemicellulose and cellulose are very high in *Thysanolaena maxima* and *Bauhinia purpurea* due to high fiber content that contributes to low dry matter intake. Therefore, low feed intake is usually associated with high fiber content and low protein. As the plant matures, dry matter and cell wall contents increase but crude protein and cell contents decrease (Gupta et al., 1976).

Anti-nutritional factors of feed values on fodder trees and shrubs are restricted by a secondary compound that may have different roles, such as protecting plants from diseases and herbivorous intake, and toxicity. Among them, tannins are mostly occurring compounds that are complex galactonic hydrolysable phenolic compounds containing approximately 80% of the dicotyledonous plants (Rhoades, 1979). Decandia et al., (1999) reported that the high level of tannin contents in fodder trees and shrubs reduce digestibility and intake as well as palatability. Tannin content is gradually increased with seasons and found highly significant with the season in *Thysanolaena maxima* and *Bauhinia purpurea*. But there is no significant difference in tannin content among fodders and forages with altitudes. It was also reported that new leaves often have higher tannin content than older leaves (Vaithiyanathen & Singh, 1989). Macloid (1974) reported that tannins above 5% can become a serious anti- nutritional factor in plant materials fed to ruminants. But the variation in the antinutritional effects of tannins due to animal species as a result of the ability to secrete proline-rich proteins (PRP) in saliva has been reported.

The tannin content in fodders like *Thysanolaena maxima* and *Bauhinia purpurea* are most palatable to goat and digest easily as compared to cattle. The tannin contents in the studied fodders were lower than the lethal dose (<10%). Mostly in ruminant, the protein tannin complex dissociates and the protein can be digested in the lower gut. Tannins at higher levels (5-9%) become detrimental (Barry, 1983), as they reduce the digestibility of fibre in the rumen (Reed et al, 1985) by inhibiting the activity of bacteria and anaerobic fungi (Akin & Rigsby, 1985) and above 9% tannins their effects can become lethal. So, the tannin content of the studied fodders is safe for ruminants.

There was no variation in the chemical composition of fodders and forages by altitude. In contract, Singh et al. (2010) reported that the high altitudinal trees population show comparatively higher nutritive values than those from low altitude. The studied fodders and shrubs are agroforestry species that have a wide range of ecological amplitude (ranges from 300 to 2000 masl) and provide excellent protein during the dry season. However, the season of harvesting (Bhandari et al., 1979; Pal et al., 1979) and source of collection, i.e., altitude (Morecroft et al., 1992b; Woodward, 1986) influence the nutritive values of tree foliage significantly. In GRB, crude fiber content increased with altitude only in *Ficus roxburghii* but other four species of fodders and shrubs did not show a significant trend. But other factors such as type of soil, organic matter contents, elevation, precipitation, temperature, daylight, and so on, might have played a more important role in such variation or similarity. The trend of lignin and NDF content in *Ficus semicordata* and *Bauhinia purpurea* gradually decreased with altitude that supports to have high dry matter intake. Bakshi & Wadhwa (2004) reported that the voluntary dry matter intake (DMI) and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin content in the fodders and forages.

Among the studied fodders, dry matter and crude protein contents showed wide variations with maturity and geographical structure such as elevation. These variations could be the function of agronomic factors such as application of various levels of nitrogen fertilizers, time of harvest, ensiling, field drying and storage. Similar findings have been reported in Italian rye grass for its dry matter yield, which varied from 18.8-75.5% mainly due to different harvesting time (Bittante & Andrightto, 1982). Like DM and CP, other nutrients could also vary in different feeds due to agroclimatic conditions, cultural practices and postharvest processing and storage conditions.

Subba (1999) has reported that crude protein contents of all the species of this study were approximately higher than 10%, sufficient for a medium level of production from ruminants. The higher proportion of the CP in the fodder tree leaves is actually in the form available to ruminants. Farmers mainly focus on fodder trees and forages good in palatability, yield performance of fodders and growth of their animals. Distel et al. (2005) reported that CP contents in different forage species decline with time. Fodders such as *Thysanolaena maxima* and *Ficus semicordata* were showed the protein content increased with maturity and time due to its new flushing come out in each month.

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CONCLUSION

The variation in fodders seemed very significant by season but less significant with altitude in the nutrient content of fodders in GRB region. Nutrient contents of some fodders increased with the season and some of them were found in decreasing trend. Consequently, the seasonal variation affects the chemical constituents in fodders and fodder trees production but no significant change is observed due to altitudinal variation. Therefore, season is an important factor to harvest the fodders and forages for the livestock husbandry. Similarly, DMI and RFV index were high in *Artocarpus lakoocha*, *Ficus roxburghii*, *Ficus semicordata* and *Bauhinia purpurea* but low in *Thysanolaena maxima*. Most of the fodders are located in the mid-hills and mountain areas which are easily grown and sustainable due to suitable ecological environment. *Artocarpus lakoocha* is suitable for cultivation in low foothills and its crude protein is going to decrease along with high hill areas. Similarly, nutritional constituents were found in decreasing trend with altitudes. Therefore, these indigenous fodders are recommended to be harvested best in the spring season for feeding livestock because of their richness of nutritional and chemical composition.

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Author Contributions

Shah, M.K.,Tamang, B.B.,Chaudhary, P., Shrestha S. and Chhetri, N. designed and performed experiments and wrote paper; Dhakal, B. developed analytical tools and analyzed data.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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