Nuritive Evalution of Forage Plants Grown in South Sulawesi, Indonesia

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ABSTRACT : In order to evaluate the nutritive value of the forage plants in South Sulawesi, Indonesia, 266 samples (61 grasses and 65 legumes grown in the dry season, 60 grasses and 80 legumes grown in the rainy season) were collected from the highland and lowland in 1998 to 2000, and were subjected to the determination of chemical composition and digestibility. The least-squares analysis of variance demonstrated that the *in vitro* dry matter digestibility (IVDMD) of grasses was not significantly affected by season or altitude. On the other hand, the some proximate components and cell wall components were significantly affected by season and altitude including the season×altitude interaction. For the legumes, the *in vitro* neutral detergent fiber digestibility (IVNDFD) and cellulose content were significantly affected by season. On the other hand, the ether extract (EE) content was significantly affected by season and altitude. The interaction of the season×altitude for IVDMD, of the year×season for some proximate components and of the year×season and the season×altitude for some cell wall components were significant. These results indicate that the forages grown at highland in dry season have a relatively high quality. The means of the total digestible nutrient (TDN) content estimated from IVDMD in grasses and in legumes were 50.3% and 57.4%, respectively, and the crude protein contents were 7.7% and 17.6%, respectively. The correlation coefficients between IVDMD and the contents of crude fiber, neutral detergent fiber and acid detergent fiber were relatively high in all of forage plants, suggesting that these components would provide an accurate prediction of digestibility or TDN content. A close relationship between IVNDFD and lignin content indicates that the lignin would be the most accurate predictor of cell wall digestibility. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 5 : 693-701)***

Key Words : Chemical Composition, Digestibility, Forage Plants, South Sulawesi, Indonesia

INTRODUCTION

South Sulawesi located in eastern region of Indonesia has an extensive area of grassland and a large number of ruminants, particularly beef cattle, buffalo and goats. However, the ruminant feeding in this area is not so productive. Bulo et al., (1994) had pointed out the seasonal imbalance between forage quality and animal requirement.

Generally, the ruminants are allowed to graze freely on the natural grassland during the day, and are kept in pens or yards near the farmer's house at night, therefore they are ingesting the various kinds of feeds. Additionally, in the intensive cropland areas, the ruminants are kept in cages and fed the cultivated forages, the grasses from waste areas and from communal grazing lands, the leaves from shrubs or trees and the crop residues by cut-and-carry system. These forages, on the whole, have a low nutritive value. In this context, the shortage of high quality feed is one of the serious problems on the ruminant production in South Sulawesi.

The quality of forage would be affected by a number of factors, some include climate, altitude and soil condition. However, only a few papers on the nutritional composition of forages grown in South Sulawesi have been reported (Ella et al., 1992, 1994; Bulo et al., 1994). An understanding of feeding characteristics of forage plants grown under different conditions in this area will enable them to be used more efficiently.

In this study, the chemical composition and digestibility of the promising grasses and legumes grown at different seasons and altitudes in South Sulawesi were examined.

MATERIALS AND METHODS

Site description

South Sulawesi extends from 0°12' North latitude to 8°0' South latitude and from 116°48' to 122°36' East longitude, being the great part of the eastern Indonesia. The area is 72,781 km^2 which is equivalent to 3.79% of the total area of Indonesia. This region has two different seasons; a rainy and dry season, and also has two different areas; a highland and lowland area.

The Enrekang regency was selected as a representative area of highland that extends from 3°14' North latitude to 3°50' South latitude and from 119°40' to 120°6' East longitude, and the altitude ranges from 500m to 3,000m above sea level. This area has a long-term rainy season. The annual precipitation is about 1,200mm to 2,300mm and the average temperature ranges from 19°C to 23°C as shown in figure 1. Usually, the precipitation is well distributed throughout the year, although the period from June to October is relatively dry.

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Received July 9, 2002; Accepted December 31, 2002

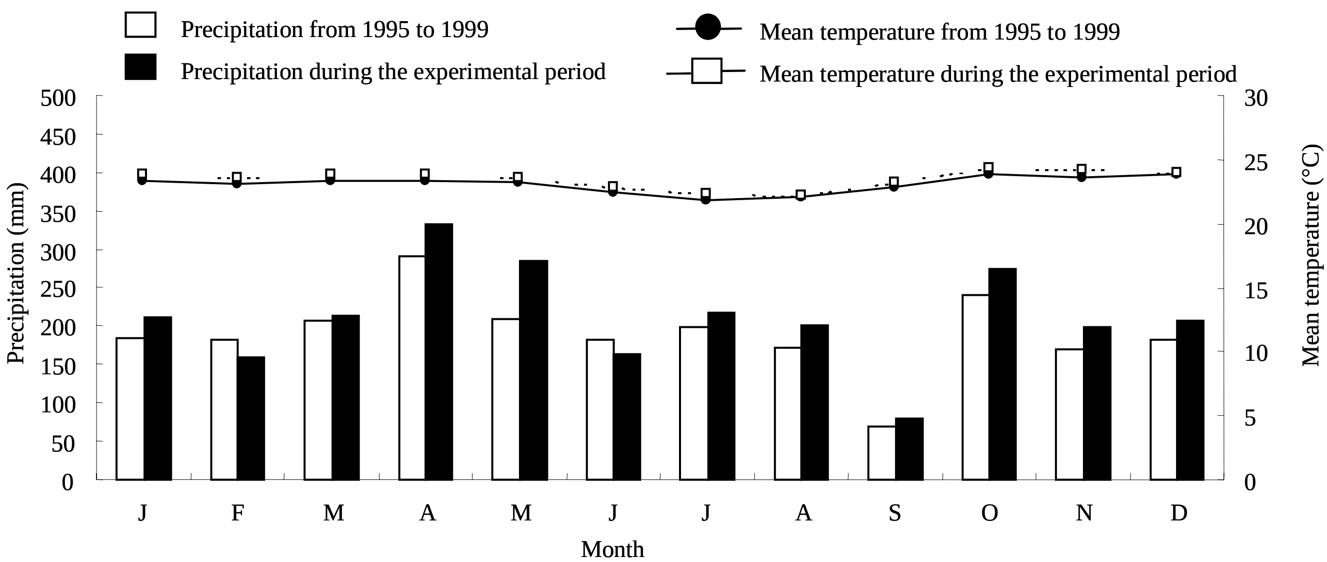

Figure 1. Seasonal changes in precipitation and average air temperature in the Highland

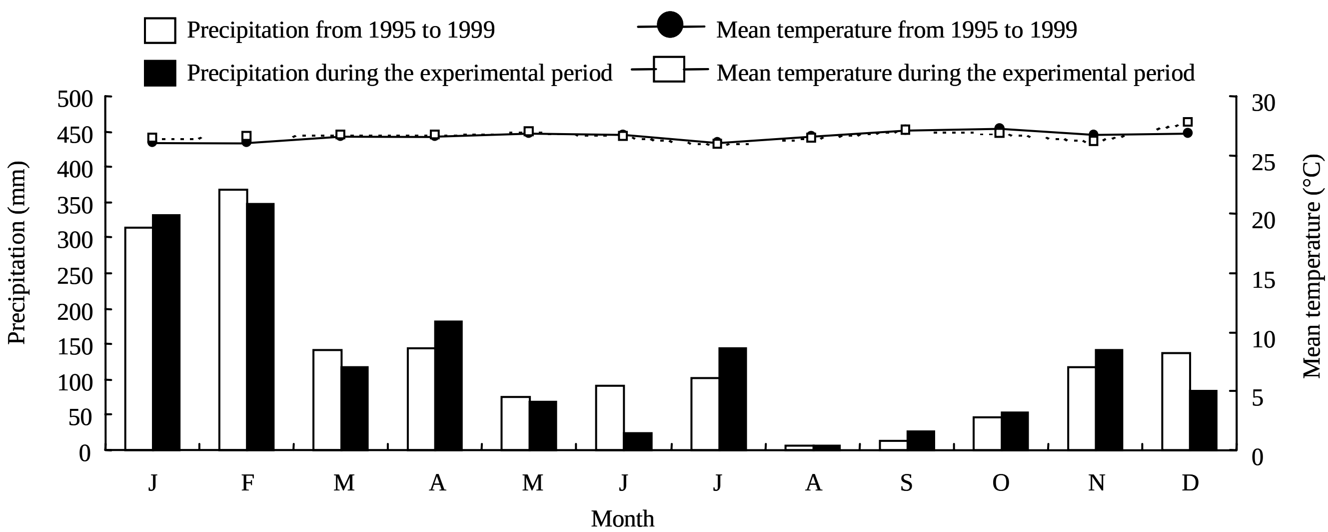

Figure 2. Seasonal changes in precipitation and average air temperature in the Lowland

The Gowa-Jeneponto regencies were selected as a representative area of lowland that extends from 5° 5' North latitude to 5°34' South latitude and from 12°33' to 13°15' East longitude, and the altitude ranges from 0m to 500m above sea level. The annual precipitation is about 900mm to 1900mm and the average temperature ranges from 24°C to 29°C as shown in figure 2. The precipitation distributed with a peak in February, and the period from June to October is usually dry.

The above two areas selected for sampling because they are important ruminant producing area and have extensive area of grassland like other larger areas of South Sulawesi.

Sample collection and preparation

In the representative areas most of the forage plants grown were natural grasses and natural legumes and were been used by farmers as major animal fodder. These forage were never been fertilised, nor any management intervene.

As the samples of forage plants grown in the dry season, 23 grasses and 24 legumes were collected in July of 1998, and 38 grasses and 41 legumes were collected in August of 2000, at late heading stage. Also in the rainy season, 26 grasses and 39 legumes were collected in February of 1999 and 34 grasses and 41 legumes were collected in March of 2000, at early heading stage. These samplings were conducted in the same highland and lowland throughout the experiment. After removing a few weeds, the samples were

Table 1. Chemical composition and digestibility of grasses (i)

Species	n	Digestibility (%) and chemical composition (% in dry matter)						
		IVDMD[1]	IVNDFD[2]	TDN[3]	CP[4]	CF[5]	EE[6]	Ash
Bothriochloa pertusa (Beardgrass)	2	66.10±4.50	48.62±8.00	51.95±8.49	5.64±0.09	28.10±0.52	2.11±0.44	12.41±4.18
Brachiaria brizantha (Palisadegrass)	7	61.10±13.02	42.46±13.80	57.37±11.80	9.41±3.81	30.85±2.37	2.23±0.91	11.57±2.01
Brachiaria decumbens (Signalgrass)	11	66.91±14.25	52.97±17.18	53.60±8.73	7.88±2.52	30.55±3.99	1.89±0.61	8.67±1.51
Brachiaria humidicola (Koroniviagrass)	2	54.48±0.52	36.10±2.68	52.17±3.30	3.37±0.39	34.18±1.39	1.55±0.56	7.04±0.42
Brachiaria mutica (Paragrass)	1	79.47 -	69.18 -	52.71 -	14.46 -	27.67 -	2.06 -	12.68 -
Brachiaria ruziziensis (Congograss)	1	64.38 -	52.21 -	42.70 -	3.33 -	34.84 -	1.70 -	6.42 -
Cenchrus ciliaris (Buffelgrass)	2	61.93±7.12	44.10±6.34	59.12±3.36	6.73±1.48	35.34±1.41	2.31±0.29	12.87±0.25
Cotario catalya (Cotario)	1	67.38 -	29.37 -	44.69 -	15.87 -	25.31 -	2.79 -	9.57 -
Cynodon dactylon (Bermudagrass)	1	59.10 -	43.38 -	39.20 -	8.91 -	25.87 -	1.54 -	15.71 -
Digitaria milanjiana (Digitgrass)	3	64.72±7.95	47.15±9.59	55.00±8.98	5.55±2.37	31.18±3.23	2.33±0.30	11.02±2.43
Euchlaena mexiana (Euchlaena)	4	65.65±7.81	50.44±10.71	52.29±6.09	6.52±3.31	32.92±2.51	1.78±0.63	9.02±3.04
Imperata cylindrica (Cogongrass)	13	44.71±10.08	28.24±8.79	36.98±8.90	4.13±1.79	36.45±2.92	1.67±0.48	9.27±3.03
Native grasses	15	63.31±8.29	45.81±10.70	51.54±11.20	7.67±3.49	29.65±4.68	1.89±0.66	11.72±3.37
Panicum maximum (Guineagrass)	11	67.63±12.16	51.71±14.30	55.04±12.91	9.96±3.34	32.47±4.46	1.86±0.69	13.47±2.29
Paspalum notatum (Bahiagrass)	2	59.13±4.02	41.85±3.58	39.22±2.67	5.98±0.35	32.22±4.66	1.96±0.08	10.68±5.08
Pennisetum purpureum (Napiergrass)	15	70.47±8.61	55.50±11.40	56.68±8.25	8.94±4.50	31.29±3.62	2.17±0.74	14.26±2.48
Pennisetum purpupoides (Kinggrass)	6	64.53±9.70	47.74±14.31	57.62±7.75	7.23±2.75	32.23±2.98	1.89±0.69	14.16±1.50
Setaria sphacelata (Golden timothy)	12	68.18±10.28	51.72±11.87	54.28±8.11	7.22±3.44	31.58±3.06	2.07±0.43	13.65±2.83
Urachloa pullulans (Witgrass)	4	66.58±13.56	51.15±16.28	53.55±13.30	8.83±4.96	30.95±5.04	1.94±0.93	13.76±3.20
Vetiver zizanioides (Vetiver)	8	44.25±9.54	25.55±11.21	40.58±11.56	7.34±2.75	38.42±10.63	1.52±0.64	8.75±1.35
Overall mean	121	63.00±8.08	45.76±10.22	50.31±6.99	7.75±3.16	31.60±3.33	1.96±0.31	11.34±2.58

[1]IVDMD: in vitro dry matter digestibility
[2]IVNDFD: in vitro neutral detergent fiber digestibility
[3]TDN: total digestible nutrients
[4]CP: crude protein
[5]CF: crude fiber
[6]EE: ether extract

oven-dried at 60°C for 24 h and then ground to pass through a 1-mm screen. The samples were including stems, leaves, and twigs of shrub species. The forage species used in this experiment were listed in the first columns of tables 1 and 2.

Chemical analysis and digestion trial

The proximate components were determined according to Association of Official Analytical Chemists (AOAC) method (1995). The neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), *in vitro* dry matter digestibility (IVDMD) and NDF digestibility (IVNDFD) with rumen microbes were determined by the methods of Goering and Van Soest (1970). The content of total digestible nutrients (TDN) was estimated by the measuring IVDMD of the standard sample known TDN content by sheep. All determinations were carried out in duplicate.

Statistical analysis

Data in this study were analyzed using Mixed Model Least-Squares and Maximum Likelihood Computer Programs of Harvey (1990), and 2 to 15 replications were made in the model as follows:

$$Y_{ijkl}= \mu+M_i+Y_j+S_k+A_l+(YS)_{jk}+(YA)_{jl}+(SA)_{kl}+e_{ijkl}$$

Table 1. Chemical composition and digestibility of grasses (ii)

Species	n	Chemical composition (% in dry matter)					
		N F E[7]	N D F[8]	A D F[9]	Hemicellulose	Cellulose	ADL[10]
Bothriochloa pertusa (Beardgrass)	2	52.92 ± 1.47	69.38 ± 2.04	36.13 ± 3.63	33.25 ± 1.59	18.58 ± 3.46	8.22 ± 4.06
Brachiaria brizantha (Palisadegrass)	7	45.94 ± 3.50	65.89 ± 3.96	36.91 ± 5.24	28.98 ± 4.32	26.79 ± 2.44	6.01 ± 3.15
Brachiaria decumbens (Signalgrass)	11	51.01 ± 3.47	68.16 ± 5.03	34.62 ± 6.19	33.55 ± 2.19	26.33 ± 2.53	4.81 ± 3.07
Brachiaria humidicola (Koroniviagrass)	2	53.84 ± 1.67	73.51 ± 1.15	40.71 ± 5.77	32.80 ± 4.62	30.65 ± 1.37	6.94 ± 4.21
Brachiaria mutica (Paragrass)	1	43.14 -	66.62 -	30.53 -	36.09 -	24.03 -	3.00 -
Brachiaria ruziziensis (Congograss)	1	53.71 -	74.75 -	39.50 -	35.25 -	32.51 -	4.52 -
Cenchrus ciliaris (Buffelgrass)	2	42.74 ± 0.11	71.89 ± 1.09	41.77 ± 5.59	30.12 ± 4.49	27.73 ± 3.61	6.98 ± 2.17
Cotario catalya (Cotario)	1	46.46 -	46.18 -	31.16 -	15.02 -	20.83 -	9.26 -
Cynodon dactylon (Bermudagrass)	1	47.96 -	72.25 -	29.94 -	42.31 -	18.34 -	5.90 -
Digitaria milanjiana (Digitgrass)	3	49.92 ± 4.45	69.37 ± 2.16	39.35 ± 5.74	30.02 ± 3.61	27.00 ± 3.82	14.65 ± 10.58
Euchlaena mexiana (Euchlaena)	4	49.75 ± 5.94	69.20 ± 1.54	36.22 ± 2.45	32.98 ± 3.31	29.68 ± 4.58	4.57 ± 3.02
Imperata cylindrica (Cogongrass)	13	48.48 ± 2.01	76.39 ± 3.26	41.52 ± 7.96	34.87 ± 7.20	28.61 ± 5.26	7.45 ± 3.06
Native grasses	15	49.06 ± 4.12	68.09 ± 3.95	34.55 ± 7.54	33.53 ± 6.95	23.07 ± 6.80	6.08 ± 2.46
Panicum maximum (Guineagrass)	11	42.24 ± 2.84	66.84 ± 6.11	36.33 ± 9.06	30.51 ± 7.18	25.64 ± 5.91	5.18 ± 2.86
Paspalum notatum (Bahiagrass)	2	49.16 ± 0.02	70.87 ± 2.44	36.98 ± 4.70	33.89 ± 2.26	26.06 ± 6.36	5.47 ± 1.58
Pennisetum purpureum (Napiergrass)	15	43.33 ± 3.92	66.96 ± 4.66	35.55 ± 4.77	31.21 ± 3.34	25.93 ± 5.06	5.03 ± 2.36
Pennisetum purpupoides (Kinggrass)	6	44.49 ± 5.78	69.37 ± 2.32	39.10 ± 3.60	30.27 ± 2.80	26.37 ± 3.77	6.65 ± 2.91
Setaria sphacelata (Golden timothy)	12	45.48 ± 4.17	66.23 ± 5.89	35.23 ± 4.55	31.00 ± 2.93	26.63 ± 3.87	4.75 ± 1.97
Urachloa pullulans (Witgrass)	4	44.53 ± 5.44	68.05 ± 8.46	36.47 ± 8.15	31.74 ± 2.00	24.57 ± 4.25	5.47 ± 3.43
Vetiver zizanioides (Vetiver)	8	43.96 ± 9.51	76.06 ± 2.28	43.41 ± 5.01	32.65 ± 5.00	30.27 ± 3.39	8.46 ± 3.74
Overall mean	121	47.41 ± 3.72	68.80 ± 6.22	36.80 ± 3.69	32.00 ± 4.95	25.98 ± 3.72	6.47 ± 2.46

[7]NFE: nitrogen free extract
[8]NDF: neutral detergent
[9]ADF: acid detergent fiber
[10]ADL: acid detergent lignin

Where,
Y_{ijkl}= the chemical composition and digestibility
μ= overall mean
M_i= effect of the i^{th} species
(i = 1, …121 in grasses; i = 1, …145 in legumes)
Y_j= effect of the j^{th} year (j = 1998, …2000)
S_k= effect of the k^{th} season (k=dry season and rainy season)
A_l= effect of the l^{th} altitude (l = highland and lowland)
$(YS)_{jk}$= interaction effect of the j^{th} year with the k^{th} season
$(YA)_{jl}$= interaction effect of the j^{th} year with the l^{th} altitude
$(SA)_{kl}$= interaction effect of the k^{th} season with the l^{th} altitude
e_{ijkl}= residual error of the dependent variable

RESULTS

Chemical composition and digestibility

The chemical composition and digestibility of grasses and of legumes were shown in tables 1 and 2, respectively. It was observed that, as well known, the TDN and crude protein (CP) contents of legumes were generally higher than those of grasses (Standard tables of feed composition in Japan, 2001; IFI tables of feed composition, 1984; and United States-Canadian tables of feed composition, 1982). Conversely, IVNDFD and contents of all the cell wall components except ADL of legumes were generally lower.

In the grasses, the mean of IVDMD was 63.0%, ranging from 44.2% in *U. pullulans* to 79.4% in *B. mutica*, while the mean of IVNDFD varied from 25.5% in *U. pullulans* to

Table 2. Chemical composition and digestibility of legumes (i)

Species	n	Digestibility (%) and chemical composition (% in dry matter)						
		IVDMD[1]	IVNDFD[2]	TDN[3]	CP[4]	CF[5]	EE[6]	Ash
Acacia confusa (Acacia)	4	71.14± 0.62	15.06± 7.99	58.02± 12.00	22.56± 4.02	16.89± 3.13	5.62± 0.73	5.34± 1.03
Aeschynomene americana (American jointvetch)	5	70.67± 11.05	40.61± 10.78	59.12± 16.32	17.05± 7.00	29.48± 8.68	3.08± 1.04	7.84± 1.72
Alysucarpus vaginalis (Alyceclover)	8	66.26± 3.97	36.32± 5.36	58.03± 7.01	14.81± 2.93	31.50± 2.81	2.46± 0.74	10.95± 2.43
Arachis hypogaea (Groundnut)	7	78.86± 5.95	47.26± 9.68	71.44± 8.61	15.61± 3.28	23.09± 4.48	2.77± 0.82	11.72± 0.73
Calliandra calothyrsus (Calliandra)	5	75.63± 5.41	28.44± 17.89	59.33± 10.27	19.75± 3.90	15.32± 4.33	4.23± 1.46	6.22± 1.55
Calopogonium muconoides (Calopo)	9	66.60± 4.11	37.33± 8.77	57.24± 11.30	15.75± 4.22	32.08± 2.92	3.57± 1.24	8.54± 1.43
Cassia pillosa (Cassia)	2	65.54± 5.00	39.11± 2.53	54.42± 10.20	13.68± 0.52	30.76± 4.38	4.41± 0.27	4.80± 0.02
Centrosema plumieri	1	58.05 -	30.74 -	39.67 -	14.51 -	35.02 -	2.00 -	9.50 -
Centrosema pubescens (Centro)	10	59.89± 6.10	29.33± 6.25	51.30± 7.43	19.34± 3.12	33.73± 2.21	2.48± 0.51	8.14± 1.03
Codariocalyx gyroides	5	66.73± 5.77	30.66± 7.31	51.75± 10.45	15.11± 3.51	26.59± 4.07	2.74± 1.13	7.22± 0.81
Clitoria ternatea (Clitoria)	4	74.15± 8.85	39.63± 3.27	60.20± 16.54	18.28± 5.10	26.45± 8.32	3.37± 0.77	8.87± 3.49
Desmodium rensonii (Desmodium)	5	75.71± 4.56	42.96± 9.15	58.78± 11.73	15.91± 5.24	26.29± 4.18	3.67± 0.61	8.05± 0.74
Desmanthus virgatus (Desmanthus)	2	79.12± 2.88	55.13± 40.38	72.88± 2.65	22.76± 2.85	17.57± 4.50	4.19± 1.24	8.09± 0.57
Dioclea guyanensis	1	62.95 -	31.67 -	43.02 -	12.12 -	32.86 -	2.60 -	6.56 -
Flemengia congesta (Flemengia)	5	65.01± 3.47	26.93± 9.97	50.00± 8.88	17.80± 2.31	25.16± 2.87	3.77± 1.08	6.18± 0.74
Gliricidia maculata (Gliricidia)	15	78.61± 8.83	42.85± 11.65	63.44± 8.94	22.69± 3.53	15.33± 3.27	4.15± 0.75	9.70± 1.39
Leucaena leucocephala (Leucaena)	15	79.71± 4.22	37.51± 6.72	64.98± 11.95	26.02± 4.32	16.55± 3.25	4.65± 0.92	9.06± 1.02
Macroptilium atropurpureum (Siratro)	9	66.51± 6.02	37.62± 6.43	56.15± 9.77	15.60± 3.02	35.15± 4.47	2.90± 0.91	7.95± 0.74
Macroptilium lathyroides (Phasey bean)	3	65.16± 3.01	39.23± 3.63	55.12± 11.17	12.56± 2.78	37.10± 4.17	2.65± 0.83	6.46± 0.52
Mimosa pudica (Sensitive plant)	1	73.24 -	41.03 -	50.05 -	15.63 -	29.35 -	2.87 -	6.53 -
Sesbania grandiflora	15	83.54± 8.18	51.04± 11.61	68.07± 13.82	26.71± 4.84	16.07± 4.85	4.30± 1.11	9.76± 1.93
Sesbania sesban (Sesbania)	5	81.35± 3.15	38.29± 6.31	62.97± 11.04	20.07± 4.30	18.78± 2.25	3.55± 0.97	8.51± 0.78
Stylosanthes guianensis (Stylo)	9	66.22± 6.37	36.44± 8.88	54.43± 9.26	11.77± 1.88	33.03± 5.22	2.28± 0.60	8.91± 2.84
Overall mean	145	70.90± 7.21	37.18± 8.45	57.41± 8.02	17.66± 4.22	26.27± 7.35	3.40± 0.91	8.04± 1.72

For abbreviations, see the footnote of Table 1 (i).

69.1% in *B. mutica*. The lowest value of TDN content (36.9%) was found in *I. Cylindrica*, and the highest value (59.1%) was in *C. ciliaris*. The mean of CP content was 7.7%, ranging from 3.3% in *B. ruziziensis* to 15.8% in *C. catalya*. The mean of crude fiber (CF) content was 31.6%, ranging from 25.3% in *C. catalya* to 38.4% in *U. pullulans*, while the mean of NDF content varied from 46.1% in *C. catalya* to 76.3% in *I. Cylindrica*. The mean of ADL content was 6.4% and the lowest value (3.0%) was found in *B. mutica*, and the highest value (14.6%) was in *D. milanjiana*.

In the legumes, the mean of IVDMD was 70.9%, ranging from 58.0% in *C. plumeiri* to 83.5% in *S. glandiflora*, while the mean of IVNDFD varied from 15.0% in *A. confusa* to 55.1% in *D. virgatus*. The lowest value of the TDN content (39.6%) was found in *C. plumeiri*, and the highest value (72.8%) was in *D. virgatus*. The mean of CP content was 17.6%, ranging from 11.7% in *S. guianensis* to 26.7% in *S. grandiflora*. The mean of CF content was 26.2%, ranging from 15.3% in *C. calothyrsus* to 35.1% in *M. atropurpureum*, while the mean of NDF content varied from 30.4% in *S. sesban* to 58.1% in *M. lathyroides*. The mean of ADL content was 8.7% and the lowest value (5.7%) was found in *C. pillosa*, and the highest

Table 2. Chemical composition and digestibility of legumes (ii)

Species	n	NFE[7]	NDF[8]	ADF[9]	Hemicellulose	Cellulose	ADL[10]
		Chemical composition (% in dry matter)					
Acacia confusa (Acacia)	4	49.59± 3.33	30.78± 0.90	17.32± 5.73	13.46± 4.99	9.71± 4.05	6.84± 1.94
Aeschynomene Americana (American jointvetch)	5	42.55± 2.39	48.21± 12.18	35.64± 11.63	12.57± 3.29	26.04± 7.09	8.99± 5.01
Alysucarpus vaginalis (Alyceclover)	8	40.29± 2.84	52.46± 2.80	37.82± 3.48	14.64± 3.01	24.08± 3.06	10.63± 2.36
Arachis hypogaea (Groundnut)	7	46.80± 1.76	39.11± 5.49	30.38± 5.97	8.73± 3.49	22.09± 3.17	6.90± 2.82
Calliandra calothyrsus (Calliandra)	5	54.48± 2.96	31.03± 7.10	20.24± 1.91	10.79± 7.74	11.71± 1.74	7.05± 0.72
Calopogonium muconoides (Calopo)	9	40.07± 3.91	53.16± 2.26	36.47± 3.25	16.70± 3.09	25.43± 3.39	9.12± 2.24
Cassia pillosa (Cassia)	2	46.35± 3.62	54.42± 5.24	24.33± 17.57	30.09± 12.32	17.23± 15.14	5.72± 3.34
Centrosema plumieri	1	38.97 -	59.34 -	41.05 -	18.29 -	27.85 -	12.41 -
Centrosema pubescens (Centro)	10	36.32± 2.79	56.81± 5.07	37.36± 3.52	19.45± 4.94	23.52± 2.87	11.32± 3.95
Codariocalyx gyroides	5	48.34± 1.00	47.91± 6.51	31.78± 7.10	16.13± 3.81	20.83± 5.35	9.59± 2.60
Clitoria ternatea (Clitoria)	4	43.03± 6.43	42.30± 11.84	31.91± 8.66	10.39± 3.70	23.06± 7.70	7.87± 1.56
Desmodium rensonii (Desmodium)	5	46.08± 5.24	42.82± 6.20	30.21± 5.71	12.61± 5.30	20.68± 6.50	7.34± 2.02
Desmanthus virgatus (Desmanthus)	2	47.40± 0.16	32.53± 9.72	20.48± 0.08	12.05± 9.81	12.97± 0.11	6.95± 0.05
Dioclea guyanensis	1	45.86 -	53.10 -	40.53 -	12.57 -	26.99 -	12.96 -
Flemengia congesta (Flemengia)	5	47.09± 1.71	45.95± 4.89	29.58± 3.29	16.37± 6.04	16.38± 2.25	11.62± 1.22
Gliricidia maculata (Gliricidia)	15	48.13± 2.27	32.97± 6.02	23.10± 4.23	9.87± 3.38	11.77± 4.32	10.15± 3.14
Leucaena leucocephala (Leucaena)	15	43.72± 2.97	31.67± 5.91	20.30± 5.03	11.28± 3.00	11.98± 3.92	7.90± 2.36
Macroptilium atropurpureum (Siratro)	9	38.39± 3.30	53.66± 5.53	35.90± 3.79	17.76± 4.70	26.78± 3.70	8.05± 1.02
Macroptilium lathyroides (Phasey bean)	3	41.22± 0.65	58.13± 4.25	43.45± 4.72	14.68± 3.57	32.48± 3.85	10.48± 2.46
Mimosa pudica (Sensitive plant)	1	45.61 -	43.97 -	33.44 -	10.53 -	23.91 -	8.53 -
Sesbania grandiflora	15	43.15± 6.46	33.43± 14.95	22.19± 6.89	11.24± 11.96	15.04± 4.95	6.36± 3.13
Sesbania sesban (Sesbania)	5	49.09± 4.09	30.49± 2.66	21.06± 3.26	9.43± 3.49	13.79± 3.71	6.48± 0.60
Stylosanthes guianensis (Stylo)	9	44.01± 3.17	52.20± 3.34	37.40± 8.53	14.80± 6.44	27.43± 7.23	8.64± 2.21
Overal mean	145	44.63± 4.24	44.63± 10.01	30.52± 7.88	14.11± 4.60	20.51± 6.49	8.78± 2.05

For abbreviations, see the footnote of Table 1 (ii).

value (12.9%) was in *D. guyanensis*.

Effect of species, year, season and altitude

The results of least-square analysis of variance for grasses and for legumes were shown in Tables 3 and 4, respectively. For the grasses, the species had significant effects for all of digestibilities and chemical components. The year had significant effects for digestibilities and ADF, hemicellulose and lignin contents. The season had significant effects for CP, ether extract (EE), Ash, nitrogen free extract (NFE), hemicellulose and ADL contents. The altitude had significant effects for CP, EE, ADF and hemicellulose contents. It was observed that the interactions of season×altitude for digestibilities, of year×season, of year×altitude and season×altitude for some proximate components and of year×season and season×altitude for some cell wall components were significant.

For the legumes, the species had significant effects for all of digestibilities and chemical components, except ADL content. The year had significant effects for CP, CF, NFE, ADF and cellulose contents. The season had significant effects for IVNDFD and contents of EE and cellulose. The altitude had significant effect only on EE content. It was observed that the interactions of season×altitude for IVDMD and of year×season for some proximate components and of year×season and season×altitude for some cell wall components were significant.

Table 3. Result of least-squares analysis of variance (grasses)

Source of variation	df	Mean square IVDMD	IVNDFD	CP	CF	EE	Ash	NFE	NDF	ADF	Hemicellulose	Celluose	ADL
n = 121													
Species	19	40595.45***	491.23***	20.45***	41.08**	0.35*	30.14***	54.75***	102.76***	40.58*	32.42*	38.79*	6.54***
Year	1	67184.47***	1430.38***	2.89	10.79	0.170	12.23	25.87	43.02	261.77***	104.92**	26.23	75.44***
Season	1	43235.93	309.71	66.89**	1.680	8.70***	83.45***	123.79*	107.19	0.150	86.02*	28.41	93.52***
Altitude	1	521.73	137.05	71.69**	0.17	1.03*	0.140	33.84	0.12	111.35*	104.09*	6.88	0.72
Year× Season	1	19951.07	489.28	165.67***	110.45*	5.00***	20.66	51.52	349.84**	1,289.86***	304.79***	77.16	224.29***
Year× Altitude	1	5276.76	25.40	14.67	4.05	0.05	23.39*	75.29*	0.14	91.56	94.41*	26.85	0.39
Season × Altitude	1	63745.77**	961.54**	58.56**	144.54**	0.25	0.06	11.18	127.36*	218.67**	16.35	26.44	3.320
Residual	95	8831.57	112.54	8.04	18.67	0.21	5.82	18.18	30.47	27.32	16.97	22.63	2.02

* p< 0.05; ** p< 0.01; *** p<0.001

For abbreviations, see the footnote of Table 1 (i and ii)

Table 4. Result of least-squares analysis of variance (legumes)

Source of variation	df	Mean square IVDMD	IVNDFD	CP	CF	EE	Ash	NFE	NDF	ADF	Hemicellulose	Celluose	ADL
n = 145													
Species	22	34,851.30***	386.47***	139.57***	383.86***	4.94***	12.18***	104.08***	622.77***	352.35***	85.43***	261.38***	15.00
Year	1	4,163.99	55.11	236.09***	74.41*	1.07	0.17	66.64*	13.94	230.27**	132.72	445.01***	57.82
Season	1	13,474.83	374.79*	25.84	0.05	20.21***	1.09	3.69	211.42	99.02	23.71	122.04**	58.61
Altitude	1	7,706.34	123.11	0.48	0.17	3.89**	9.73	0.01	1.27	1.23	0.05	11.19	23.69
Year× Season	1	6,607.91	78.29	371.52***	374.14***	11.29***	0.68	6.75	87.27	312.48**	65.63	82.85*	10.41
Year× Altitude	1	2,032.74	66.91	29.88	2.04	0.12	3.81	2.740	1.73	11.07	4.72	9.12	10.18
Season× Altitude	1	40,279.29**	336.17	2.34	61.53*	0.02	015	41.23	113.97	115.39*	0.02	24.96	196.87*
Residual	116	3,697.64	88.60	10.37	13.81	0.47	2.48	12.78	55.78	29.19	34.51	16.61	29.45

* p< 0.05; ** p< 0.01; *** p<0.001

For abbreviations, see the footnote of Table 1 (i and ii)

Table 5. Correlation coefficient between digestibilty and chemical composition

	Chemical composition CP	CF	EE	Ash	NFE	NDF	ADF	Hemicellulose	Cellulose	ADL
All grasses (n = 121)										
In vitro DM Digestibility	0.545**	-0.628**	0.313**	0.460**	-0.108ns	-0.752**	-0.624**	-0.053 ns	-0.397**	-0.535**
In vitro NDF Digestibility	0.507**	-0.570**	0.297**	0.404**	-0.102 ns	-0.650**	-0.638**	0.078 ns	-0.341**	-0.610**
All legumes (n = 145)										
In vitro DM Digestibility	0.578**	-0.795**	0.445**	0.280**	0.428**	-0.836**	-0.751**	-0.491**	-0.610**	-0.636**
In vitro NDF Digestibility	0.196*	-0.302**	0.196*	0.309**	0.104 ns	-0.172*	-0.235**	0.01 ns	-0.086 ns	-0.415**
All Forage Plants (n = 266)										
In vitro DM Digestibility	0.629**	-0.732**	0.516**	0.107 ns	0.028 ns	-0.724**	-0.722 **	-0.488 **	-0.587 **	-0.300**
In vitro NDF Digestibility	-0.013 ns	-0.194**	-0.008 ns	0.437**	0.063 ns	0.042 ns	-0.224 **	0.244 **	-0.028 ns	-0.556**

NS, not-significant, p>0.05; * p<0.05; ** p<0.01.

For abbreviations, see the footnote of Table 1 (i and ii)

DISCUSSION

In the results of analysis of variance, *in vitro* digestibilities of grasses were not significantly affected by season or altitude. However, the season×altitude interaction was significant (p<0.01). This result indicates that the grasses grown at highland in the dry season had higher digestibility than those at lowland in the rainy season. On the other hand, IVNDFD of legumes was significantly (p<0.05) affected by season with no any interactions. This result indicates that the legumes grown in the dry season had higher IVNDFD than those in the rainy season. This is similar to the observations in other countries (Hernándes et al., 1990; Ramos et al., 1990; Coto et al., 1990; Crespo, 1981; Santana et al., 1991; Ramos et al., 1993; Herrera and Hernández, 1993), in which the quality (e.g. nitrogen content and digestibility) of the pasture during the dry season was better than that during the rainy season.

The CP content of grasses was significantly (p<0.01) affected by season and altitude. And also the interaction of year×season (p<0.001) and season×altitude (p<0.01) were significant. This result indicates that the grasses grown at lowland in the dry season were higher in CP content than at highland in the rainy season. This finding was contrary to the results in some other papers (Martin, 1998; CIAT, 1994; Villareal, 1994; Rodríguez et al., 1994), in which the grasses had more CP content in the rainy season than in the dry season. On the other hand, the CP content of legumes was not significantly affected by season and altitude in the present experiment. However, year×altitude and season×altitude interactions were not significant.

In this study, the CP contents of some grasses (*Brachiaria ruziziensis*, *Brachiaria humidicola*, *Imperata cylindrica*, *Digitaria milanjiana*, *Bothriochloa pertusa* and *Vetiver zizanoides*) were less than 6.0%. This suggests that these grasses were deficient in CP for normal voluntary intake, because Minson (1990) has pointed out a rapid fall in voluntary intake below about 6.2% in protein content.

Correlation coefficients between digestibility and chemical composition were shown in Table 5 for all grasses, for all legumes and for all forage plants combined. The correlations between *in vitro* digestibilities and contents of CP, EE and Ash of both all grasses and all legumes were significant positively. In contrast, there were negatively significant correlations between *in vitro* digestibilities and cell wall components. The highest correlation coefficients between *in vitro* digestibilities and NDF in all grasses and in all legumes were calculated out. This indicates that the NDF provided an accurate prediction of digestibility and TDN content in all grasses and in all legumes.

In the all forage plants combined, the correlations between IVDMD and contents of CP and EE were significant ($p<0.01$) positively. Also, there were negatively significant correlations between IVDMD and the all of cell wall components ($p<0.01$), but the correlations between IVNDFD and CP, EE, NFE, NDF and cellulose contents were not significant. The correlation coefficients between IVDMD and contents of CF, NDF and ADF were high. This indicates that CF, NDF and ADF provided an accurate prediction of dry matter digestibility or TDN content. Also a close relationship between IVNDFD and ADL content is indicating that the lignin content can be the most accurate predictor of cell wall digestibility, as Van Soest (1994) has pointed out.

In conclusion, the quality of forage plants grown in South Sulawesi generally appear to be poor, especially the grass species of lowland areas grown in rainy season. However, the forage plants grown at highland in dry season are relatively higher in quality. Similarly, the TDN and CP contents of legumes were generally higher than those of grasses. Conversely, IVNDFD and contents of all the cell wall components except lignin of legumes generally lower.

The results of this study should be made available to teach farmers the chemical composition and digestibility of forage so that they can fully utilize the available forage sources around them. The farmers should be educated about the nutritional composition of forage that is appropriate for animal feeding. The awareness among farmers about the importance of forage will eventually lead them to grow high quality grasses and legumes which is essential for good feeding of ruminants in South Sulawesi.

ACKNOWLEDGEMENT

The authors wish to thank Prof. Hiroshi HARADA, Department of Animal Science, Miyazaki University, for helpful advice on the statistical analysis.

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