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Chemical Composition of Leaf and Stem of Tropical Grasses at Different Stages of Growth

(Komposisi Kimia Daun dan Batang Rumput Tropis pada Fase Pertumbuhan yang Berbeda)

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ABSTRAK: Komposisi kimia daun dan batang dari rumput tropis, *Sorghum stipodeum, Themeda australis, Iseilema vaginiflorum, Brachyacne convergens, Dicanthium fecundum* (berdaun lebar, bl dan berdaun kecil, nl), *Enneapogon polyphyllus, Panicum sp,* and *Eriachne obtuse* dianalisa. Rumput-rumput tersebut mulai dipanen pada saat permulaan berbunga sampai tanaman menjadi kering dengan interval 9, 12, 16, 23 dan 36 hari. Pada semua jenis rumput yang dianalisa, kandungan konstituen dinding sel yang diukur dengan analisis *neutral detergent fiber* (NDF) lebih tinggi didalam batang dari pada didalam daun (84% vs 75%). Lima dan 8 dari 9 species tersebut berbeda nyata antara batang dan daun masing-masing untuk kandungan ADF (54,20% vs 51,10%) dan lignin (8,60% vs 5,40%). Pada 5 species yang dianalisis, semuanya mengandung protein kasar (CP) lebih tinggi didalam daun dari pada didalam batang (5% vs 2,5%), dan semuanya mengandung karbohidrat larut dalam air (WSC) yang tidak berbeda nyata (3%) didalam daun maupun didalam batang. Tiga dari 5 species yang dianalisis menunjukkan kandungan extrak larut dalam air (WSE) yang lebih tinggi didalam daun dari pada di dalam batang (12,30% vs 9,40%). Enam dari 9 jenis rumput tersebut, mengandung NDF, ADF dan lignin yang tidak berbeda nyata antara periode panen karena rumput-rumput tersebut sudah pada tingkat pertumbuhan yang lanjut. Empat dari 5 species yang dialanisis untuk CP dan 2 dari 5 species yang dianalisa untuk WSE dan WSC menunjukkan kecenderungan penurunan dengan bertambahnya umur tanaman. Diperkirakan bahwa dengan tingginya kandungan NDF dan rendahnya kandungan CP pada rumput-rumput tersebut, akan membatasi konsumsi ternak dan ternak akan kehilangan bobot badan. Daun dapat dijadikan faktor untuk seleksi pada rumput tropis.

Kata Kunci: Rumput tropis, batang, daun, dinding sel, pertumbuhan tanaman

Introduction

Reid (1994) defined forage quality as the product of voluntary intake, digestibility and the efficiency of nutrient used by the animal. These parameters are associated with plant anatomic-histological characteristics and its chemical composition, which varies with species, cultivar, climate, soil, crop and storage conditions but mainly, stage of plant growth (Buxton and Fales, 2004; Nelson and Moser, 1994; Rotz and Muck, 1994; Van Soest, 1996; Wilson and Hatfield, 1997). When ruminant production system is based on forage as protein and energy sources, the efficiency of nutrient used will be highly dependent on forage maturity, which is often considered to be the primary factor that determines nutritional quality.

There is a general agreement that low quality is inherent characteristic of tropical grasses, mainly as a result of a high content of cell wall constituent (CWC). This places increased emphasis on the microbial and mechanical processes of digestion in the reticulo–rumen, especially with respect to limitation of voluntary intake. The high content of CWC also places increased importance on the digestion of CWC since it represents a high proportion of the total digestible organic matter. Lignin contained in CWC is insoluble, unaffected by most enzymes, and acting as a constraint on polysaccharide utilization by forming an encrusting barrier. As plant mature, the ratio of leaf: stem usually declines, resulting in reduced forage quality as lignin content in developing stems increases and protein content and digestibility decline (Colleman, 1992; Van Soest, 1996). This paper reports the chemical composition of leaf and stem at different stage of growth in some tropical grasses.

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Research Methods

Treatments

There were nine species of grasses used in this experiment: *Sorghum stipodeum*, *Themeda australis*, *Iseilema vaginiflorum*, *Brachyacne convergens*, *Dicanthium fecundum* (broad and narrow leaf), *Enneapogon polyphyllus*, *Panicum sp*, and *Eriachne obtuse*. The forage grew under natural conditions, therefore the exact day of germination of any plant sampled was not known. However, the stages of growth were recorded at each time they were harvested. Harvesting was carried out at interval of 9, 12, 16, 23 and 36 days. The stage of maturity of the grasses at each time of harvesting is presented in Table 1. All grasses were harvested at the ground level. Unfortunately, neither the production nor the leaf/stem ratios were possible to be determined.

Samples of grasses were separated into their botanical component, leaf and stem. Since the separation is time-consuming, being done by hand, the petiole and the leaf were not separated but mixed together as one leaf sample. Prior to grinding, they were oven dried at 80 ^{0}C overnight. Samples were ground to pass through 1 mm sieve in a small laboratory mill. After being ground, they kept in closed containers, ready for chemical analysis. All analysis was determined on a DM basis (constant weight). Duplicate samples were included in each run and repeated if the difference between the duplicate exceeded 2 percentage units. The water soluble extract (WSE), water soluble carbohydrate (WSC), and crude protein were determined only on the 5 species.

Cell wall constituent (CWC) were described by detergent fiber analysis (Goering and Van Soest, 1970). Neutral detergent fiber (NDF) was assayed to define the amount of total CWC present in the grass sample. Acid detergent fiber (ADF) was determined, and residues were used in analyses for cellulose, lignin and acid insoluble ash content (Goering and Van Soest, 1970). ADF contains cellulose, lignin and acid insoluble ash. ADF residue was reacted with 72% H_2SO_4. It is assumed that all cellulose was dissolved in 72% H_2SO_4. The residue was assumed to be lignin and acid insoluble ash. Lignin was calculated as weight loss after ashing the residue. Percent crude protein (N x 6.25) was calculated from the amount of nitrogen in samples as determined by micro Kjeldhal method (AOAC, 1995).

Statistical Analysis

Not being a field trial, this experiment has no replication. In order to obtain an estimate of error, we must assume a linear relationship between the response and the stage of maturity. The analysis fitted Part as a qualitative factor, enabling to assess whether leaf and stem have different concentration of the chemical component. We regressed linearity on Period to see if there is a steady change over time. Interaction between Part and Period was also fitted to test for different responses between stem and leaf over stage of maturity. Data on chemical composition were subjected to one-way analysis of variance using the general linear model of SAS (1988). Multiple comparisons was done using Duncan's multiple–range test (Snedecor and Cochran, 1980).

Results and Discussion

The CWC measured as NDF content was higher in the stem than in the leaf (84% vs. 75%) of all species studied (Table 2 and Table 8), although the difference in the fiber component (ADF and lignin) was either non significant or the content of the stem was higher than that of the leaf fraction. Except *Sorghum*, all species showed a significantly higher lignin content in the stem than that in the leaf (8.20% vs. 5.60%); whereas for ADF content, 5 out of 9 species studied showed the value in the stem was higher than that in the leaf (55% vs. 51%) (Table3, Table 4, and Table 8). This result is in agreement with what stated by Colleman (1992) and Van Soest (1996).

Three out of 5 species measured showed that WSE content was higher in the leaf than that in the stem (12.30% vs. 9.40%) (Table 6 and Table 8) and none of them had no significant difference between leaf and stem (3%) for WSC (Table 7 and Table 8). However, all species analyzed indicated higher CP content in the leaf than in the stem (5% vs. 2.50%) (Table 5 and Table 8).

These results could be due to differences in the composition of the tissue type that constitute the plant fraction, and thus the differences may vary with the species. Akin *et al.* (1977) studied the histochemistry of 5.5 months Coastal Bermuda Grass, and found that the composition of the tissue types that constitute sheath (leaf) was different from that of the stem fraction, and as a result the chemical composition of these fractions was different also.

When the chemical content of the stem and leaf differed, the difference at each harvest varied with species. This difference can be constant, suggesting that the rate of change in the chemical content over the period of harvesting was similar for both fractions. The difference may also increase as maturity advances, and this suggests that the increase in the chemical content with maturity was faster in the stem than in leaf or *vice versa*. This may be associated with the accumulated and translocation of assimilates to or from the stem or leaf. For example, in species where increase in CWC with maturity was faster in stem than in leaf, the stem may translocate more assimilate for seed production than the leaf, this in turn causes higher CWC content in stem than in leaf. When the decrease in soluble material was faster in leaf than in stem, the leaf translocates assimilates, more than in stem.

Table 1. Plant species and stage of maturity at each harvest

Harvesting period	*Sorghum* *Themeda* *Iseilema*	*Brahyacne* *Dicanthium* (bl) *Dicanthium* (nl)	*Enneapogon* *Panicum* *Eriachne*
1	Early flowering	Late flowering	Setting seed
2	Late flowering	Setting seed	Late seed set
3	Setting seed	Late seed set	Seed shedding
4	Seed shedding	Seed shedding	Seed shedding
5	Drying off	Drying off	Drying off

bl = broad leaf, nl = narrow leaf

Table 2. Neutral detergent fiber (% DM) content of stem and leaf at different stage of growth

Species	EF		LF		SS		SSh		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	76.50	71.30	69.30	67.00	88.00	75.20	86.20	76.30	90.70	76.10
Themeda	85.40	71.70	83.00	73.30	79.20	70.40	81.30	73.00	82.40	73.90
Iseilema	82.10	74.00	82.40	72.30	80.10	73.40	82.40	73.70	85.30	76.50
Brachyacne	82.50	78.20	79.10	75.30	79.50	76.40	78.90	75.70	81.10	77.00
Dicanthium (bl)	82.60	74.40	84.20	74.70	81.60	75.30	81.00	73.50	83.50	74.70
Dicanthium (nl)	82.70	70.60	82.50	75.30	85.00	76.10	81.20	75.00	86.10	80.50
Enneapogon	81.80	73.00	78.90	70.70	80.10	71.00	84.00	73.40	86.10	72.40
Panicum	80.00	72.80	79.00	69.50	84.10	75.60	83.00	79.40	87.60	80.20
Eriachne	86.60	81.40	84.00	80.10	86.10	78.40	86.20	81.40	85.00	82.50
Average	82.20	74.10	80.30	73.10	82.60	74.60	82.70	75.70	86.30	77.10
SE	0.97	1.17	1.54	1.28	1.08	0.88	0.81	0.97	0.95	1.12

DM: Dry matter, EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, SE: standard error, bl : broad leaf, nl : narrow leaf

Table 3. Acid detergent fiber (% DM) content of stem and leaf at different stage of growth

Species	EL		LF		SS		SH		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	49.60	41.30	39.60	47.20	63.70	47.60	57.20	52.10	62.10	54.70
Themeda	53.50	49.10	61.30	46.80	53.10	46.50	55.10	50.20	53.60	49.20
Iseilema	59.20	58.60	60.00	57.00	56.20	53.50	58.00	56.30	64.00	63.40
Brachyacne	53.80	54.20	54.40	42.00	49.60	49.10	50.20	47.80	50.00	51.70
Dicanthium (bl)	52.40	48.20	62.60	54.00	58.40	56.10	61.40	52.80	59.10	54.30
Dicanthium (nl)	52.70	48.50	50.80	46.30	57.50	51.70	53.90	48.70	55.40	57.30
Enneapogon	55.40	55.30	47.00	47.00	53.30	53.70	54.50	54.00	58.10	53.30
Panicum	49.60	47.40	54.50	45.00	51.60	47.20	53.70	50.40	57.30	53.30
Eriachne	53.80	58.90	44.40	50.30	50.90	56.70	47.50	52.50	50.90	56.10
Average	53.30	51.30	52.70	48.40	54.90	51.30	54.60	51.60	56.70	54.80
SE	0.97	1.94	2.65	1.54	1.48	1.29	1.37	0.88	1.58	1.33

DM: Dry matter, EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, SE : standard error, bl : broad leaf, nl : narrow leaf

Table 4. Lignin content (% DM) in stem and leaf at different stage of growth

Species	EL		LF		SS		SH		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	4.40	3.60	4.80	5.60	6.50	5.90	7.00	6.40	7.60	7.90
Themeda	8.40	6.80	8.60	5.60	7.60	4.80	8.60	6.10	8.70	6.40
Iseilema	9.30	6.70	10.70	6.10	9.60	5.90	9.40	5.90	11.80	7.00
Brachyacne	11.10	7.10	9.20	4.90	7.60	5.70	7.20	4.50	8.60	5.10
Dicanthium (bl)	5.60	3.80	10.30	5.00	7.70	5.80	8.90	5.00	9.80	5.50
Dicanthium (nl)	6.40	5.00	6.00	3.70	7.10	5.50	7.30	4.50	8.90	6.80
Enneapogon	9.00	4.70	7.60	4.60	12.90	3.70	8.30	4.40	10.60	4.70
Panicum	4.90	2.60	8.00	4.20	6.40	4.80	7.20	3.50	8.10	4.40
Eriachne	8.60	6.50	7.00	6.50	14.30	7.10	8.00	5.60	8.10	8.50
Average	7.50	5.00	8.00	5.10	8.80	5.30	8.00	5.10	9.10	6.20
SE	0.76	0.55	0.64	0.30	0.95	0.31	0.29	0.32	0.45	0.47

DM: Dry matter, EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, SE : standard error, bl : broad leaf, nl : narrow leaf

Table 5. Crude protein content (%DM) of leaf and stem at different stage of growth

Species	EL		LF		SS		SH		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	3.50	6.00	3.30	12.40	1.80	5.20	1.70	2.30	0.80	1.40
Themeda	2.20	5.40	1.90	4.70	1.40	4.80	1.00	2.50	0.80	3.10
Iseilema	2.10	3.30	1.10	2.90	1.40	2.80	1.10	1.80	0.70	1.40
Brachyacne	5.10	5.60	6.10	8.60	6.20	8.10	4.20	5.60	2.70	3.90
Dicanthium (bl)	3.20	6.90	1.70	4.60	1.70	5.10	1.30	3.80	1.40	3.90
Average	3.20	5.40	2.80	6.60	2.50	5.20	1.90	3.20	1.20	2.70

DM: Dry matter, EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, bl : broad leaf

Table 6.Water soluble extract (% DM) of stem and leaf at different stage of growth

Species	EL		LF		SS		SH		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	19.20	15.60	23.90	17.20	7.80	11.90	8.50	10.40	3.90	7.80
Themeda	6.50	12.30	7.50	11.10	10.10	13.50	7.90	10.80	5.70	6.80
Iseilema	9.90	9.40	9.70	10.80	11.20	9.10	7.90	7.40	5.70	4.30
Brachyacne	12.50	14.50	14.90	16.50	12.80	14.80	14.00	16.00	9.20	10.60
Dicanthium (bl)	9.50	15.40	7.30	11.40	7.50	10.30	8.90	11.50	6.40	9.10
Average	11.50	13.40	12.70	13.40	9.90	11.90	9.40	11.20	6.20	7.70
SE	2.14	1.17	3.13	1.42	1.01	1.03	1.15	1.38	0.86	1.06

DM: Dry matter, , EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, SE : standard error, bl : broad leaf

Table 7. Water soluble carbohydrate (% DM) of stem and leaf at different stage of growth

Species	EL		LF		SS		SH		DO	
	S	L	S	L	S	L	S	L	S	L
Sorghum	7.50	5.00	7.80	7.00	3.60	3.20	4.30	3.70	1.20	1.60
Themeda	1.00	3.40	2.10	3.80	5.90	5.00	5.60	4.50	3.70	3.20
Iseilema	2.10	1.30	4.30	2.80	4.80	2.60	1.80	1.70	1.20	0.90
Brachyacne	1.20	1.60	2.60	3.30	2.10	3.10	3.60	3.20	3.00	3.40
Dicanthium(bl)	1.60	1.80	3.10	2.70	3.30	2.30	5.80	3.00	3.20	2.20
Average	2.70	2.60	4.00	3.90	3.90	3.20	4.20	3.20	2.50	2.30
SE	1.22	0.70	1.15	0.80	0.65	0.46	0.73	0.46	0.53	0.47

DM: Dry matter, EF: Early Flowering, LF: Late Flowering, SS: Setting Seed, SSh: Seed Shedding, DO: Drying Off, S: Stem, L: Leaf, SE : standard error, bl : broad leaf

Table 8. Summary of statistical analysis of chemical component vs. plant part

Species	CWC		ADF		Lignin		CP		WSE		WSC
Sorghum	+	S>L	NS		NS		++	L>S	NS		NS
Themeda	++	S>L	++	S>L	++	S>L	++	L>S	++	L>S	NS
Iseilema	++	S>L	NS		++	S>L	++	L>S	NS		NS
Brachyacne	++	S>L	NS		++	S>L	+	L>S	++	L>S	NS
Dicanthium(bl)	++	S>L	+	S>L	++	S>L	++	L>S	++	L>S	NS
Dicanthium(nl)	++	S>L	+	S>L	++	S>L					
Enneapogon	++	S>L	NS		++	S>L					
Panicum	++	S>L	++	S>L	++	S>L					
Eriachne	++	S>L	+	S>L	++	S>L					

+ : significant at 5 % level, + + : significant at 1 % level, NS: non significant, CWC: Cell wall constituent, ADF: Acid detergent fiber, CP: crude protein, WSE: Water soluble extract, WSC: Water soluble carbohydrate, S: Stem, L: Leaf, bl : broad leaf, nl : narrow leaf

Cell Wall Constituent (CWC)

In all of the samples the value of NDF was very high, ranging from 69% to 90% in the stem and from 67% to 84% in the leaf fraction. This is not surprising as all the sample material is already in an advanced stage of growth (the earliest stage being flowering). Therefore in this study, 6 out of nine species showed no difference in NDF and ADF content with period of harvesting (Table 9). In an earlier stage, The CWC of tropical grasses should have been lower, although it may be still higher than that of temperate grasses at the same stage of growth (Minson, 1990)

ADF consists mainly of lignin, cellulose and acid insoluble ash (AIA). Since AIA contributes only a very small proportion of the total quantity, cellulose and lignin are the main components which influence the behavior of ADF. Lignin and ADF have been suggested as being useful for prediction of digestibility (Van Soest and Mertens, 1977). As lignin often limits the availability of cellulose, the association of ADF with digestibility depends largely upon the association of lignin with cellulose. The concentration of lignin was always higher in the stem than that in the leaf fraction, except in *Sorghum*. However, only 3 out of 9 species studied, showed an increase in lignin content with advancing maturity.

Lignin which is part of CWC by NDF determination may loss in the cell content (neutral detergent-soluble) appear as lignin-carbohydrate complex (Lowry *et al.*, 2002). Although in this study such lignin-carbohydrate complex was not determined, result from Lowry *et al.* (2002) showed lignin-carbohydrate complex could account for 3.50%, 3.60%, 4.20% and 7.90% in cell content of *Iseilema, Panicum, Sorghum* and *Themeda* respectively. It may be anticipated that for those species, the correlation between lignin (measured through ADF determination) and digestibility would be low.

Soluble Materials

While structural carbohydrate, the CWC increased with maturity, the concentration of water soluble extract (contains some WSC and some protein) usually decreased with advancing maturity. Like CWC, however, the response to maturity depends upon the species. Of the five species measured, WSE decreased in *Sorghum* and *Iseilema,* WSC decreased in *Sorghum* and increased in *Themeda*, whereas crude protein decreased in all species except in *Dicanthium.*

The content of WSC in forage is a useful guide to silage making. While the mean value of WSC in this study was 3%, Yang *et al.* (2006) found that the grass initial WSC content of at least 7% is required for the lactic acid bacteria to multiply to drop the pH to 4 (the best pH silage is 3.8 – 4.2). The low WSC content in this study may be due to the samples were oven dried, it would be higher if they were analyzed as fresh sample (Piccaglia and Galetti, 1987; Kerepesi *et al.*, 1996).

Application

The high CWC concentration (>60%) in these tropical grasses may have an effect on voluntary intake. The limitation of intake caused by the high CWC content can be expected particularly when it is lignified for it may limit the accessibility of microbial enzymes to substrate (Wilson and Hatfield, 1997) and therefore may prolong the residence time of feed material in the reticulo-rumen.

Table 9. Summary of statistical analysis of chemical component vs. period

Species	CWC	ADF	Lignin	CP	WSE	WSC
Sorghum	+	+	++	+	++	++
Themeda	NS	NS	NS	++	NS	++
Iseilema	+	NS	NS	++	++	NS
Brachyacne	NS	NS	NS	++	NS	NS
Dicanthium (bl)	NS	NS	NS	NS	NS	NS
Dicanthium (nl)	NS	++	++			
Enneapogon	NS	NS	++			
Panicum	++	+	NS			
Eriachne	NS	NS	NS			

+ : significant at 5 % level, + + : significant at 1 % level, NS: non significant, CWC: Cell wall constituent, ADF: Acid detergent fiber, CP: crude protein, WSE: Water soluble extract, WSC: Water soluble carbohydrate, S: Stem, L: Leaf, bl : broad leaf, nl : narrow leaf

Considering that the crude protein (CP) content of the plant material was less than 7% which is below the dietary requirement of maximum bacterial growth (11% to 14%) (Satter and Roffler, 1975), it would be expected that animals may loose weight for stored energy would be used. Minson (1990), reported that 7% CP is the level at which nitrogen begin to limit intake in sheep. Feed intake may be limited by the nitrogen status of the animal. And feed intake may increase as the nitrogen status is increased. However, since dietary protein is often degraded by micro-organism in the rumen, a dietary supplement may not be efficient for satisfying the protein requirement unless it is protected from digestion in the rumen.

The amount of protein that the animal has available for utilization is dependent upon the undegraded feed protein and microbial protein flowing from the rumen to the small intestine. In condition where the protein requirement is not met, the inclusion of NPN such as urea (for microbial growth) and protected protein in the diet may be useful. However, this may be an expensive solution. Inclusion of forage legume in the swards could offer several advantages to farming system. This cover crop is able to conserve soil, improve organic matter content and compete with weeds (Humpreys, 1995), convert atmospheric nitrogen (N) to form plant N and cycle within the plant-animal-soil system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N while production is environmentally clean. This symbiosis does not involve the consumption of soil fuel as occurs in the production of fertilizer N which contributes to global warming. N fixing legumes have higher concentration of cellular protein than tropical grasses as such. However, the different growing habits and optimum harvesting frequencies between grasses and legumes makes them difficult to maintain in the mixed sward. Following regular harvesting, the grass would quickly shade legumes, thus reducing their growth rates. Moran (2005) suggested, to maintain the longevity of the forage legumes, they should be sown as a single species sward.

Tropical legumes are rich in protein which is usually the most limiting nutrient in tropical animal diets. Tree legumes offer another choice to improve tropical grasses. Usually they are planted in an alley or rows and can be easily harvested at different intervals than the grass. The photosynthetic efficiency of the grass can be improved when the grass grown in association with tree legumes. During dry season the tree will protect the grass from drought. In addition to that some of the protein (tannin-protein complex) in tropical tree legumes are protected from degradation in the rumen (McSweeney *et al.*, 1999) and thus may be better absorbed by the animal. As maturity progresses the protein content decreases and the CWC increases in concentration, and therefore it is advisable to harvest at an immature stage (Moran, 2005). In evaluating forage quality, chemical composition alone cannot be used for predicting forage quality. Concentration *perse* is not the only attribute to a chemical factor depressing or influencing digestibility; solubility or insolubility of the masking substance and its distribution over potentially digestible substrate surface is also important.

Leafiness seems to be another factor that should be considered when evaluating forage quality. As indicated in the present results, leaf tends to have a lower cell wall constituent and a higher soluble material than those in stem. Thus, the ratio of leaf/stem is an important factor affecting diet

selection and quality of a forage. It has been recently found that near-infra red reflectance spectroscopy can be used as a rapid means of estimating leaf/stem ratio of grasses (Smart *et al.*, 2004).

Conclusion

Mature tropical grasses contain very high cell wall constituents and very low crude protein. The leaf has lower cell wall constituents than the stem. It is recommended to harvest at immature stage and select grasses with more leaves than the stems.

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