PROXIMATE AND ANTI-NUTRITIONAL CONSTITUENTS OF FORAGE LEGUMES AT DIFFERENT STAGES OF GROWTH

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ABSTRACT
Five non-conventional forage legumes used as alternative plant protein sources in livestock nutrition in Nigeria were assayed for proximate and anti-nutritional compositions. The forages, Cajanus cajan, Vigna radiata, Mucuna ghana, Mucuna conchinchinensis and Mucuna rajada were harvested at emergence, 4 and 8 weeks of growth and subjected to chemical evaluation. The proximate compositions and the anti-nutritional constituents were quantified per stage of growth and data obtained subjected to analysis of variance. Results showed that CF, EE and ash values of each forage legume significantly increased (P< 0.05) with age while CP, NFE and moisture values were highest at the emergent stage. Cajanus cajan had the highest CF (13.53%) and EE (2.04%) values at 8 weeks while highest CP (16.80%), NFE (85.04%) and DM (19.7%) at the emergent stage were recorded for V. radiata, M. conchinchinensis and C. cajan, respectively. Highest CP (12.60%) was also obtained for M. rajada at the 4th week; and also for M. Ghana and M. rajada (13.30%) at the 8th week of growth. The anti-nutritional profile increased with age and differed significantly (P<0.05) among forages per growth stage; the highest concentrations of oxalate (0.73%) and HCN (15.39%) at 8 weeks were from M. conchinchinensis. Similarly peak concentrations of phytate (0.44%) and tannin (0.44%) were obtained from M. ghana and saponin, (1.42%) from C. cajan, at 8 weeks of growth. Mucuna ghana had the highest concentration of all the anti-nutritional factors at the emergent stage, except for saponin. These forage legumes hold good nutritional promise for ruminant production in Nigeria and can be used as supplemental browse during lean period of dry season (November-February), especially at their 8th week of growth when their dry matter content is appreciable and the forages contain tolerable levels of anti-nutritional properties.

Key words: Forage legume, proximate composition, emergent, phytate, oxalate, tannin, saponin

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INTRODUCTION
Ruminant livestock production in Nigeria suffers from inadequate feed supply (Mohammed, 1989). This perennial problem had persisted owing to the imbalance in protein supply of tropical pasture which happens to be the major source of fodder (Ekemezie *et al*., 2008). Ensuing from this is the need to supplement ruminant feed intake with concentrate formulations which mostly are derived from conventional protein and energy feedstuffs. Competition between man and livestock has however made even the conventional energy and protein feedstuffs scarce for cost-effective livestock production; consequently, products from ruminant livestock are no longer competitive giving their unrealistic prices. The concerned efforts of animal nutritionists to lower cost of animal production have elicited current interest in the search for alternative feedstuf

Seed cakes from forage legumes such as groundnut and soya are used extensively for livestock production in Nigeria (Ibeawuchi *et al*., 2002). A few available non-conventional, hitherto neglected legumes are also undergoing nutritional trials in Nigeria as alternative plant protein sources for livestock. They include *Cajanus cajan, Vigna radiata, Mucuna ghana, Mucuna conchinchinensis* and *Mucuna rajada*; to mention but a few. Current research interest on these legumes is on the nutritional promise of their seeds. The forages perhaps may also hold inestimable potentials as fodder for ruminant livestock.

The quality and quantity of forage consumed by ruminants affect nutrient intake and animal response (Woodford and Murphy, 1988). These nevertheless are influenced by the forage anti-nutritional properties which invariably depress forage intake and utilization. Effective utilization of forages therefore would depend on their proximate and anti-nutritional constituents.

Several studies (Nworgu *et al*., 2001; Omokanye, 2001; Nworgu and Ajayi, 2003) have been documented on the proximate and mineral compositions of forage legumes in Nigeria. Much of these evaluations were carried out in late stages of maturity. There is skeletal information on the anti-nutritional and proximate compositions of forage legumes at early and mid stages of maturity (Ekemezie *et al.*, 2008). This preliminary study is aimed at establishing the proximate compositions and anti-nutritional properties of some of these forage legumes at different periods of growth.

MATERIALS AND METHODS

Experimental site/Seed handling

The study was conducted in a green house in the Department of Plant Health Management of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Seeds of *Cajanus cajan*, *Vigna radiata*, *Mucuna conchinchinensis, Mucuna rajada* and *Mucuna ghana* were obtained from National Root Crop Research Institute (NRCRI), Umudike, Abia State, Nigeria.

Treatment of seeds

Forty-five plastic pots of 10 cm depth each and measuring 20 cm in diameter, were filled with 10 kg of top (0-15 cm) pulverized processed loamy garden soil and divided randomly into 5 groups containing 9 pots each, with 3 pots designated per forage per stage of growth (5 x 3 x 3). Each group was spaced 30 cm apart from the other in a greenhouse. The forage legume seeds were then allocated to the 5 groups in a completely randomized experiment. Each pot was planted 8-10 of the assigned seed and were watered daily before, during and after germination. Regular weeding at 4 weeks interval was maintained to ensure effective growth and minimal interference. Thereafter, forages of each legume were then harvested at emergence (7 days after planting), 4 and 8 weeks of growth with the aid of a sharp penknife cutting through the plant stalk. Harvested forages were taken to the Central Service Laboratory, National Root Crop Research Institute (NRCRI), Umudike and analysed for proximate and anti-nutritional constituents.

Chemical analysis

Samples at different stages of maturity were oven dried at 65^0 C for 48 hours, milled and analysed for proximate compositions (A. O. A. C.1990). Anti-nutritional properties like saponin were determined by gravimetric method, oxalate by permanganate titrimetric method, phytates by bi-pyridine spectophotometric method, tannins by Folin-Dewis spectophotometric method and cyanogens as described by Onwuka (2005).

Experimental Design/ Statistical analysis

Data collected were subjected to analysis of variance procedures (Steel and Torrie, 1980) appropriate for a Completely Randomized experiment. Significant means were separated using Duncan's (1955) Multiple Range Test.

RESULTS AND DISCUSSION

The proximate compositions of the forages at different stages of harvest are presented in Table 1a. The CP, NFE and moisture content (MC) were highest ($P<0.05$) for all forages at the emergent stage. The high CP and NFE may be due the presence of cotyledons which were still part of the emergent plant. The cotyledons are the major nutrient reservoir in seeds while the high MC may be attributed to presence imbibed of water in the cotyledons prior to germination. The highest CP at emergence stage was recorded for *Vigna radiata* (16.80%) while both *Mucuna conchinchinensis* and *Mucuna rajada* had the least (14.70%). Similarly, NFE and MC values were respectively highest in *Mucuna rajada* (85.02%) and *Vigna radiata (*86.06%) but lowest (83.89; 80.30%) in *Cajanus cajan*. There was a constant and significant ($P<0.05$) increase in CF, EE and ash content of the forages with age with *Cajanus cajan* having the highest values of CF (13.53%) and EE (2.04%) at the 8^{th} week. Highest concentration of ash (3.41%) at the 8^{th} week was however recorded in *Mucuna rajada*. In a similar experiment, Ekemezie *et al*. (2008) observed that while CP decreased, CF and ash contents of forages increased with maturity. These authors observed that EE decreased with maturity which was not consistent with the findings of this study. Ether extract is a proximate component of plants and is used to estimate levels fats and oil present in plant tissues.

The EE (38.2, 35.6), CP (24.42, 23.10), CF (21.11, 22.91), ash (86.3, 89.20) and MC (59.8, 57.1) values (%) obtained on the 4^{th} and 8^{th} week by Ekemezie *et al*. (2008) for *M. conchinchinensis* were at variance with values expressed for the same legume within corresponding period of growth in this study. The differences may be due to season and location of study. Ruminants would probably derive more from these forages at the 8^{th} week of growth when there likely would be enhancement in their dry matter and a balance in the CP, CF and MC contents. Tender succulent forages which are low in CF and DM tend to predispose ruminants to bloat. Bloat is a nutritional disorder which could manifest in ruminants consuming high plane of concentrate diet or lush green forages of early rains that are characteristically low in DM and fibre. In both dietary regimens, insufficient or low fibre may lead to decreased rumen motility which invariably results in the accumulation of gas pockets in the rumen (bloat) causing discomfort and eventual death.

Table 1b shows the comparative evaluation of the proximate compositions of all the forages at the 3 stages of harvest. The proximate values differed (P<0.05) significantly among the forages why because forages have innate morphological potentials to mobilize nutrients. At the emergence stage, CP was highest for *Vigna radiata* (16.80%). The CP value for *Cajanus cajan* (15.75%) and *Mucuna ghana* (15.40%) were similar (P>0.05) and differed significantly (P<0.05) from that of *Mucuna conchinchinesis* (14.70%) and *Mucuna rajada* (14.70%). Crude fibre was highest in *Cajanus cajan* (0.27%); also *Cajanus cajan* and *Mucuna ghana* had the highest (85.04, 0.14%) while MC was at peak in *M. rajada* (85.18%). Generally, ruminants EE (0.06%) value. Similarly, NFE and ash values were highest for *Mucuna conchinchinesis* consuming any of the forages solely at the emergence stage may encounter digestive difficulties due to bloat because of their low DM and CF contents. At the 4th week, the proximate values also differed (P<0.05) significantly. The highest values of CP (15.40%), NFE (84.32%), and MC (84.96%) were obtained in *Mucuna ghana*; ash (1.28%) in *Mucuna rajada*; CF (5.02%) in *Cajanus cajan* and EE (0.66%) in *Vigna radiata*. The EE values of *Vigna radiata*, *Cajanus cajan* and *Mucuna rajada* were however comparable (P>0.05).

Comparative evaluation of the proximate compositions of the forages at the 8th week also followed similar pattern as in the 4th week. Proximate values also differed significantly (P<0.05) among the forages. *Mucuna ghana* and *Mucuna rajada* had the highest CP (13.30%), *Cajanus cajan*, the highest CF (13.48%) and EE (2.04); *Vigna radiata*, the highest NFE (71.34%) and MC (80.57%) while peak ash value (3.41%) was observed in *Mucuna rajada*; the ash value was nevertheless similar (P>0.05) to what was recorded for *Vigna radiata* (3.36%). Generally, NFE values obtained for the forages in this study were comparably higher than the average values of 60 and 65% reported by Adegbola (1980) and Le Houerou (1980) respectively, for Nigeria and West African leguminous browse. The disparity may be due to differences in age of forage at harvest. This underscores the benefit of exploiting forages early in their developmental stage as this would ensure maximization of their nutrient potentials. It is amazing to behold the enormous array of green fodder that is neglected in the tropics which nevertheless is available for exploitation.

Table 1a. Proximate Compositions of Forages at Different Stages of Growth

FORAGE	STAGE OF GROWTH	PROXIMATE CONSTITUENTS (%) CP	CF	EE	NFE	ASH	MC
Cajanus cajan	EMERGENT	15.75 ^{a}	0.27 ^{c}	0.06 ^{c}	83.89 ^{a}	0.04 ^{c}	80.30 ^{a}
	4 WEEKS	10.85 ^{b}	5.02 ^{b}	0.65 ^{b}	82.25 ^{b}	1.22 ^{b}	76.36 ^{ab}
	8 WEEKS	11.20 ^{b}	13.53 ^{a}	2.04 ^{a}	70.46 ^{c}	2.76 ^{a}	74.80 ^{b}
	SEM	0.08	0.001	0.004	0.06	0.004	4.73
Vigna radiata	EMERGENT	16.80 ^{a}	0.12 ^{c}	0.04 ^{c}	83.95 ^{a}	0.05 ^{c}	86.06 ^{a}
	4 WEEKS	10.61 ^{C}	3.76 ^{b}	0.66 ^{b}	82.98 ^{b}	1.01 ^{b}	80.57 ^{b}
	8 WEEKS	11.55 ^{b}	12.38 ^{a}	1.36 ^{a}	71.34 ^{c}	3.36 ^{a}	73.59 ^{c}
	SEM	0.086	0.001	0.001	0.01	0.003	4.24
Mucuna ghana	EMERGENT	15.40 ^{a}	0.14 ^{c}	0.06 ^{b}	84.32 ^{a}	0.06 ^{c}	84.96 ^{a}
	4 WEEKS	10.50 ^{C}	4.04 ^{b}	0.09 ^{b}	84.05 ^{a}	1.30 ^{b}	76.06 ^{b}
	8 WEEKS	13.30 ^{b}	13.04 ^{a}	1.70 ^{a}	68.98 ^{b}	2.96 ^{a}	77.42 ^{b}
	SEM	0.08	0.0001	0.002	0.07	0.0009	2.49
Mucuna conchinchinensis	EMERGENT	14.70 ^{a}	0.08 ^{c}	0.04 ^{c}	85.04 ^{a}	0.14 ^{c}	83.63 ^{a}
	4 WEEKS	10.56 ^{C}	4.47 ^{b}	0.12 ^{b}	83.43 ^{b}	1.13 ^{b}	75.49 ^{b}
	8 WEEKS	12.25 ^{b}	12.62 ^{a}	1.64 ^{a}	70.38 ^{c}	3.10 ^{a}	73.79 ^{c}
	SEM	0.05	0.0001	0.0001	0.06	0.0002	0.04
Mucuna rajada	EMERGENT	14.70 ^{a}	0.18 ^{c}	0.03 ^{c}	85.02 ^{a}	0.06 ^{c}	85.18 ^{a}
	4 WEEKS	12.60 ^{C}	4.06 ^{b}	0.65 ^{b}	81.40 ^{b}	1.28 ^{b}	78.04 ^{b}
	8 WEEKS	13.30 ^{b}	12.44 ^{a}	1.60 ^{a}	69.2 ^{c}	3.41 ^{a}	76.44 ^{c}
	SEM	0.08	0.0001	0.0001	0.09	0.0006	0.01

CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, NFE = Nitrogen Free Extract, MC = Moisture Content
^{abc} Means on the same column with different superscripts differ significantly (P<0.05)

The CF content of the forages ranged from 0.08% in *M. conchinchinensis* to 13.48% in *C. cajan*. Earlier investigations on leguminous tropical legumes (Udedibie and Nkwocha, 1990) reported CF range of 6.49-12.87% for genus Canavalia- another array of unutilized forage legumes. Fibre is important for farm animals. In ruminants, it is a source of energy and plays a major role in rumen motility.

The ash content of the forages ranged from 0.04-3.41% and is lower than the average ash content of West African browse legumes (10.9%) (Le Houerou, 1980; Mecha and Adegbola, 1980). Ruminants subsisting on these forages even at 8 weeks of growth may require some mineral supplementation which can be provided through salt lick.

The anti-nutritional compositions of the forages per stage of harvest are given Table 2a. Peak concentration for all anti-nutritional factors (ANF's) was at the 8th week for each forage; with the values varying significantly (P<0.05). Okoyo (2004) had observed that tannin content of *Cajanus cajan* increased with age. Tropical forages and browse plants contain varying levels of anti-nutritional properties in their biomass which affect their optimal utilization by animals (Abdu *et al.,* 2008). This accounts for why their nutritive potentials are not fully exploited. To forestall damage to crops and reduce menace of animals in urban areas, small ruminants are usually confined and fed cut-and-carry forages in Nigeria. During dry season when fodder becomes scarce and forage quality declines, farmers sometimes are compelled to feed abundant but less preferred forages to animals for sustenance. In severe cases, unconventional browses with possibly high concentrations of anti-nutritional factors (ANFs) may be fed resulting in loss of condition among small ruminants; death may result if the situation is unchecked. This practice perhaps is responsible for most of the avoidable mortality recorded during periods of scarcity (dry season) among small ruminants in the country.
Mucuna Ghana. Correspondingly, *Cajanus*
The concentrations of tannin and HCN at the 8th week of growth were moderately high but would not be life threatening to ruminants consuming these forages at this stage. As a matter of fact a moderate level of tannin (2 - 4% of DM) in ruminant diet has been found to increase protein flow into duodenum (Barry, 1989) which ultimately improves the protein fraction absorbed and consequently animal growth. Other benefits of low tannin ingestion by ruminants include improved live-weight gain (Waghorn *et al.,* 1999), improved lambing percentage (Min *et al.,* 1999) and reduced parasite infection (Hoskin *et al.,* 2000).

Table 1b. Comparative Proximate Constituents of Forages within Different Stages of Growth

STAGE OF GROWTH	FORAGES	PROXIMATE CONSTITUENTS (%) CP	CF	EE	NFE	ASH	MC
EMERGENT	*C. cajan*	15.75 ^{b}	0.27 ^{a}	0.06 ^{a}	83.89 ^{b}	0.04 ^{b}	80.30 ^{b}
	V. radiata	16.80 ^{a}	0.12 ^{c}	0.04 ^{ab}	82.98 ^{c}	0.05 ^{b}	86.06 ^{a}
	M. ghana	15.40 ^{b}	0.14 ^{c}	0.06 ^{a}	84.32 ^{b}	0.06 ^{b}	84.96 ^{a}
	M. conchin	14.70 ^{c}	0.08 ^{d}	0.04 ^{ab}	85.04 ^{a}	0.14 ^{a}	83.63 ^{a}
	M. rajada	14.70 ^{c}	0.18 ^{b}	0.03 b	85.02 ^{a}	0.06 ^{b}	85.18 ^{a}
	SEM	0.06	0.0001	0.0001	0.06	0.0002	2.20
4 WEEKS	*C. cajan*	10.85 ^{c}	5.02 ^{a}	0.65 ^{a}	82.25 ^{c}	1.22 ^{ab}	76.36 ^{c}
	V. radiata	10.61 ^{c}	3.76 ^{d}	0.66 ^{a}	83.95 ^{ab}	1.01 ^{c}	73.59 ^{d}
	M. ghana	15.40 ^{a}	4.14 ^{c}	0.06 ^{c}	84.32 ^{a}	0.06 ^{d}	84.96 ^{a}
	M. conchin	10.56 ^{c}	4.74 ^{b}	0.12 ^{b}	83.43 ^{b}	0.13 ^{b}	75.49 ^{c}
	M. rajada	12.6 ^{b}	4.06 ^{c}	0.65 ^{a}	81.40 ^{d}	1.28 ^{a}	78.04 ^{b}
	SEM	0.06	0.0001	0.0001	0.06	0.002	0.35
8 WEEKS	*C. cajan*	11.20 ^{c}	13.48 ^{a}	2.04 ^{a}	70.46 ^{b}	2.76 ^{d}	74.80 ^{b}
	V. radiata	11.55 ^{c}	12.38 ^{c}	1.36 ^{c}	71.34 ^{a}	3.36 ^{a}	80.57 ^{a}
	M. ghana	13.30 ^{a}	13.04 ^{b}	1.70 ^{b}	68.98 ^{c}	2.96 ^{c}	77.42 ^{ab}
	M. conchin	12.42 ^{b}	12.62 ^{c}	1.64 ^{c}	70.38 ^{b}	3.10 ^{b}	73.79 ^{b}
	M. rajada	13.30 ^{a}	12.44 ^{d}	1.60 ^{d}	69..23 ^{b}	3.41 ^{a}	76.44 ^{b}
	SEM	0.11	0.0007	0.0003	0.11	0.001	3.34

CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, NFE = Nitrogen Free Extract, MC = Moisture Content
^{abcd} Means on the same column with different superscripts differ significantly (P<0.05)

Table 2a. Anti-Nutritional Compositions of Forages at different stages of Growth

FORAGE	STAGE OF GROWTH	ANTI-NUTRITIONAL FACTORS (%)				
		OXALATE	PHYTATE	TANNIN	HCN	SAPONIN
Cajanus cajan	EMERGENT	0.22^{c}	0.17^{c}	0.04^{c}	4.63^{c}	0.11^{c}
	4 WEEKS	0.32^{b}	0.28^{b}	0.26^{b}	6.29^{b}	0.28^{b}
	8 WEEKS	0.42^{a}	0.41^{a}	0.35^{a}	13.46^{a}	1.42^{a}
	SEM	0.00009	0.0006	0.00005	0.001	0.01
Vigna radiata	EMERGENT	0.25^{c}	0.08^{c}	0.03^{c}	4.53^{c}	0.06^{c}
	4 WEEKS	0.30^{b}	0.18^{b}	0.16^{b}	9.40^{b}	0.16^{b}
	8 WEEKS	0.37^{a}	0.27^{a}	0.24^{a}	10.80^{a}	0.36^{a}
	SEM	0.00008	0.0006	0.00007	0.01	0.0003
Mucuna ghana	EMERGENT	0.30^{c}	0.24^{b}	0.10^{c}	4.75^{c}	0.06^{c}
	4 WEEKS	0.53^{b}	0.31^{b}	0.23^{b}	5.98^{b}	0.26^{b}
	8 WEEKS	0.70^{a}	0.44^{a}	0.44^{a}	13.55^{a}	0.44^{a}
	SEM	0.00007	0.003	0.00006	0.002	0.0008
Mucuna conchinchinensis	EMERGENT	0.29^{c}	0.05^{b}	0.04^{c}	4.48^{c}	0.04^{c}
	4 WEEKS	0.59^{b}	0.21^{a}	0.21^{b}	6.02^{b}	0.30^{b}
	8 WEEKS	0.73^{a}	0.27^{a}	0.35^{a}	15.39^{a}	0.40^{a}
	SEM	0.00002	0.002	0.00008	0.001	0.0004
Mucuna rajada	EMERGENT	0.24^{c}	0.08^{c}	0.09^{c}	4.61^{c}	0.07^{c}
	4 WEEKS	0.28^{b}	0.22^{b}	0.21^{b}	6.24^{b}	0.15^{b}
	8 WEEKS	0.33^{a}	0.38^{a}	0.38^{a}	13.42^{a}	0.40^{a}
	SEM	0.00004	0.0002	0.00007	0.002	0.0002

^{abc} Means on the same column with different superscripts differ significantly ($P<0.05$)

Tannin concentrations lower than 50 g per kg DM in feedstuffs would likely not affect most rumen fermentation parameters (Barry and McNabb, 1999). However at 8 weeks, highest concentrations of oxalate (0.73%) and HCN (15.39%) were in *Mucuna conchinchinesis* while Phytate (0.44%) and tannin (0.44%) were at the highest levels in *cajan* had highest concentration of saponin (1.42%). The comparative evaluation of anti-nutritional constituents at different stages of growth is presented in Table 2b. At the emergent stage, *M. ghana* had the highest concentration of all the ANFs except for saponin which was highest in *C. cajan*; *Vigna radiata* had the lowest, relatively. At the 4th week, Oxalate (0.59%) and saponin (0.30%) were highest in *M. conchichinensis*; phytate (0.31%) in *M. Ghana*; tannin (0.26%) in *C. cajan* and HCN (9.39%) in *Vigna radiata*. At the 8th week, the peak values of oxalate (0.73%) and HCN (15.39%) were in *M. conchichinensis*; saponin (1.42%) in *C. cajan* and tannin (0.44%) and phytate (0.44%) in *M. ghana*.

Generally in this study, tannin content of the forages was observed to be low. Tannins are known to bind proteins, thus impairing protein digestion and reducing palatability (Olomu, 1995). It can be beneficial or detrimental to the ruminant depending on the concentration. From 2 - 4% tannin concentration in the diet protects protein from rumen degradation and increases the absorption of essential amino acids whereas 4 - 10% dietary tannin depress voluntary feed intake (Barry and McNabb, 1999, Silanicove *et al*., 2001).

Table 2b. Comparative Anti-Nutritional Constituents of Forages within Different Stages of Growth

STAGE OF GROWTH	FORAGES	ANTI-NUTRITIONAL FACTORS (%)				
		OXALATE	PHYTATE	TANNIN	HCN	SAPONIN
EMERGENT	*C. cajan*	0.22 [b]	0.17 [b]	0.04 [b]	4.63 [ab]	0.11 [a]
	V. radiata	0.25 [b]	0.08 [bc]	0.03 [b]	4.53 [b]	0.02 [c]
	M. ghana	0/30 [a]	0.24 [a]	0.10 [a]	4.75 [a]	0.06 [ab]
	M. conchin	0.29 [a]	0.05 [c]	0.04 [b]	4.48 [b]	0.04 [bc]
	M. rajada	0.24 [b]	0.08 [bc]	0.09 [a]	4.61 [ab]	0.07 [ab]
	SEM	0.0001	0.001	0.00006	0.007	0.0005
4 WEEKS	*C. cajan*	0.32 [c]	0.28 [a]	0.26 [a]	6.29 [b]	0.26 [a]
	V. radiata	0.30 [d]	0.18 [b]	0.16 [c]	9.39 [a]	0.16 [b]
	M. ghana	0/53 [b]	0.31 [a]	0.23 [b]	5.98 [c]	0.26 [a]
	M. conchin	0.59 [a]	0.21 [b]	0.21 [b]	6.02 [c]	0.30 [a]
	M. rajada	0.28 [c]	0.22 [b]	0.21 [b]	6.24 [b]	0.15 [b]
	SEM	0.0005	0.0006	0.00006	0.001	0.001
8 WEEKS	*C. cajan*	0.42 [c]	0.41 [a]	0.35 [c]	13.46 [c]	1.42 [a]
	V. radiata	0.37 [d]	0.27 [b]	0.24 [d]	10.80 [d]	0.36 [c]
	M. ghana	0/70 [b]	0.44 [a]	0.44 [a]	13.55 [b]	0.44 [b]
	M. conchin	0.73 [a]	0.27 [b]	0.35 [c]	15.39 [a]	0.40 [bc]
	M. rajada	0.33 [c]	0.38 [a]	0.38 [b]	12.42 [c]	0.40 [bc]
	SEM	0.00003	0.001	0.00008	0.001	0.0005

[abc] Means on the same column with different superscripts differ significantly ($P<0.05$)

The cyanogens content of the forages in this study also was generally low. Cyanogens can be hydrolyzed in the rumen by microbial activity to release HCN making ruminants more susceptible to cyanide poisoning than non-ruminants. The lethal dose of HCN for cattle and sheep is 2.0 – 4.0 mg /kg body weight while that for cyanogens would be 10-20 times greater (Kumar, 2003). Ruminants consuming forage of 18% HCN composition would manifest lethal symptoms (Ahamefule and Odoemelam, 2006). Excess HCN can inactivate the cytochrome oxidase system causing anoxia and death. Other symptoms include abnormal breathing, convulsion and respiratory failure (Odoemelam and Ahamefule, 2006).

The Phytate concentration in the forages was fairly low compared with levels in legume seeds (Ahamefule and Odoemelam, 2006); ruminants readily utilize phytate because of phytase produced by rumen micro-organisms. Phytic acid is a strong chelator of important minerals such as calcium, magnesium, iron, zinc and can therefore contribute to mineral deficiencies. It is also known to increase requirements for phosphorous by forming insoluble complexes with phytic acid (Tuleun *et al.*, 2008).

Oxalate concentration in the forages was tolerable. Oxalates are broken down by the rumen micro organism to carbon dioxide and formate (Allison, 1985). Hence forages containing oxalates are less of a problem for ruminants, but at high concentration may cause digestive disturbances (Seifert, 1996) and even kidney failure and death (Acamovic *et al*., 2004). Oxalate cause precipitation of insoluble calcium oxalate in the rumen and kidneys resulting in kidney damage, rumen stasis, gastroenteritis, calcium deficiency and possible death. Voluntary feed intake is significantly depressed by 3% dietary oxalate (Burritt and Provenza, 2000). However, given its very low solubility, calcium oxalate is often present as crystals in the sediments of concentrated ruminant urine (Van Metre, 1998).

Saponins were also generally low in concentration in the forages. They are produced by a range of different plants and are designed to combat plant pathogens. Saponins have a bitter taste and so cause a reduction in feed intake. They can be tolerated by adult ruminants and can indeed increase the efficiency of rumen fermentation by reducing the amount of methane produced while increasing the amount of microbial protein to the animal (Babayemi et al., 2004). At low levels, they are excellent foaming agents forming strong insoluble complexes with cholesterol. High level of saponin in ruminant diet is however disadvantageous because it decreases apparent digestibility, especially that of nitrogen (Abdu *et al*., 2008).

In conclusion, all the ANFs were present in tolerable levels that would not adversely influence digestibility and utilization of these forage legumes if fed at the 8^{th} –week to ruminants. Their proximate assays, especially high CP content, also portray these forages as good sources of green fodder that could constitute valuable sources of fodder for ruminant livestock in Nigeria. These forage legumes can be used to supplement conventional vegetable protein sources for ruminants. Optimum benefits would be derived at 8 weeks of growth when there would likely be a balance in the CP, CF and MC content of the forages. The next stage of this research would be to correlate the chemical assay of these forages with their biological evaluation through animal trials. This will indeed highlight the true feeding value of these legumes.

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