# PROXIMATE COMPOSITION AND ANTI-NUTRITIONAL FACTORS OF SOME FORAGE SPECIES USED IN FEEDING RABBITS IN UMUDIKE, HUMID SOUTHEASTERN NIGERIA

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***ABSTRACT***

*The proximate and anti-nutritive constituents of the foliage of twelve plant species used as forage for rabbits in Umudike, Southeastern Nigeria was examined. The plants were made up of three groups: Grasses, herbaceous weeds and legumes. The plants' leaves were collected during the rainy season and were assayed for their proximate and anti-nutritional constituents. The result showed variations among forage species, which differed significantly ($p<0.05$) in proximate and anti-nutritive constituents. Crude protein (CP) values varied from 9.54% in Panicum maximum to 24.76% in Leucaena leucocephala. Crude fibre (CF) content varied from 11.41% in Emilia sonchifolia to 34.18% in Pennisetum purpereum. A high variability in ash content was obtained, which ranged from 4.91% in Setaria barbata to 10.30% in Emilia sonchifolia. Tannin content ranged from 0.38- 1.24% in Setaria barbata and Calopogonium mucunoides, respectively. Oxalate content ranged from 0.53% in Centrosema pubescens to 1.25% in Panicum maximum. Saponin, phytate and hydrocyanic acid content were low with overall mean levels of 0.46%, 0.75% and 0.62% or 62.0mg/kg, respectively. It can be concluded that most of the plants are not toxic and could supply nutrients and satisfy the nutrient requirements of rabbits.*

***Keywords: Rabbit, forage, proximate composition, anti-nutritional factors, humid Nigeria,***

## INTRODUCTION

Forages are extensively used in rabbit production as supplements to concentrate meal, pellets or in complete diets. In addition to supply of proteins and energy, forage supply fibres to aid proper digestion in rabbits. The potential of forage as feed for rabbit is of particular significance because of their ability to effectively digest leaf protein (Cheeke and Patton, 1980).

The nutritional potential of forage is enormous for rabbits, yet many farmers do not know the right types of forage to feed their rabbits. Many forage plants have not been identified as feed for rabbits while several identified plants are undervalued because of insufficient knowledge about their potential feeding value. This is more glaring in the Nigerian humid environment, where information on the nutritional potential of forages within the area as feedstuffs for rabbits is scanty. Such information, however, is necessary for a well planned, balanced and cost effective feeding regimen.

Commercial feeds are expensive in most developing countries, and out of reach of smallholder farmers who mainly raise rabbits in their backyards. This has necessitated the need to seek for alternative protein sources in forage (Iyeghe-Erakpotobor *et al*., 2009). The inclusion of forage will greatly reduce the amount of concentrate fed to rabbits. Feeding of rabbits with forage allowed for better rate of growth when compared to rabbits which were not fed forage (Aduku and Olukosi, 1990; Onwudike, 1995).

The diversity of forage species that is available for rabbit feeding is vast (Carew *et al*., 1989; Raharjo *et al*., 1986; Cheeke, 1987; Fielding, 1991). In Nigeria, several forage species have been identified and traditionally used for feeding rabbits (Ekpenyong, 1986; Aduku *et al*., 1989; Bello, 2003). Rabbits are never fed sole concentrate in other to meet their crude fibre requirement (Bamikole and Ezenwa, 1999) but are fed forage in mixed concentrate-forage diets. This underscores the need to study the nutrient potential of forage crops available for feeding rabbits. However, forage species contain a diverse range of secondary compounds which are capable of precipitating toxic and anti-nutritional effects in farm livestock. The estimation of the nutrient and anti-nutrient concentration in forage plants is an important step in selecting forage for feeding livestock, especially for smallholder rabbit farmers who practice mixed feeding system, on the forage plants to use.

In other to exploit the unique position of forage in rabbit feeding system, a significant number of forage plants which are acceptable to rabbits should be assessed for their proximate composition and toxic factors. This information is lacking for most of the forage plants that is available for feeding rabbits in Southeastern Nigeria and that forms the basis of the present study.

## MATERIALS AND METHODS

### Experimental site

The study was carried out at the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike and National Root Crops Research Institute, Umudike, Abia State, Nigeria. The experimental site bears the co-ordinates of 5 $^0$ 28' North and 7 $^0$ 32' East and lies at an altitude of 122m above sea level. This area is situated within the tropical rainforest zone of Nigeria and characterized by 9 months of rainfall and 3 months of dry season. Average rainfall is 2169.88 mm in 148-155 rain days. The relative humidity during the rainy season is over 72% on the average and monthly ambient temperature ranges between 17 $^0$C and 36 $^0$C with an average of 26 $^0$C.

### Experimental materials, sample collection, identification and preparation

Tender stems and leaves of twelve forage plants named A-L made up of four legumes, four weeds and four grasses with their botanical and common names namely, *Centrosema pubescens* Benth (Centro) (A), *Pueraria phaseoloides* (Peuro) (B), *Calopogonium mucunoides* Desv (Calopo) (C), *Leucaena leucocephala* Lam de wit (Leucaena) (D), *Aspilia africana* Pers C.D Adams (African marigold; Haemorhage plant) (E), *Tridax procumbens* (L)(Tridax*)* (F), *Emilia sonchifolia* (L.) Dc (Emilia) (G), *Gomphrena celosiodes* Mart (Globe amaranth) (H), *Panicum maximum* Jacq (Guinea grass) (I), *Andropogon tectorum* Schum and Thonn. (Southern gamba grass; Giant blue stem) (J), *Pennisetum purpereum* Schumach (Elephant grass) (K) and *Setaria barbata* (Lam.) Kunth (Bristly foxtail) (L) were used for the study. The plants were identified in the Forestry Department of Michael Okpara University of Agriculture, Umudike, Abia State. The leaves of the forage plants were collected from secondary bushes and farm lands within the university campus, from young and maturing plant tops, separated from the stalk and the latter discarded.

### Chemical analysis

Harvested foliage samples of the browse plants were air-dried in a room for 3 days and later oven-dried at 60 $^o$C for 48 hours. Dried samples were ground in a Willey mill through a 2mm sieve, packed and labeled for laboratory analysis. The proximate composition was determined according to AOAC (1990). Tannin was assayed by the Fellin-Dennis procedure as described by Pearson (1976). Phytin was estimated as phytic acid using the methods of Maga (1982). Oxalic acid was estimated using the precipitation method (AOAC, 1990) while hydrocyanic acid (HCN) was estimated by the Knowles and Watkins distillation method (AOAC, 1990). Saponin content was determined according to the methods of Obadoni and Ochuko (2001).

### Statistical analysis

Mean values for the proximate composition and anti-nutritional factors of the forage species were statistically compared using standard error (Steel and Torrie, 1980).

## RESULTS

The proximate composition of the forage plants is shown in table 1. The dry matter (DM) content of the various forage species ranged from 89.30% in *Panicum maximum* to 91.26% in *Leucaena leucocephala*, with a mean of 90.11 ± 0.11% (Table 1*).* The DM content of *Leucaena leucocephala* was significantly ($p<0.05$) higher than the DM content of the other forage plants. DM content of *Pueraria, Aspilia africana, Tridax procumbens, Calopogonium mucunoides*, *Emilia sonchifolia* and *Gomphrena mucunoides* were similar to one another but significantly different ($p<0.05$) from the DM values of *Andropogon tectorum* and *Centrosema pubescens.* Similarly DM contents of *Pennisetum* and *Setaria barbata* were similar ($p>0.05$) but significantly different ($p<0.05$) from the DM content of *Andropogon tectorum* (89.75%), *C. pubescens* (89.38) and *Panicum maximum* (89.28%).

On DM basis, the crude protein (CP) content of the forages was moderately high, ranging from 9.54 - 24.76%, with a mean of 16.83 ± 0.02%. *Leucaena* contained the highest level of CP (24.76%) which was significantly higher ($p<0.05$) than the CP content of *Calopogonium (*24.15%*)*, *Emilia* (22.66%), *A. africana* (19.47%), *C. pubescens* (18.72%) and *Setaria barbata* (17.58%). However, *Pennisetum* (13.82%) and *Tridax procumbens* (13.82%) contained similar ($p>0.05$) levels of CP which differed significantly ($p<0.05$) from *Andropogon* (11.85%), *Pueraria* (11.85%) and *G. celosioides* (13.74%).

The crude fibre (CF) values of the plants ranged from 11.41% in *Emilia sonchifolia*, a herbaceous weed to 34.18% in *P. purpureum*, a grass. *P. purpereum*, commonly called elephant grass contained significantly ($p<0.05$) more crude fibre than the other plants. The levels of CF in *C. mucunoides* (21.69%) and *C. pubescens* (21.69%) were similar ($p>0.05$) but significantly different ($p<0.05$) from the CF levels in *Setaria* (19.41%), *Gomphrena* (17.64%), *Pueraria* (16.35%) and *Tridax* (15.17%). The CF levels of *Aspilia* (11.75%), *Leucaena* (11.42%) and *Emilia* (11.41%) were comparable ($p>0.05$) but significantly lower than the values obtained for the other forage plants

**Table 1: Proximate composition of selected forage species used in feeding rabbits in Umudike**

| Forage species | Proximate | fractions | (%DM) | | | |
|---|---|---|---|---|---|---|
| | DM | CP | CF | EE | ASH | NFE |
| *Panicum maximum* | 89.28[fg] | 9.54[j] | 23.62[c] | 2.76[e] | 6.93[ef] | 46.92[e] |
| *Aspilia africana* | 90.25[c] | 19.47[d] | 11.75[i] | 2.15[h] | 7.84[d] | 49.04[d] |
| *Calopogonium mucunoides* | 89.84[cd] | 24.15[b] | 21.69[d] | 3.18[d] | 9.79[b] | 31.03[l] |
| *Andropogon tectorum* | 89.75[de] | 11.85[i] | 24.62[b] | 2.78[e] | 6.96[e] | 43.53[f] |
| *Pennisetum purpereum* | 90.68[bc] | 13.82[g] | 34.18[a] | 2.51[g] | 6.76[g] | 33.41[k] |
| *Leucaena leucocephala* | 91.26[a] | 24.76[a] | 11.42[i] | 8.21[a] | 5.81[h] | 41.05[i] |
| *Setaria barbata* | 90.72[b] | 17.58[f] | 19.41[e] | 6.30[b] | 4.91[j] | 42.51[g] |
| *Gomphrena celoisoides* | 89.89[cd] | 13.74[h] | 17.64[f] | 2.05[i] | 7.26[e] | 49.20[c] |
| *Pueraria phaseoloides* | 90.25[c] | 11.85[i] | 16.35[g] | 1.90[j] | 5.96[i] | 54.17[a] |
| *Centrosema pubescens* | 89.38[ef] | 18.72[e] | 21.69[d] | 3.16[d] | 8.31[c] | 37.49[j] |
| *Emilia sonchifolia* | 89.30[cd] | 22.66[c] | 11.41[i] | 3.34[c] | 10.30[a] | 42.09[h] |
| *Tridax procumbens* | 90.26[c] | 13.82[g] | 15.17[h] | 2.70[f] | 6.91[f] | 51.65[b] |
| Mean | 90.11 | 16.83 | 19.08 | 3.42 | 7.31 | 43.51 |
| SEM | 0.11 | 0.028 | 6.52 | 1.85 | 1.53 | 6.96 |

[abcdefghij] Means in the same column with different superscripts are significantly different (p<0.05). DM= Dry matter, CP= Crude protein, CF= Crude fibre, EE= Ether extract, NFE= Nitrogen-free extract. SEM= Standard Error of Mean.

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The ether extract (EE) content of the plants in the present study ranged from 1.90% for *P. phaseolioides* to 8.21% for *L. leucocephala*, with a mean EE content of 3.42 ± 1.85%. *L. leucocephala* contained significantly (p<0.05) more ether extract than the other forage plants. The EE content of *Setaria* (6.30%), was significantly (p<0.05) higher than the EE content of *E. sonchifolia* (3.34%), *C. mucunoides* (3.18%), *C. pubescens* (3.16%), *Andropogon* (2.78%), *P. maximum* (2.76%), *Tridax* (2.70%), *P. purpereum* (2.51%), *Aspilia* (2.15%), *G. celosiodes* (2.05%) and *Pueraria* (1.90%). The EE content of two grasses, *Andropogon* (2.78%) and *P. maximum* (2.76%) were similar (p>0.05) but significantly (p<0.05) higher than the EE content of *Pennisetum, Tridax, Gomphrena and Pueraria.*

The ash content ranged from 4.91% in *S. barbata* to 10.30% in *E. sonchifolia*, with a mean of 7.31 ± 1.53%. *E. sonchifolia* contained significantly higher (p<0.05) ash level than the other forage species. The ash content of *C. mucunoides* (9.79%) was significantly higher (p<0.05) than the ash content in *C. pubescens* (8.31%), *A. africana* (7.84%), *G. celosioides* (7.26%), *Andropogon* (6.96%) and *P. maximumi* (6.93%). The ash content in *G. celosioides* (7.26%), *Andropogon* (6.96%) and *P. maximumi* (6.93%) were similar (p>0.05) and significantly (p<0.05) higher than the content in *Pennisetum* (6.76%), *Pueraria* (5.96%) and *Leucaena* (5.81%). *Setaria* contained significantly (p<0.05) lower level of ash than the other forage plants studied.

The nitrogen free extract (NFE) content of the forage plants ranged from 31.03% in *C. mucunoides* to 54.17% in *Pueraria,* with a mean NFE content of 43.51 ± 6.96%. The NFE content of the plants differed significantly (p<0.05) among the forage plants. The NFE values of *P. phaseoloides* was significantly (p<0.05) higher than the values in the other forage species. The NFE values of *T. procumbens* was significantly (p<0.05) higher than the values in *G. celosioides* (49.20%), *A. africana* (49.04%), *Panicum maximum* (46.92%) (Table 1). The NFE values of *C. mucunoides* was significantly (p<0.05) lower than the values in *Setaria* (42.05%), *Emilia* (42.09%), *Leucaena* (41.05%), *P. purpereum* (33.41%) and *A. tectorum* (43.53%).

The anti-nutritional constituents of the forage plants are shown in table 2. The tannin levels differed significantly (p<0.05) among some plants studied and ranged from 0.38% to 1.24%, with a mean of 0.77%. The tannin content of *C. mucunoides* (1.24%) was significantly different (p<0.05) from the tannin content of the other forage plants. *Andropogon* (1.09%) and *Pennisetum* (1.07%) contained similar (p>0.05) levels of tannin but significantly higher (p<0.05) levels than the tannin content of the other plants, except *C. mucunoides*. The tannin content of *Setaria barbata* (0.38%) was significantly lower (p<0.05) than the tannin content of the other forage plants.

**Table 2: Anti-nutritional factors of selected forage species used in feeding rabbits in Umudike**

| Forage species | Anti-Nutritional factors (% DM) | | | | |
|---|---|---|---|---|---|
| | Tannin | Phytate | Oxalate | HCN (mg/kg) | Saponin |
| *Panicum maximum* | $0.82^{d}$ | $0.77^{d}$ | $1.25^{a}$ | $0.39^{f}$ | $1.08^{d}$ |
| *Aspilia Africana* | $0.75^{e}$ | $0.83^{c}$ | $0.78^{d}$ | $0.13^{h}$ | $1.45^{a}$ |
| *Calopogonium mucunoides* | $1.24^{a}$ | $0.82^{c}$ | $0.81^{de}$ | $0.38^{f}$ | $0.44^{h}$ |
| *Andropogon tectorum* | $1.09^{b}$ | $0.46^{g}$ | $0.74^{f}$ | $0.60^{d}$ | $0.71^{f}$ |
| *Pennisetum purpureum* | $1.07^{b}$ | $1.24^{a}$ | $0.74^{f}$ | $0.17^{g}$ | $0.18^{j}$ |
| *Leucaena leucocephala* | $0.49^{h}$ | $0.51^{f}$ | $0.58^{h}$ | $0.77^{a}$ | $1.06^{d}$ |
| *Setaria barbata* | $0.38^{i}$ | $0.62^{e}$ | $0.84^{c}$ | $0.24^{g}$ | $1.15^{c}$ |
| *Gomphrena celoisoides* | $0.54^{g}$ | $0.85^{c}$ | $1.07^{b}$ | $0.66^{c}$ | $0.95^{e}$ |
| *Pueraria phaseoloides* | $0.62^{f}$ | $1.07^{b}$ | $0.75^{c}$ | $0.36^{f}$ | $0.21^{i}$ |
| *Centrosema pubescens* | $0.76^{e}$ | $0.35^{h}$ | $0.53^{i}$ | $0.48^{e}$ | $0.49^{g}$ |
| *Emilia sonchifolia* | $0.98^{c}$ | $0.62^{e}$ | $0.65^{g}$ | $0.73^{b}$ | $1.07^{d}$ |
| *Tridax procumbens* | $0.52^{gh}$ | $0.86^{c}$ | $0.80^{de}$ | $0.62^{d}$ | $1.25^{b}$ |
| Mean | 0.77 | 0.75 | 0.79 | 0.46 | 0.83 |
| SEM | 0.054 | 0.050 | 0.039 | 0.043 | 0.083 |

$^{abcdefghij}$ Means in the same column with different superscripts are significantly different (p<0.05). SEM = Standard Error of Mean. HCN= Hydrocyanic acid

The phytate content of the plants ranged from 0.35 to 1.24% with a mean of 0.75%. The phytic acid content of *Tridax* (0.86%), *G. celosioides* (0.85%), *A. africana* (0.83%) and *C. mucunoides* (0.82%) were similar (p>0.05) but significantly higher (p<0.05) than the phytate content of *P. maximum* (0.77%), *Setaria* (0.62%) and *Emilia* (0.62%). The phytate values of both *Setaria* and *Emilia* (0.62%) were similar (p>0.05) to each other, but significantly higher (p<0.05) than the phytate content of *Leucaena*, *Andropogon* and *Centrosema*.

The oxalate content of the forage plants ranged from 0.53% in *Centrosema* to 1.25% in *Panicum* with a mean of 0.79%. The oxalate content of *P. maximum* (1.25%) was significantly (p<0.05) higher than the oxalate content of the other plants. The oxalate content of *Setaria* (0.84%) and *Pueraria* (0.75%) were similar (P>0.05) but the oxalate value of *Setaria* was *significantly* higher (p<0.05) than the oxalate content of *Aspilia* (0.78%), *Tridax* (0.80%) and *Calopogonium* (0.81%). The oxalate content of two grasses *A. tectorum* and *P. purpureum* were similar (p>0.05) but significantly (P<0.05) higher than the oxalate content of *Emilia* (0.65%), *Leucaena* (0.58%) and *Centrosema* (0.53%).

The HCN content of the forage plants ranged from 0.13 to 0.77 mg/kg with a mean of 0.46 mg/kg. The HCN content of *Leucaena* (0.77 mg/kg) was significantly higher (p<0.05) than the HCN content of the other forage plants. The HCN content of *Pueraria* (0.36 mg/kg), *Calopogonium* (0.38 mg/kg) and *Panicum* (0.39 mg/kg), were similar (p>0.05) but significantly higher (p<0.05) than the HCN content of *Setaria* (0**.**24mg/kg), *Pennisetum* (0.17 mg/kg) and *Aspilia* (0.13 mg/kg).

The saponin content of the various forage species ranged from 0.18% in *Pennisetum* to 1.45% in *A. africana*, with a mean of 0.83%. The saponin content of *Aspilia* was significantly higher (p<0.05) than the saponin content of the other forage plants. The saponin content of *Emilia* (1.07%), *Leucaena* (1.06%) and *Panicum* (1.08%) were similar (p>0.05) but significantly higher (p<0.05) than the saponin content of *Gomphrena* (0**.**95%), *Andropogon* (0.71%), *Centrosema* (0.49%), *Calopogonium* (0.44%) and *Pueraria* (0.21%).

## DISCUSSION

The dry matter content of the forage plants obtained in the present study compared favourably with the findings of Oduozo and Adegbola (1992) (90.50 - 92.70%) and Okoli *et al.* (2001; 2003) (85.71- 88.73%; 91.40 -93.60%). However, they differed from those reported by Mecha and Adegbola (1980) (14.48 - 55.22%) and Oji and Isilebo (2000) (26.54 – 47.69%) and Bello (2003) (8.32 - 40.0%). The difference in the dry matter content of the grasses, weeds and legume species with the earlier results could be due to the processing methods adopted, period of establishment (wet or dry season) or harvesting of the forage plant (Ajayi, 2012). The variability in the nutrient content of fodder trees and shrubs have been attributed to the state of hydration (fresh, wilted, dry) and drying procedure (Palmer and

Schlink, 1992; Dzowela *et al.*, 1995), age of cutting, season and geographical location (Ajayi, 2012). Oguntona (1998) had ascribed wide variation in the values of nutrient content of leafy vegetables to variation in nutrient status of the soil on which the crops were grown, sample preparation procedure before analysis and analytical procedure which may vary in technique and quality.

Umoh *et al.* (1996) reported a high DM of 61.2% for *P. maximum.* Taiwo *et al.* (2005), Arigbede *et al.* (2005) and Bamikole *et al.* (2003) reported a low DM of 29.98, 27.60 and 27.30%, respectively for *P. maximum.* Mecha and Adegbola (1980) reported a DM content of 25.36% and 36.12% for *C. mucunoides* and *A. africana*, respectively. Taiwo *et al*. (2009) reported similarly high DM for *C. pubescens* (88.63%) and *C. mucunoides* (88.70%) as obtained in the present study. Okoli *et al.* (2001) reported average high DM content of 88.73% for several forage species in Southeastern Nigeria. Ajayi (2012) reported a low DM content of 38.74% for *C. pubescens* while Mecha and Adegbola (1980) reported low DM values of 25.36% and 36.12% for *C. mucunoides* and *A. africana*, respectively.

The mean crude protein content of 16.83% obtained for the forage plants in the present study was reasonably high and similar to the mean values of 17.30% reported by Larbi *et al.* (1993) and 12.50% and 16.80% for non-legumes and legumes, respectively reported by Le - Houerou (1980a). Mean CP value of 18.27% and 15.87% have been reported for browse plants in West Africa and southern Nigeria by Mecha and Adegbola (1980) and Okoli *et al.* (2003), respectively. A review of studies of browses from other parts of southern Nigeria suggests that they have medium to high crude protein content (120-298 g $kg^{-1}$DM) (Topps, 1992), 109.4–298g$kg^{-1}$DM with a mean of 184.6g $kg^{-1}$DM (Carew, 1980), 10.0 – 29.20% (Larbi *et al.*, 1996; 1997), and 15.59 to 20.99% (Oji *et al.*, 1998). Getachew *et al.* (2002) reported a range of 5.0–27% CP, with a mean of 18.12% for 37 tropical browses.

In the present study, the CP is within the range of 11-20% reported for non-leguminous browse species (Larbi *et al.*, 1993; Rittner and Reed, 1992), 4.79-35.16% (Ekpenyong, 1986) and 9.0-29.7% (Bello, 2003) for tropical forage plants available for rabbit feeding. The CP value of 9.54% which was reported in the present study for *P. maximum* was higher than 7.20% (Bamikole *et al.*, 2003) and 7.68% (Ajayi, 2012) reported for the grass. Higher CP content has been reported by several researchers for *P. maximum.* Umoh *et al.* (1996) and Arigbede *et al.* (2005) reported CP values of 10.64 and 8.5%, respectively. Adegbola and Mecha (1988) reported lower value of 3.20 – 4.88% CP for dry season grasses in southern guinea savanna. Mecha and Adegbola (1980) reported higher CP values of 11.82 and 13.13% for *A. tectorum* and *P. purpereum*, respectively.

The CP value of 18.72% reported for *Centrosema* in the present study compared favourably with CP value of 16.71% (Ajayi, 2012) and 18.4% (Osakwe and Ekwe, 2007) but lower than the values of 21.45% and 22.45% reported by Ojewola *et al.* (1999) and Nworgu and Fasogbon (2006), respectively. The *C. mucunoides* CP value of 24.15% in the present study agreed with the value of 22.6-27.6% reported by Asongwed *et al*. (2003). Aderinola *et al*. (2008) and Omole (2010) reported CP values of 21.73 and 22.36% for *C. mucunoides* while Ikhimioya and Olagunju (1996) reported similar CP value of 24.3% for the same plant. Cobbina *et al.* (1990), Babayemi and Bamikole (2006), Arigbede *et al.* (2008) and Onwudike (1995) reported slightly lower CP values for *Leucaena* (21.31%; 19.91%; 22.68%; 21.1%) in Nigeria, compared to the value of 24.76% reported for the same plant in the present study.

Variations were observed between the CP values obtained in the present study and elsewhere. Mecha and Adegbola (1980) obtained a comparable CP value of 19.92% for *Aspilia* while Ayo-Enwerem *et al.* (2008), Ahamefule *et al.* (2006b) and Taiwo *et al.* (2008) reported values of 18.0, 14.70 and 24.89%, respectively for *Aspilia* compared to 19.47% reported in the present study. Similarly, the CP value obtained for *Tridax* (13.82%) in the present study is lower than 24.47% (Taiwo *et al.*, 2005), 24.06% (Ibeawuchi *et al.* 2002), 16.35% (Bello, 2003), 25.5% (Aduku *et al*., 1989) and 17.80% (Ahamefule *et al.* 2006b) but higher than the values of 6.50 and 10.28% reported by Taiwo *et al.* (2009) and Asuquo (1997), respectively. The crude protein content of *Pueraria* (11.85%) and *Emilia* (22.66%) obtained in the present study is lower than the values of 17.63% and 22.49% obtained by Asuquo (1997) for the same plants. Similarly, CP value obtained for *G. celosioides* (13.74%) in the present study is lower than 16.92% (Akinmutimi *et al*., 2008), 15.86% (Akinmutimi and Obioha, 2010) and 31.31% reported by Taiwo *et al*. (2008). Variations in CP values have been ascribed to soil type, age of the plant, season and geographical location (Smith, 1992; Norton, 1994; Nworgu and Ajayi, 2005).

Except for the grass species, the CP values obtained in the present study for the other plants were on the average within the recommended level for rabbits (Abdella *et al*., 1988; Raharjo *et al*., 1986). The crude protein and crude fibre content are enough to meet the nutrient requirement of different classes of rabbits (Abdella *et al.*, 1988; Deblass *et al*., 1986). The present mean CP value exceeds the crude protein requirements of rabbits (12 to18% CP) (Lebas *et al*., 1986; Aduku and Olukosi, 1990). The crude protein levels of 16.3-18% (NRC, 1984;

Champe and Maurice, 1983) and 16.2% CP (Obinne and Okorie, 2008) have been recommended for growing rabbits.

The crude fibre (CF) content of the forages obtained in this study was moderately high averaging 19.08%, and ranging from 11.41-34.18%, but was lower than the average CF content reported by Mecha and Adegbola (1980) (20.82%) for forage plants of southern Nigeria. It was higher than values reported by Oji and Isilebo (2000; 11.7%) and Okoli *et al.* (2003; 11.62%) for southern Nigerian browse plants. Asongwed *et al*. (2003) and Aderinola *et al*. (2008) reported for *C. mucunoides*, CF values of 24.19 % and 21.73%, respectively. Bello (2003) reported CF values ranging from 5.0 - 27.20%, and average CF values of 15.76, 18.90, 14.14 and 18.95% for trees, grasses, non-leguminous and leguminous herbs, respectively.

The CF values reported for *Andropogon* and *Pennisetum* are consistent with report of Mecha and Adegbola (1980) for the same plants. Le - Houerou (1980a) reported an average crude fibre content of 18.30% for browses in West Africa. Ahamefule *et al.* (2006a) had reported that crude fibre of various forage species varied widely. The grasses had the highest average CF of 32.21% followed by the non-leguminous browse. The leguminous browse plants had the least average CF value. Considerable variations in the crude fibre contents of edible tree and shrub leaves were due to leafiness, extent of stemmy and more fibrous materials, stage of maturity, season of harvest (dry and wet) and type of browse plants (Skerman *et al.,* 1988; Devendra, 1995).

Level of 13 - 14% CF content is known to be satisfactory for growing rabbits (Lebas *et al*., 1986). Generally, the CF content of the forage species are within the recommended range of 10-20% for optimum growth and performance of rabbits (Aduku and Olukosi, 1990).Crude fibre intake of 10 - 15% have been recommended for optimum production of rabbits (Deblass *et al*., 1986). Lower levels have been shown to depress growth rate and increase the incidence of diarrhoea while at higher levels (<19%) growth rate is also depressed by restricting energy intake (Champe and Maurice, 1983; Bello, 2003). Crude fibre level of between 10 - 17% was found to support weight gain in rabbits (Cheeke *et al.*, 1983). The range in the level of fibre required in the diet of rabbits shows a high requirement for forage which could supply the fibre in the diet of rabbit for optimum growth. Fibre level and composition of forages could be a factor in the level of weight gain in rabbits (Iyeghe-Erakpotobor *et al*., 2012).

The mean EE content of 3.42% obtained in the present study fell within the range of 2.30%-5.80% recorded by Mecha and Adegbola (1980), and less than the value of 5.30% obtained by Okoli *et al.* (2001). Amakiri and Udenze (2000) and Arigbede *et al.* (2005) reported EE values of 2.20% and 2.80% for *P. maximum*, respectively compared to a value of 2.76% obtained for *P. maximum* in this study. Mecha and Adegbola (1980) also reported similar EE content of 2.0% and 3.10% for *Aspilia* and *Calopogonium,* respectively. Ahamefule *et al*. (2006b) reported an EE content of 6.40% and 1.66% for *Aspilia* and *Calopogonium,* respectively. Mecha and Adegbola (1980) reported comparable EE values for *A. tectorum* and *Pennisetum purpereum* to the values obtained in the present study.

The mean NFE content (43.51%) of the forage plants obtained in this study was lower than the value of 50.30% and 49.92% obtained by Mecha and Adegbola (1980) and Okoli *et al.* (2003), respectively, but higher than the values of 36.75% reported by Oji and Isilebo (2000). The high content of ether extract and NFE of the browses is not understood. However, when a good percentage of the ether extract is true fat and NFE consists of mainly sugars and starch among other component then the forages are expected to have higher energy content than those with lower EE and NFE values (Mecha and Adegbola, 1980).

Le - Houerou (1980b) reported an average ash content of 10.90% for West African browse plants, while Mecha and Adegbola (1980) reported a value of 7.19%. In the present study, a mean ash content of 7.31% obtained was similar to the value (8.51%) obtained by Okoli *et al.* (2003) for southeast Nigerian browses. However, Mecha and Adegbola (1980) reported similar ash content for *C. mucunoides* and *A. africana* (3.10% and 2.10%) compared to the present study. Ibeawuchi *et al*. (2002) and Taiwo *et al.* (2009) reported higher ash content of 11.0 and 13.72%, respectively for *C. mucunoides*. Similarly, Ibeawuchi *et al*. (2002) and Taiwo *et al.* (2009) reported higher ash content of 20.50% and 9.0% for *Tridax*, compared to a value of 6.9% obtained for the same plant in the present study. On the other hand, lower ash values of 7.90% and 7.79%, respectively have been reported for *Emilia* and *Centrosema* (Asuquo, 1997; Ojewola *et al*., 1999) compared to the values of 10.3% and 8.31% reported in the present study for the two plants.

Arigbede *et al.* (2005), Amakiri and Udenze (2000), Bamikole *et al.* (2004) and Anugwa *et al*. (2000) reported ash contents of 9.70, 11.5%, 8.75 and 7.0%, respectively for *P. maximum.* These values are higher than the value (6.93%) reported in the present study for *P. maximum.* However, Adegbola and Mecha (1988) reported a lower ash content value of 5.83% for *P. maximum* in the dry season, in southeast Nigeria. Mecha and Adegbola (1980) reported mean ash values of 6.92, 6.10, 8.93

and 7.96% for trees, shrubs, herbs and grasses, respectively.

Little *et al. (*1989) had reported a decline in ash content with age. The leaves of forage plants used in the present study were relatively young leaves and re-growths. Mecha and Adegbola (1980) had reported that the stage of plant growth and soil types affect plant ash values and might explain the variation in values obtained in the present study. Ash content reflects the mineral composition of the forage plants and is an indication of the intrinsic ability of the plants to supply minerals to farm animals.

The observed variations in chemical composition of the forages agree with earlier reports (Asiegbu and Anugwa, 1988; Topps, 1992). It has been reported that the ratio of leaf to twigs, seasonal variations in climatic and soil conditions of the area, cell wall lignification, and inherent genetic characteristics of each plant also go a long way to determining the level of nutrients in its foliage (Arigbede and Tarawali, 1997). Really, the high variability in the nutrient content of plants often encountered in research have been attributed to within species variability, plant part, leaf age, season, harvesting regimen, soil type, location (Smith, 1992; Norton, 1994), and soil nutrient status, time of harvest (Oji *et al.*, 2001).

Variations in the crude protein values of these forage species could be due to the age of cutting, season and geographical location (Nworgu and Ajayi, 2005). The plant materials in the present study were collected from different locations and were at different stages of re-growth and age. This may have contributed to the variations in chemical composition reported in the present study.

In the present study, the wide variation in tannin contents suggests considerable differences in the nutritional quality of the different forage species. The tannin levels obtained in this study were low but were similar to values reported by Leinmuller *et al.* (1991). However, the tannin level of 3.3% reported for *A. africana (*Ayo-Enwerem *et al.,* 2009) was higher than the value of 0.75% tannin obtained in this study. Okwu and Josiah (2006) reported lower tannin level of 0.04% for the same plant. Akinmutimi and Obioha (2010) reported a low tannin content of 0.094% for *G. celosioides* compared to the tannin level of 0.54% reported for the same plant in this study. Arthun e*t al.* (1992) reported that tannin concentrations increased as the season progressed and attributed it to factors such as rainfall, temperature and humidity which may be peculiar to different locations. Differences in season and stage at which these plant species were harvested (Singh, 1984; Oduguwa *et al.,* 1998) or differences in assay methodology of tannin (Reed, 1995), may have contributed to the variations in tannin level obtained in the present study. Getachew *et al.* (2002) concluded that tropical browses with less than approximately 45 and 20g/kg of total phenols and tannin respectively are not likely to produce significant adverse effects on livestock. It would appear that most of the forage plants analyzed in this study contained tannin at levels tolerable to rabbits.

The HCN levels in the forage plants in the present study were low. Similarly, low HCN levels have been reported for browse plants in Southeastern Nigeria (Okoli *et al.,* 2003). Siegler *et al.* (1989) reported that many commonly consumed plants are cyanogenic, however, the quantity of HCN produced by most of these species is too low to pose major animal health problems (Kumar and D'Mello, 1995). Generally, only plants that produce more than 20 mg of HCN / 100g fresh weight are considered deleterious (Everist, 1981). Smith (1992) reported that levels below 50 mg / kg are harmless to farm animals. Ravindran *et al*. (1986) found that 84 mg / kg HCN was well tolerated by growing rabbits.

The oxalate content of the forage plants are within the range of 0.01 - 2.50 mg / 100g reported in trees, shrubs, herbs and grasses (Onwuka, 1996). The levels are within the range of 0.10 - 3.59 mg / 100g in shrubs and 0.33 - 2.06 mg / 100g in trees (Onwuka, 1996). The oxalate levels of 0.53 - 1.25% reported in the present study fall within the level of 25.36 - 223.00 mg / 100g reported by Alector and Omodara (1994) for leguminous browse plants in Nigeria. Alector and Omodara (1994) reported oxalate levels of 70.17 mg / 100g for *C. pubescens*. This is higher than the level of 0.53% or 53 mg/100g reported for the same plant in the present study. Akinmutimi and Obioha (2010) reported an oxalate content of 1.24% for *G. celosioides* compared to the oxalate content of 1.07% reported for the same plant in this study. Oxalates affect calcium and magnesium metabolism (Onwuka, 1983). Generally, the oxalate concentration in the plants foliage were low and within reported range by Oke (1969).

The phytate levels of 0.35 - 1.24% reported in the present study fall within the range of 82.03 – 248 mg/g for trees and 65.05 - 293.62 mg/g for shrubs (Onwuka, 1996) and 5.07 -82.26 mg/g for browse plants in southwest Nigeria (Alector and Omodara, 1994). However, Alector and Omodara (1994) reported slightly lower phytate level for *C. pubescens* (26.85 mg/g) than 0.35% obtained in the present study. Phytate interferes with the utilization of mineral elements by forming compounds with anions and proteins (Akinmutimi and Abasiekong, 1997).

The saponin content of the forage plants was generally low, as found in other studies (Gestetner *et al*., 1966). Similar saponin content has been reported for *A. africana* (1.46 mg / 100g) by Okwu and Josiah (2006). Some characteristics of saponin such as cholesterol binding properties and bitterness (Sodipo *et al*., 2000; Okwu, 2004), bestow high medicinal activities on the extracts and leaves of plants. The level of saponin content obtained in this study is unlikely that the saponin content of the forages may affect their nutritional potentials to any significant extent.

## CONCLUSION

The result obtained in this study show that most of the forage analyzed have considerable variability in nutrient and anti-nutrient constituents and have potential to supply enough nutrients for rabbit feeding based on nutritive value. The foliage of the plants contained moderate to high in crude protein. The level of anti-nutritional factors was generally low. The need for incorporation of these forage plants in rabbits diet is to reduce cost of conventional feed ingredients and meet the nutrient needs of the animal. This has called for a greater knowledge of the proximate and anti-nutrient constituents of these plants.

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