COMPARATIVE EVALUATION OF NUTRITIVE VALUES OF FOUR FODDER PLANT SPECIES IN UMUDIKE ABIA STATE, SOUTH-EASTERN NIGERIA

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Abstract
As essential as animal production is to mankind, there is a challenge of nutrient inadequacy especially with the local animal farmers. This study was conducted to evaluate the nutritive value dry matter (DM), moisture content (MC), crude protein (CP), crude fiber (CF), ash content, ether extract (EE), carbohydrate (CHO) and calorific value (CV) of fresh leaf and leaf litter of four fodder plant species (Maesobotrya barteri, Cola millenii, Napoleonaea vogelii and Uvaria chamae) in Umudike, Nigeria. Maesobotrya barteri and Napoleonae vogelii had similar DM results (95.48% and 94.95%, respectively) while Cola millenii had the least (93.08%). The MC contents of the species were within the range of 4.53 – 5.41%. U. chamae had a CP value of 22.86% while others ranged between 18.71% – 19.82%. M. barteri had the highest CF value (10.15%). N. vogelii recorded the highest ash content (8.51%), while U. chaemae had the least (6.95%). The EE values of U. chamae and C. millenii (7.38% and 7.09%) were significantly higher than those of N. vogelii and M. barteri (5.26% and 4.71%). The CHO value of N. Vogelii and M. barteri were 60.17g and 58.67g, respectively and were higher than those of U. chamae and C. millenii (54.73g and 56.68g, respectively). The CV values for U. chamae and M. barteri were the highest and the least (376.78 J/kg and 352.35 J/kg, respectively). The study concludes that the incorporation of these species into fodder banks, home gardens and alley farms can help to overcome problems of livestock nutrition.

***Keywords**: Animal production, nutrient inadequacy, nutritive value, fodder banks, home gardens*

Introduction

Animal production is an essential component of traditional agriculture in the humid tropics. The lack of forage is a significant cause of insufficient animal protein, especially in the developing world. In Southeastern Nigeria, livestock production contributes to food security and rural livelihood. However, inadequate nutrient supplies especially during the dry season is a major challenge to livestock production. The impact of this challenge is more evident in the small-scale sector (Odeyinka, 2001; Anyanwu *et al*., 2021). Fodder trees and shrubs have always played a vital role in feeding livestock and could be planted to overcome the effects of troughs in fodder supply and guard against the risk of drought or fire (Khan *et al*., 2014). Thus, leaves, twigs, and fruits of naturally occurring browse trees, shrubs, and other woody plants species have been incorporated as a significant component of livestock production in many regions of the world, mainly on grasslands (Aganga and Tshwenyane, 2003; Khan *et al*., 2014).

Any fodder crop's forage value depends on its nutritional content and palatability; fodder is fed to animals to meet specific productive purposes (Waziri *et al*., 2013). Reports have shown that trees and shrubs provide animals with protein and energy to keep rumen microbes active, increase their ability to digest fiber and enable livestock to use dry season pastures. Their availability almost all year round further increases their dietary contributions (Asefa *et al*., 1992).

Fodder trees and shrubs have relatively higher concentrations of crude protein, mineral, neutral detergent fiber (NDF) and acid detergent fiber (ADF) and lower average dry matter digestibility than grasses (Wilson, 1977). However, choosing fodder crops with low nutrient contents and nutritive value could be detrimental to sustainable productivity in animals (Waziri *et al*., 2013). There is a need to recognize, evaluate and select browse plants (trees and shrubs) with the fodder characteristics to incorporate them into the sustainable production systems. Therefore, this study was undertaken to determine the nutritive values of fresh leaves and leaf litters of four bush fallow fodder plants commonly found in south-eastern Nigeria.

Materials and method

The Study Site

This study was carried out in Umudike, South-Eastern Nigeria, which is in the tropical rainforest zone of Nigeria (Agro-Metrological Station, NRCRI, Umudike). Umudike lies between latitudes 5º25' and 5º32'N and longitudes 7º32' and 7º35'E. It has two distinct seasons; the rainy and dry seasons. The dry season lasts from November to March, while the rainy season kicks off in Mid-March and ends in October, with peaks in July and September. The average annual rainfall range is 2,238 mm, while the mean minimum and maximum temperatures are 23ºC and 30ºC, respectively (Tembe, 2005). The relative humidity is usually high, between70-85% during the rainy season as low as 45% during the peak of the dry season. The soil is well-drained, deeply weathered, sandy loam of up to 30cm depth and rich in organic matter with an overlying uniform clay content all through the profile depth (Federal Department of Agricultural and Land Resources (FDALR), 1990).

Sample Collection and Processing

The plant species studied were: *Maesobotrya barteri*, *Cola millenii*, *Napoleonaea vogelii* and *Uvaria chamae*. The four bush fallow species' fresh leaves and leaf litter were collected, enclosed into brown envelopes, and then oven dried at 70°C for 48 hours at the National Root Crop Research Institute (NRCRI) Umudike, Nigeria. The oven-dried leaf samples were milled then sieved with a 0.5 mm sieve and stored in the harvest brown envelope for chemical analysis.

Laboratory Analysis
The milled samples were used to determine the nutritive values of dry matter (DM), moisture content (MC), Crude protein (CP), Crude fiber (CF), total ash, ether extract (EE), carbohydrate (CHO), and Calorific value (CV) of the fresh leaves and leaf litters of the bush fallow fodder species. Also, the Percentage Nitrogen (%N) was determined to get the Crude Protein (CP) (Gosukonda *et al*., 2020).

Extraction of Samples for Analysis by Wet Acid Digestion Method
0.2g of each of the milled samples was weighed and put into a 100ml conical flask. 5ml of the multiple nutrient extraction reagents (H_2SO_4 selenium catalyst + salicylic acid) was added to a milled sub-sample, covered and allowed to stand for about 16 hours. Each sub-sample was placed on a hot plate set at $30^{\circ}C$, heated for 2 hours, and then brought down. 5ml of concentrated perchloric acid ($HClO_4$) was added and heated vigorously until the sample became clear, indicating complete digestion. 20ml of water was added to the digest, heated gently for just two minutes (2minutes), and then allowed to cool. The digest was transferred into a 50ml volumetric flask and made to mark with distilled water ready for mineral nutrients analysis (Okafor *et al*., 2018).

Determination of Total Nitrogen (N)
Nitrogen (N) was determined from the sample using the semi-micro Kjedhal distillation method (Jackson, 1962). From the multiple nutrient digests, 10ml of the sample was gradually introduced (pipetted) into the Markhan distillation apparatus for the semi-micro Kjeldahl nitrogen distillation. 10ml of 45% sodium hydroxide (NaOH) was added to the digest and allowed to distil out into a 10ml of 4% boric acid indicator through a condenser where about 50ml of the distillate was collected in a conical flask and titrated with 0.02 N of H_2SO_4 to a point. A blank distillation was also carried out and titrated 0.02 N of H_2SO_4 to a pink endpoint. The values obtained were used to calculate the percentage nitrogen (%N).

Determination of Nutritive Values
The ether extract (EE) carbohydrate (CHO) and calorific value (CV) were determined using the procedures of the Association of Official Analytical Chemists (AOAC, 1990). Crude fiber (CF) was determined by the Weende method and crude protein was by the semi-micro Kjeldahl in accordance with AOAC (1990) standard procedures. The formulas for the determination of the various nutritive values are as follows.

a. Ether extract (EE) (%) = $\frac{\text{Weightofoil}}{\text{weightofsample}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$

b. % Carbohydrate (CHO) = $100 - (\%\ \text{CP} + \ \%\ \text{CF} + \%\ \text{Ash} + \ \%\ \text{EE} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$

c. Calorific value (CV) (g cal^{-1}) = $(\%\ \text{EE} \times 9) + (\%\ \text{CP} \times 4) + (\%\ \text{CHO} \times 4) \ldots\ldots\ldots\ldots\ldots (3)$

d. %Crude protein (CP) = $\%\ \text{N} \times 6.25 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$

e. % Ash = $\frac{\text{weight of Ash}}{\text{weight of sample}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$

Where: Weight of Ash = Ash + crucible-weight of the crucible

Experimental Design and Analysis
The nutritive values of four bush fallow fodder plant species in Umudike, South Eastern Nigeria, were determined using a 2x4 factorial experiment in a randomized complete block design (RCBD) with three replications. The study involved two factors which are the leaf types and the four bush fallow fodder plant species studied. The two leaf types are the fresh leaves and leaf litters which were randomly selected from bush fallows. Fisher's Least Significant Differences (F-LSD) at $P \leq 0.05$ was used to determine the significant differences between means.

Results and discussion
Dry Matter (DM)
Table 1 shows that the similar dry matter results of *M. barteri* and *N. vogelii* were significantly greater than the DM values of *C. millenii* which gave the least result. The DM of *N. vogelii* and *U. chamae* were statistically similar. Leaf litter had significantly higher DM than fresh leaf, in terms of SXL treatment interactions, the similar DM results of the leaf litters of *M. barteri*, *U. chamae*, *C. millenii* and *N. vogelii* were statistically greater than the DM of the fresh leaves of the four plant species.

Moisture Content (MC)
Table 1 shows that the fresh leaves of *C. millenii* had significantly highest MC while *N. vogelli* had the least. However, the MC values of *C. millenii* and *U. chamae*; *M. barteri* and *N. vogelii*, and U. chamae and *N. vogelii* were similar. The SXL treatment interactions (Table 1) show that the moisture contents of the leaf litters of the four species were significantly lower than those of the fresh leaves of the same species.

Crude Protein (CP)
Table 1 also shows that *U. Chamae* had significantly higher crude protein (CP) than *N. vogelii*, *M. barteri* and *C. millenii* which had statistically similar CP values. Fresh leaf had significantly higher CP values than leaf litter. However, no significant differences existed between the CP contents of the SXL treatment interactions (Table 2).

Crude Fiber (CF)

In terms of the species, *M. barteri* followed by *C. millenii* had the highest crude fiber content significantly. *N. vogelii* gave the least CF results. Thus, the order in descending magnitude of the various species' CF contents were significantly as follows: *M.barteri* > *C. millenii* > *U. chamae* > *N. vogelii*. Leaf litter had significantly higher CF content than fresh leaves. The SXL treatment interactions (Table 1) show that the leaf litter of *C. millenii* had significantly the highest CF value while the fresh leaf *of N. vogelii* gave the least. Except for the leaf litter of *N. vogelii*, the leaf litters of *M. barteri*, *U. Chamae* and *C. Millenii* had significantly higher CF contents than the fresh leaves of three species.

Ash

Leaf type (L) and the SXL treatment interactions had no significant effect on the ash content. *Uveria chamae* had statistically lower ash content than *N. vogelii* and *C. millenii*. However, the ash contents of *U. chamae* and *M. barteri* were similar (Table 2).

Table 1: Nutritive values (Dry Matter, Moisture Content, Crude Protein, Crude Fibre, Ash) of leaves and leaf litters of four bush fallow fodder plant species in Umudike Nigeria

Species	DM (%)			MC (%)			CP (%)			CF (%)			Ash (%)		
	Fresh	Litter	Mean	Fresh	Litter	Mean	Fresh	Litter	Mean	Fresh	Litter	Mean	Fresh	Litter	Mean
Maesobotrya barteri	94.97	95.99	95.48	5.04	4.01	4.53	19.69	17.84	18.77	8.87	11.44	10.15	5.95	9.35	7.65
Uvaria chamae	92.92	96.09	94.51	7.08	5.17	6.13	24.28	21.44	28.86	6.45	9.71	8.08	6.76	7.14	6.95
Cola millenii	90.23	95.93	93.08	9.77	4.07	6.92	19.03	18.38	18.71	7.37	11.53	9.45	10.51	5.16	7.84
Napoleonaea vogelii	93.60	95.59	94.59	6.40	4.42	5.41	22.38	17.25	19.82	4.92	4.92	6.51	8.19	8.82	8.51
Mean	92.93	95.90		7.07	4.42		21.35	18.73		6.90	9.40		7.85	7.62	

Table 2: Statistical result for interaction between factors in the experiment nutrient content (Dry Matter, Moisture Content, Crude Protein, Crude Fibre, Ash)

	DM	MC	CP	CF	Ash
Bush fallow species (S)	0.19	1.12	1.16	0.31	0.85
Leaf type (L)	0.64	0.79	0.82	0.22	NS
Interaction (SXL)	1.29	1.58	NS	0.44	NS

Ether Extract (EE)

Table 3 shows that, *U. chamae* and *C. millenii* had similar ether extracts (EE) which were significantly higher than those of *M. barteri* and *N. vogelii*. *M. barteri* gave significantly the least EE. Table 3 also shows that fresh leaf had significantly higher EE than leaf litter. The SXL interaction shows that the fresh leaves of *M. barteri*, *U. chamae*, *C. millenlii* and *N. vogelii* had significantly higher EE values than the leaf litters of the same species. The fresh leaf of *U. Chamae* had statistically the highest EE while the leaf litter of *M. barteri* had similar EE value with the leaf litter of *N. vogelii* which was less than the EE values of the fresh leaves and leaf litters of *C. millenii* and *U. chamae*.

Carbohydrate (CHO)

Napoleonaea vogelii and *M. barteri* had statistically similar CHO contents, which were significantly greater than those of *C. millenii* and *U. chamae*. *U. chamae* gave significantly the least CHO content. Thus, the order of CHO contents in decreasing magnitude as shown in Table 3 is significantly as follows: *N. vogelii >M. barteri > C. millenii >U. chamae*. Table 3 also shows that the fresh leaf had significant high CHO content than the leaf litters. In terms of SXL interactions (Table 4), the leaf litter of *N. vogelii*, followed by *C. millenii*, had the significantly highest CHO content. The fresh leaf of *U. chamae* had the least CHO value.

Calorific Value (CV)

Table 3 shows that *U. chamae* gave the highest calorific value (CV) among the browsed plants studied. The CV of *C. millenii* and *N. vogelii* were statistically similar. However, *M. barteri* had significantly the least calorific value. In terms of the leaf types, fresh leaf had significantly higher CV than leaf litter. The SXL treatment interactions (Table 3) show that the leaf and leaf litter of *U. chamae* had the least CV results significantly. However, the fresh leaves of *U. chamae, N. vogelii, C. millenii* and *M. barteri* had significantly higher CV than the leaf litters of the four species.

Table 3: Nutritive Values (Ether Extract, Carbohydrate, Calorific Value) of fresh leaves and leaf litters of four bush fallow fodder plant species in Umudike Nigeria

Species	EE (%)			CHO (g)			CV (J/kg)		
	Fresh	Litter	Mean	Fresh	Litter	Mean	Fresh	Litter	Mean
Maesobotrya barteri	6.19	3.23	4.71	59.30	58.04	58.67	371.70	332.99	352.35
Uvaria chamae	10.07	4.69	7.38	52.44	57.02	54.73	397.51	356.05	376.78
Cola millenti	9.15	5.02	7.09	53.44	59.92	56.68	372.23	358.34	365.29
Napoleonaea vogelii	6.83	3.68	5.26	58.19	62.14	60.17	381.71	350.74	366.23
Mean	8.06	4.16		55.84	59.28		380.79	349.53	

Table 4: Statistical result for interaction between factors in the experiment Nutrient content (Ether Extract, Carbohydrate, Calorific Value)

	EE	CHO	CV
Bush fallow species (S)	0.44	1.51	2.74
Leaf type (L)	0.67	0.06	4.15
Interaction (SXL)	1.34	0.99	08.31

The dry matter (DM) values (93.08-95.48%) of the four bush fallow fodder species were within the range reported by Waziri (2013) except for crude protein value, which ranged from 4.19 -7.12%. The species' relative moisture contents (MC) show the need for inclusion/incorporation of the species into fodder banks as moisture supplies necessary minerals and helps plants in growth and development (Attah-Krah, 1989). The crude protein (CP) values (18.71-22.86%) agree with Omokanye *et al.* (2001). Since research has shown that fodder trees and shrubs can be considered a supplement to protein-deficient pastures (Cheema *et al*., 2011), the findings of this study show that the species studied are enormous potential sources of protein for ruminants in the tropics.

The crude fiber (CF) contents (6.51-10.15%) were lower than the results (20-30%) obtained by Miraglia *et al.* (2008). The values obtained for ash (6.95-8.51%) were greater than the ash results of 1.66% and 1.48% reported by Onyekwelu *et al.* (2015) for seeds and fruits of *Chrysophyllum albidum*, respectively.

The ether extract values (4.71-7.38%) were lesser than an average of 14.1% and 34.7% reported by Silva *et al.* (2011) for forage and concentrates, respectively. The carbohydrate (CHO) value (54.73-60.17%) and the calorific value (CV) of (352.35-376.78g J/kg) are within the range of 51.9% and 351.30 J/kg, respectively reported by Antia *et al*. (2006).

The variability observed among the nutritive values of the four fodder plant species studied could be due to the genetic characteristics of the species, site factors, species age, etc. However, the results obtained indicate the high potential of leaf litters in the tropics, especially during the dry season and periods of environmental stress.

Conclusion and recommendations

This study has provided information on the nutritive values of four bush fallow fodder plant species commonly found in Umudike, Nigeria. The results of this study have shown that the four bush fallow species studied have comparatively good nutritive values, especially *Uvaria chamae* (which gave the highest results significantly). This makes them highly recommended for incorporation into fodder banks and home gardens and encourages bush fallows and alley farms to overcome livestock nutrition problems. The results further show that these species' fresh leaves and leaf litter could be used to overcome seasonal feed shortages. Therefore, the information provided in this study will help enhance the overall development, management, and production of fodder banks and livestock production in the humid tropics.

The study recommends that the fodder species studies should be established in fodder banks, home gardens, and alley farms, while bush fallows should also be encouraged to reduce farmers-herders clash. Also, leaf litter of the studied species should be used as supplementary feed for livestock during the dry seasons. Furthermore, the agronomic evaluation, including seed production and seed storage techniques of the four studied fodder species and other potential fodder species, should be embarked upon to encourage their growth and development in fodder banks. Therefore, further research should be conducted on the food and industrial utilization potentials of these four studied fodder species and other browse plants as there is a need to incorporate these studied fodder species in livestock feed composition to boost the nutritive value of the feed given to animals since this will enable them to grow healthy, attain maturity on time, and increase livestock production in the country.

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