Nutritional potential of *Piliostigma reticulatum* (dc.) Hochst. pods in the semi-arid zone of Nigeria

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Abstract

The study was conducted to evaluate the nutritive values of *Piliostigma reticulatum* pods from field grown stands within the semi-arid zone of Nigeria. 250 fruiting trees from five locations within coordinates of longitude 11°42' to 12° 27' and latitude 07°29' to 11°04' with 50 stands per location were monitored up to pod maturity to 80% dried pods. The harvested pods were sampled and bulked in 50kg jute bag per location and analyzed for nutritive values, antinutritional factors (ANFs), macro-and micro-minerals. Multi-stage sampling technique was employed to select the fruiting trees and which were monitored in completely randomized design (CRD). The results revealed that locations had significant differences ($P<0.05$) in all parameters evaluated except for Phytate (PHY) and Saponins (SAP). DM (94.83%), OM (89.23%), EE (3.66%), K (14.05g/kg) and Cu (35.53mg/kg) obtained from Itas-Gadau were statistically superior ($P<0.05$) to others; sample obtained from Dutse-Ma proved superior ($P<0.05$) in ASH (6.16%), CP (19.46%), P (1.06g/kg), Zn (33.26mg/kg), Hydrogen cyanide (HCN) (0.36mg/g) and Tannins (TAN) (1.21mg/g); Results obtained from Potiskum revealed superiority ($P<0.05$) in CF (16.90%), NDF (53.17%) and HEMCELL (13.62%) than others; Jahun sample lead ($P<0.05$) in NFE (68.94%), ADF (40.51%) and Mn (208.77mg/kg) and sample from Dambatta had higher values ($P<0.05$) in Ca (2.08g/kg) and Fe (29.80mg/kg). The study concluded that the values obtained on nutritive, antinutritive and minerals compositions of *Piliostigma reticulatum* pods were within the recommended requirement for ruminant nutrition and therefore recommended its use as feedstuff.

Keywords: Nutrition, Pods, *Piliostigma reticulatum*, Semi-Arid Zone

Introduction

Rangeland resources are very significant to the economy of many countries and still afford about 70% of feed requirements of domestic ruminants and 95% of wild ruminants (Holechek *et al.*, 1995). The daily nutrient requirement of livestock fluctuates according to the physiological functions of grazing livestock and therefore growth, gestation, lactation and fattening play key roles in determining daily nutrient demands (Muhammad *et al.*, 2013).

The tender shoots, twigs and leaves of shrubs and woody plants including fruits and pods are referred to as browse (Gutteridge and Shelton, 1994; Devendra,

1995). Browse form an important component of the diet, especially for a variety of herbivores (Aganga and Mesho, 2008). Browse plants beside grasses compose one of the cheapest sources of feed for animals in many parts of the World (Muhammad *et al.*, 2013). Mostly the browses have advantage of maintaining their nutritive value and greenness during the dry season when grasses dry up and decline in both quantity and quality (Kibon and Orskov, 1993). This nutritious profusion and perennial performance of browse species afford round the year provision of forage for grazing livestock (Aganga and Mosase, 2001). In contrast, the chemical composition

Nutritional potential of Piliostigma reticulatum (dc.) Hochst. pods in the semi-arid zone of Nigeria

of browse plants in rangelands varies according to species, soil type (location), climate, phenology, anti-nutritive factors and abiotic factors (Greene *et al.*, 1987). In sequence with the above this study was designed to evaluate the nutritional potential of *Piliostigma reticulatum* pods from semi-arid zone of Nigeria.

Materials and methods

Description of the study area

The study was conducted in the semiarid zone of Nigeria; the zone consists of Sahel and Sudan savanna vegetation (Adamu and Odion, 2002). The study location covers areas between longitude 11°42' to 12° 27' and latitude varying from 07°29' to 11°04'.

Rain fall amount between 653mm and 768mm/annum covering northern parts; Yobe, Bauchi, Jigawa, Kano and Katsina states (Table .1). The zone has growing season of 90–180 days with long and severe dry season (Ibrahim, 1998; Adamu and Odion, 2002). The vegetation is mainly grassland with scattered trees. Both arable farming and pastoralism thrive here. The major crops are millet, sorghum, groundnuts, peppers, tomatoes, cowpea, cotton, onions, and rice. Cattle, sheep, goats, camel, donkey and poultry are very important in the zone. In some areas within this zone, human and livestock population densities are high (Adamu and Odion, 2002).

Table 1: Attributes of study locations in the semi-arid zone of Nigeria

S/N	State	Location	Longitudes	Latitudes	Average annual rainfall (mm)	Average annual temperature (°C)	Altitudes above sea level (m)
1	Yobe	Potiskum	11°42'33"N	11°04'10"E	713	24.9	426
2	Bauchi	Itas-Gadai	11°52'0"N	09°58'0"E	768	26.4	420
3	Jigawa	Jahun	12°04'0"N	09°38'0"E	653	27.0	377
4	Kano	Dambatta	12°25'59"N	08°30'55"E	752	26.1	484
5	Katsina	Dutse-Ma	12°27'18"N	07°29'29"E	743	26.5	434

Source: Koppen World Map Hi-Res.png, (2011)

Sampling technique

Multi-stage sampling technique was employed to select two hundred and fifty (250) *Piliostigma reticulatum* fruiting trees within the study area. The first stage involved the purposive selection of five study locations within the semi-arid zone of Nigeria based on the availability of Kargo plants. The second stage was the selection of five villages in each study location. This was followed by identifying 10 *Piliostigma reticulatum* trees with pods per village. Thereafter from each tree 5 matured pods were harvested manually. The matured *Piliostigma reticulatum* pods harvested were packed in 50kg jute bags

per location and transported to Department of Animal Science experimental farm, Federal University Dutse where they were further dried under shade and later crushed with machine to small particles (3mm).

Chemical analysis

The collected samples of *Piliostigma reticulatum* pods from five different locations were oven dried at 65°C for 48 hours and thereafter sub-samples were grounded in hammer miller to pass a 1mm mesh sieve for determination of dry matter (DM), crude protein (CP), crude fibre (CF), nitrogen free extract (NFE), ether extract (EE) and ash (ASH) according to procedures described by AOAC (1999). Fibre fractions:

neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin according to procedures described by Van Soest *et al.* (1991). Macro minerals: calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P), were determined by using Atomic Absorption Spectrometer, while dietary micro minerals copper (Cu), zinc (Zn), iron (Fe), cobalt (Co) and manganese (Mn) were determined by procedures described by AOAC (1999). Anti-nutritional factors: Hydrogen cyanide (HCN) Tannins (TAN), Saponins (SAP), Oxalates (OXA) and Phytate (PHY) by spectrophotometric method.

Statistical analysis

The data from nutritional analyses were subjected to analysis of variance (ANOVA) using General Linear Model of SAS (2013). Differences in means was detected by Fisher's least significant difference (FLSD) at 5% level of probability.

Results

Table 2 shows the chemical composition of *Piliostigma reticulatum* pods (PRP) from five different locations in the semi-arid

zone of Nigeria. The locations revealed significant differences ($P < 0.05$) in all parameters evaluated. In terms to DM and organic matter (OM) contents, the values obtained from Itas-Gadau (94.83% DM; 89.23% OM) were statistically superior ($P < 0.05$) to others, followed by Jahun and the inferior was that of Potiskum (91.39%DM; 86.35%OM). Values for ASH (6.16%) and CP (19.46%) was highest ($P < 0.05$) from samples obtained in Dutse-Ma followed by Itas-Gadau and the lowest values was from Potiskum (5.03%ASH; 17.36%CP). Highest values ($P < 0.05$) of CF and NDF were obtained from Potiskum (16.90%CF; 53.17%NDF) while the lowest values were from Dutse-Ma (15.38%CF; 46.21%NDF). In terms of EE, the highest value ($P < 0.05$) was obtained from Itas-Gadau (3.66%) followed by Jahun and the lowest was from Potiskum (2.65%). Jahun sample (68.94%) lead in respect to NFE and the lowest was that of Itas-Gadau (65.65%). Jahun had ADF values of (40.51%) and the least was Dutse-Ma with (32.1%). Sample from Potiskum lead ($P < 0.05$) in terms of HEMCELL (13.62%), while that of Dutse-Ma was the least (9.00%).

Table 2: Chemical composition of *Piliostigma reticulatum* pods (PRP) from five different locations in Semi-Arid Nigeria

Parameters (%)	Sources of <i>Piliostigma reticulatum</i> Pods					SE $\pm$
	Dambatta	Dutsinma	Jahun	Itas-Gadau	Potiskum	
DM	93.16 ^c	92.81 ^d	93.47 ^b	94.83 ^a	91.39 ^e	0.30
Ash	5.20 ^c	6.16 ^a	4.97 ^d	5.61 ^b	5.03 ^{cd}	0.12
OM	87.95 ^c	86.64 ^d	88.50 ^b	89.23 ^a	86.35 ^e	0.29
CP	17.81 ^{bc}	19.46 ^a	16.67 ^d	18.48 ^b	17.36 ^{cd}	0.27
CF	15.97 ^c	15.38 ^d	15.94 ^c	16.61 ^b	16.90 ^a	0.14
EE	3.31 ^b	2.93 ^c	3.48 ^{ab}	3.66 ^a	2.65 ^c	0.10
NFE	57.71 ^b	56.07 ^c	58.94 ^a	55.65 ^c	58.07 ^{ab}	0.35
NDF	46.63 ^d	46.21 ^e	50.01 ^b	49.35 ^c	53.17 ^a	0.68
ADF	36.87 ^d	37.21 ^c	40.51 ^a	39.61 ^b	39.55 ^b	0.38
HE	9.77 ^b	9.00 ^c	9.50 ^b	9.74 ^b	13.62 ^a	0.45

Means in the same row bearing different superscripts are significantly different ($P < 0.05$) DM-Dry matter, OM-Organic matter, CP-Crude protein, CF-Crude fibre, EE-Ether extract NFE-Nitrogen free extract, NDF-Neutral detergent fibre, ADF-Acid detergent fibre and HE-Hemicellulose.

Nutritional potential of Piliostigma reticulatum (dc.) Hochst. pods in the semi-arid zone of Nigeria

Table 3 Shows the anti-nutritive factors of *Piliostigma reticulatum* pods (PRP) from five different locations in the Semi-Arid Zone of Nigeria. The results obtained revealed significant differences ($P<0.05$) in HCN, OXA and TAN evaluated. The maximum value ($P<0.05$) of HCN was 0.36mg/g in sample from Dutse-Ma followed by Potiskum while the minimum was from Dambatta and Itas-Gadau both had (0.22mg/g). With regard to OXA, the highest value ($P<0.05$) was 3.10mg/g in

Jahun while the lowest was from Itas-Gadau (1.71mg/g). Nevertheless, values obtained from Dambatta and Potiskum were statistically the same likewise that of Dutse-Ma and Jahun follow the same trend. PHY ranged from 0.59mg/g in Jahun to 0.43mg/g in Dambatta. SPN value differed ($P<0.05$) from 0.67mg/g in Dambatta while that of Itas-Gadau (0.60mg/g) was the lowest. The maximum TAN value was attained in Itas-Gadau (1.21mg/g) and the minimum was (0.99mg/g) from Dutse-Ma. The variation were significantly different ($P<0.05$).

Table 3: Anti-Nutritive Factors of *Piliostigma reticulatum* pods in Semi-Arid Nigeria

Antinutritive factors (mg/g)	Sources of <i>Piliostigma reticulatum</i> Pods					SE $\pm$
	Dambatta	Dutsinma	Jahun	Itas-Gadau	Potiskum	
Hydrogen Cyanide	0.22 ^c	0.36 ^a	0.21 ^d	0.22 ^c	0.28 ^b	0.01
Oxalate	2.55 ^{ab}	2.86 ^a	3.10 ^a	1.71 ^b	2.51 ^{ab}	0.18
Phytate	0.43	0.50	0.59	0.53	0.50	0.05
Saponins	0.67	0.63	0.53	0.60	0.63	0.04
Tannins	1.12 ^{ab}	1.04 ^{ab}	0.99 ^b	1.21 ^a	1.04 ^{ab}	0.03

Means in the same row bearing different superscripts are significantly different ($P<0.05$).

Table 4 Shows the mineral composition of *Piliostigma reticulatum* pods (PRP) from five different locations in the semi-arid zone of Nigeria. The results revealed that there were significant differences ($P<0.05$) across all samples evaluated. Sample from Dambatta had the higher ($P<0.05$) Ca content (2.08g/kg), followed by Jahun and the lower was Itas-Gadau (1.08g/kg). Sample from Itas-Gadau was highest ($P<0.05$) in terms of K content (14.05g/kg) while Dutse-Ma was the least (2.86g/kg). With regards to Mg composition sample from Dambatta and Dutse-Ma were statistically the same (0.33g/kg) likewise those of the remaining three locations (0.17g/kg). Sample from Dutse-Ma (1.06g/kg) was superior ($P<0.05$) than all

others in terms of P content and that of Potiskum (0.74g/kg) was inferior.

In terms of Cu, values range from 35.53mg/kg in Itas-Gadau to 25.58mg/kg in Potiskum while Zn content varies from 33.26mg/kg in Dutse-Ma to 24.43mg/kg in Dambatta. However, the higher value ($P<0.05$) of Fe composition was found in Dambatta sample (29.80mg/kg), followed by Itas-Gadau while the least was Potiskum (18.19mg/kg). Samples from Dutse-Ma (0.36mg/kg) and Potiskum (0.37mg/kg) were statistically similar likewise the remaining three locations 0.19mg/kg. The highest value of Mn was found in Jahun (208.77mg/kg), followed by Dutse-Ma (125.59mg/kg) while that of Itas-Gadau was 84.30mg/kg.

Table 4: Macro and micro minerals composition of *Piliostigma reticulatum* pods (PRP) from five different locations in Semi-Arid Nigeria

Mineral content	Sources of <i>Piliostigma reticulatum</i> Pods					SE $\pm$
	Dambatta	Dutsinma	Jahun	Itas-Gadau	Potiskum	
Macro – minerals (g/kg)						
Ca	2.08 ^a	1.79 ^c	1.84 ^b	1.08 ^c	1.17 ^d	0.11
K	10.41 ^b	2.86 ^c	8.38 ^c	14.05 ^a	7.47 ^d	0.98
Mg	0.33 ^a	0.33 ^a	0.17 ^b	0.17 ^b	0.17 ^b	0.02
P	0.91 ^b	1.06 ^a	0.76 ^d	0.82 ^c	0.74 ^c	0.03
Micro - minerals (mg/kg)						
Cu	23.46 ^d	26.55 ^c	28.63 ^b	35.53 ^a	25.58 ^c	1.11
Zn	24.43 ^e	33.26 ^a	29.56 ^b	27.48 ^c	25.85 ^d	0.84
Fe	29.80 ^a	18.57 ^c	13.72 ^d	19.26 ^b	18.19 ^c	1.42
Co	0.19 ^b	0.36 ^a	0.19 ^b	0.19 ^b	0.37 ^a	0.02
Mn	116.89 ^c	125.59 ^b	208.77 ^a	84.30 ^e	91.14 ^d	11.89

Means in the same row bearing different superscripts are significantly different (P<0.05).

Ca-Calcium, K-Potassium, Mg-magnesium, P-Phosphorus, Cu-Copper, Zn-Zinc, Fe-Iron, Co-Cobalt, Mn-manganese

Discussion

The factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem and pod), age of leaf and season. With regard to the location, some authors have reported that browse plants in the semi-arid zone are higher in N compared to plants in the humid zone (Rittner and Reed, 1992, Okoli *et al.* 2003). Younger leaves are richer in N than mature leaves, which however contain more N than the litter. The fruits are shown to have N content with values in between young and old leaves, and vary little with stage of maturity (Breman and Kessler, 1995).

The DM content of *Piliostigma reticulatum* Pods obtained from samples of five locations vary from 94.83% to 91.39%, this is in conformity with 88.40% to 95.00% reported by Ndlovu *et al.* (1995); Mandibaya and Chihora (1999); Foguekem *et al.* (2011) on the same plant pods, but slightly lower than 96.13% to 98.19%DM reported by Uguru (2014) in *Acacia nilotica* pods. The OM content of *Piliostigma reticulatum* Pods 89.23% to 86.35%OM was slightly less as compared with 90.18% reported by Foguekem, *et al.*

(2011) on the same plant pods. ASH obtained range from 6.16% to 5.03% and is in line with early reports of 3.80% to 6.10% ASH by Ndlovu *et al.*, 1995; Mandibaya and Chihora, 1999; Foguekem, *et al.* (2011) on the same plant pods. It is also in accordance with 4.12% to 5.14%ASH as reported by Uguru, 2014 on *Acacia nilotica* pods.

Crude Protein obtained in this study 19.46% to 17.36% is above the 7% CP requirement for ruminants (Leng, 1990; Meissner, 1997) which will provide nitrogen required by rumen micro-organism to support optimum microbial activity. The value was high as compared with early studies (5.90 to 10.80%CP) by Ndlovu *et al.*, 1995; Foguekem, *et al.* (2011) on the same plant pods. The above CP values were within the range of 10-30% reported by Norton (1998) for most tropical legumes; Sikosana *et al.* (2002) for most browse plants. This perhaps suggested that *Piliostigma reticulatum* Pods will conveniently satisfy the protein requirement of ruminant animals. Norton (2003) justifies the use of browse forages in small quantities in order to supplement poor quality pastures and crop residues. CF in this study ranges from 15.38% to 16.90%, this agreed with the early findings by Le

Nutritional potential of Piliostigma reticulatum (dc.) Hochst. pods in the semi-arid zone of Nigeria

Houérou, (1980) who reported 16.3%CF in *Piliostigma reticulatum* pods.

The HCN values (0.21mg/g to 0.36mg/g) obtained in the current study is slightly higher than 0.04mg/g to 0.08mg/g reported by Njidda (2010) for semi-arid browse forage of North-Eastern Nigeria but lower than 1.52mg/g to 6.4mg/g reported by Okoli *et al.* (2003) for browse of southeastern Nigeria. The HCN content of *Piliostigma reticulatum* pods was equally low. Generally, only plants that produce more than 20mg HCN/100g fresh weight are considered deleterious (Okoli *et al.*, 2003; Njidda, 2010).

The OXA values (1.71mg/g to 3.10mg/g) examined in this study was in agreement with 2.64mg/g to 3.96mg/g reported by Uguru (2014) for *Acacia nilotica* pods. On a contrary Njidda (2010) reported 4.58mg/g to 8.15mg/g for browse forage of semi-arid zone. The difference could be perhaps, due to difference in soils of the location.

Oxalate content in this present study was low. Oxalate has been shown to deplete the calcium reserve, but this browse species are found to contain reasonable amount of calcium, magnesium and phosphorus. Ca and carbon are also released from the hydrolysis of Ca Oxalate some of which will be either absorbed or excreted by the ruminant animals (Njidda, 2010).

The tannin range (0.99mg/g to 1.21mg/g) is in line with 0.80mg/g to 1.30mg/g as reported by Uguru (2014) for *Acacia nilotica* pods. The level of tannin in this study was within the normal range (2%) for safe animal feeding (Oloyo, 2004). However, in ruminants, dietary tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex (Njidda, 2010). The level is lower than the range of 60 to 100g Kg DM that is considered to depress

feed intake and growth.

A threshold concentration of tannin of 5% has been reported beyond which there may be rejection of browses by goats and wild browsers (Okoli *et al.* (2003).

Macro-minerals assay were within the recommended levels reported all over the world for ruminant production. The Ca concentration 1.08 to 2.08g/kg in the present study was slightly higher than 0.50g/kg to 1.50g/kg reported early by Ndlovu *et al.* (1995); Mandibaya and Chihora (1999) for *Piliostigma reticulatum* Pods. Regardless of difference in Ca concentration (1.08 to 2.08g/kg), all location samples had adequate levels of Ca to meet adult goat requirement of 1.3 to 3.3g/kg in the diet (NRC 1981; Kessler 1991; Norton 1994) except Itas-Gadau (1.08g/kg) and Potiskum (1.17g/kg) which both had Ca concentration below the requirement. Ca is not usually deficient, for optimal livestock performance, in foliage from browse plants that grow in tropical regions (Ramirez *et al.* 2001; Lundu *et al.* 2012). Ca and P are both important in the development and maintenance of the animal's body; the recommended calcium to phosphorus ratio in the diet is a minimum of 2:1 and a deficiency of either or both in growing animals leads to poorly developed bones (Lundu *et al.* 2012). However, in the present study, this ratio was achieved in Dambatta and Jahun. Range forages often contain high levels of Ca in relation to P (Norton 1994). However, goats are known to be tolerant to high Ca: Pratiós (Cohen 1975). The values of K in pods (2.86 to 14.05g/kg) are similar to those recorded by Ramirez *et al.* (2001) who found higher K concentrations in shrubs grazed by goats. The values also agreed with 1.58 to 37.1g/kg reported by Lundu *et al.* (2012) for browse of southern Zambia. In a similar study in semi-arid zone of Botswana, Keitirele (2012) reported K values of 4.9g/kg to 8.9g/kg in

Pods of *Leucaena diversifolia* and 6.0g/kg to 6.3g/kg in *Leucaena leucocephala*. With all variation in location, the K values obtained in this study met the daily adult goat requirements 1.8–2.5 g/kg in their diets (NRC 1981). Variation of K in plants within different location may partially be attributed to difference in K content of the soil and different stages of plant maturity at the time of sampling. With maturity, mineral concentration declines due to a natural dilution process and the translocation of minerals to the root system (Jones 1998). Sample from Dutse-Ma with 2.86g/kg and that of Itas-Gadau with 14.05g/kg had K concentrations as much as 5 times the required levels. This may become a problem because of the relationship that exists among K, Mg and Ca. High K concentrations first result in a Mg deficiency; and an imbalance, that may cause a Ca deficiency (Jones 1998).

The Mg concentration of *Piliostigma reticulatum* Pods evaluated (0.17g/kg to 0.33g/kg) was very low compared with 16.50g/kg to 18.00g/kg reported by Ndlovu *et al.* (1995). Also it was lower than daily adult goat requirements of 0.8g/kg to 2.5g/kg (NRC 1981). This may be related with the high K concentrations which usually resultant to Mg deficiency as observed by Jones (1998). The author also reported that some plant species have a particular sensitivity to Mg such that they will become Mg deficient under temperature stress even though Mg may be at sufficient availability levels in the soil. The P value (0.74g/kg to 1.06g/kg) obtained in the present study was low compared with 12.50g/kg to 16.20g/kg reported by Ndlovu *et al.* (1995); Mandibaya and Chihora (1999). Also lower than 1.6-3.8 g/kg (NRC 1981; Kessler 1991) for adult goat requirements.

Micro-minerals evaluated were mostly in

harmony with values reported elsewhere. It is believed that Cu functions as an essential component of a number of enzymes in plants, the values obtained for Cu (23.46mg/kg to 35.53mg/kg) in the present study was higher than 4.80mg/kg-7.45mg/kg reported by Ogunbosoye *et al.* (2015) on browse from southern guinea savannah. However, all samples from the five locations had met the 18.00mg/kg Cu daily requirement of range goats (Kessler, 1991). Zn in the current study varies from 24.43mg/kg to 33.26mg/kg this agreed with the values 27.50 to 34.80mg/kg obtained by Ogunbosoye *et al.* (2015). Tiffany *et al.* (2001) reported 30mg/kg as Zn critic dietary level. Fe obtained (13.72mg/kg to 29.80mg/kg) was lower than 50mg/kg level tabulated as the daily requirement for ruminant animals, even though, availability of Fe could vary due to the fact that its absorption would depend o dietary factors, age and Fe level in the animal body Ogunbosoye *et al.* (2015). High forage concentration of Mn in the dry season was detected and attributed to low rates of Mn translocation and accumulation of Mn in older tissue (Khan *et al.*, 2009). All locations had higher levels (84.30mg/kg to 208.77mg/kg) of Mn than the normal dietary requirements of 20-40mg/kg-1DM (NRC, 2001).

Conclusion and recommendation

The study concluded that the values obtained on nutritive, antinutritive and minerals compositions of *Piliostigma reticulatum* pods were within the recommended requirement for ruminant nutrition and therefore recommended its use as feedstuff and in ration formulation to serve as supplement to avert dry season feed scarcity.

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