Original Research

Nutrient Composition and in Vitro Digestibility of 3 Neglected and Underutilized Browse Species in the Dry Savanna Zone of Ghana

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Abstract

The nutrient composition and in vitro gas production of 3 neglected and underutilized browse specie (NUS) in the dry savanna zone of Ghana were evaluated. The NUS were Detarium microcarpum, Piliostigma thonningii and Icacina oliviformis. Leaves and seeds of NUS were harvested from 15 randomly selected matured trees within native fields in Nyankpala in the Guinea savanna zone. The in vitro gas production was evaluated in a 3 x 2 x 2 factorial design. The factors were the 3 NUS, 2 fractions (seed and leaf) and 2 levels of Polyethylene glycol (PEG). With the exception of I. Oliviformis, the seed fraction of all NUS was found to be higher in CP than the leaf. The NDF was in the range of 463.3 and 663 g/kg with the seed fraction of D. microcarpum having the highest. The ADF concentration of the seed was relatively lower than that of the leaf fraction with the least reported in the seed of I. Oliviformis. There was a significant effect of NUS x Fraction x PEG interaction on the asymptote gas production. The in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME, MJ/Kg DM) were significantly affected by the Fraction x NUS interaction. The study revealed that the 3 NUS had nutritional potentials for use in ruminant feeds. The seed fraction of most of the NUS had higher CP and lower ADF than the leaf fraction. The ME reported for all the treatments was above the 4.7 MJ/Kg/d of growing lambs gaining 0-50 g/d.

Key words: Crude Protein, *In vitro* Digestibility, Leaves, Seeds, Neglected, Under Utilized Species

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Introduction

Forage, remain the single most important feed resource for livestock particularly ruminants worldwide and in most communities Northern Ghana natural pasture forms a major feed source for ruminant livestock (Ansah *et al*., 2014; Dynes *et al*., 2003). Browse, the leaves and twigs of shrubs, woody vines, trees, cacti and other non-herbaceous vegetation play a very important role in the nutrition of ruminants during the dry season in most tropical countries (Ansah *et al*., 2016; Allen *et al*., 2010; Okoli *et al*., 2003). They serve as a source of protein and carbohydrate with relatively less concentration of recalcitrant fiber and are often fed as protein supplement to ruminants grazing natural pasture (Ansah *et al*., 2016).

Protein is a very important nutrient which is normally limited in most natural pastures in the dry season. The lack of degradable dietary protein could reduce overall dry matter digestibility by reducing the concentration of rumen ammonia nitrogen (McDonald *et al*., 2011). Most browse plants have been reported to contain various concentrations of plant secondary metabolites which may interfere with microbial degradation of dietary protein (Getachew *et al*., 2000; Hariadi and Santoso, 2010). In recent times, interest in the use of some minor crops or trees (browse plants) in sustainable livelihoods have increased. Most of these trees and crops have been classified as Neglected and underutilized species (NUS) because they are of less importance than staple crops and agricultural commodities in terms of global production and market value (IPGRI. 2002; Padulosi *et al*., 2013). Many neglected and underutilized species are nutritionally rich and are adapted to low input agriculture. The existence of various neglected and underutilized species (NUS) in most protected parks in Africa could serve as a major source of feed supplement for ruminant.

The study was therefore conducted with aim of determining the nutrient composition and *in vitro* digestibility of three NUS (*Detarium microcarpum, Icacina oliviformis, Piliostigma thonningii*) found in the savanna zone of Ghana.

Materials and Methods

Study Area

The study was conducted in Nyankpala in the Guinea savanna zone of Ghana. It is located on latitude 9° 25′ 41″ N and longitude 0° 58′ 42″ W at an altitude of 183 m above sea level. It has one rainy season which begin in April, rising to a peak in August to September and ending in October or November. Rainfall averages 1060 mm per annum. Temperatures range from as low as 15°C in January when the weather is under the influence of the North Easterly (Harmattan) winds and as high as 42°C around the end of the dry season in March.

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Harvesting, Processing Analysis of Nutrient and *In vitro Digestibility of* Plant Samples

Leaves and seeds of three browse plants were harvested from native fields within the environs of the Faculty of Agriculture of the University for Development Studies (UDS) in Nyankpala. Leaves and seeds were harvested from 15 randomly selected matured neglected and underutilized browse species (NUS). The samples were pooled and about 500 g sub-sampled. This was dried in a forced air oven (60^0C) for 48 h and milled with a hammer mill through a 1 mm sieve screen. The chemical analysis and *in vitro* gas production was carried out in the Forage Evaluation Unit of the Agriculture Sub-Sector Improvement Project Laboratory.

The milled samples were analyzed for their CP, NDF, ADF and ash concentration. Approximately 2 g of the leaf and seed samples of each NUS was placed in porcelain crucibles and combusted in a furnace at a temperature of 600^oC for 4 h to determine the ash concentration (AOAC 2000). The nitrogen (N) content was determined using the Kjeldahl method according to the method of AOAC (2000) and was multiplied by the factor 6.25 to obtain the CP. The method of Van Soest *et al.* (1991) was used in the determination of neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentration. The NDF was determined exclusive of residual ash with sodium sulfite and α- amylase whilst ADF was determined exclusive of residual ash using the Ankom^{200} fiber analyzer. The *in vitro* gas production technique of Theodorou *et al.* (1994) was adopted. Approximately 200 mg of oven dried samples from each treatment (leaf and seed) was weighed into 50 ml test tubes and incubated in McDougall's under anaerobic condition. The treatments were further divided in to two sub-groups with 4 g of PEG (MW 6000) added to one group whiles the other had no PEG. This experiment was conducted as 3x2x2 factorial in completely randomized design. The factors were the 3 NUS (*Detarium microcarpum, Icacina oliviformis, Piliostigma thonningii*), 2 fractions (leaf and seed) and 2 levels of PEG (+ or -).

The gas production was measured using a digital manometer at 3, 6, 12, 24 and 48 h. The gas measurements were then fitted to the exponential curve of Orskov and McDonald (1979) without an intercept using SigmaPlot 10th edition (Systat Software Inc. 2006). The degradation parameters (b and c) were derived from exponential model.

$$Y = b\ (1 - e^{-ct})$$

Where,
Y = gas volume at time t (ml)
b = asymptotic gas production (%)
t = time (h)
c = fractional rate of gas production (ml/h)

The digestible organic matter (DOM) was calculated using the equation

$$DOM\ (\%) = 16.49 + 0.9042\ GP + 0.0492\ CP + 0.0387$$

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ash by Menke and Steingass (1988) whilst the metabolizable energy was calculated using the equation

ME (MJ / kg DM) = 2.20 + 0.136 *GP + 0.057 *CP (according to Menke *et al.*, 1979).

Where,
GP= gas production (ml/200mg DM at 24 hour)
CP= crude protein (g/kg DM)

Statistical Analysis

The three-way analysis of variance (ANOVA) in completely randomized design (CRD) from Genstat 11th edition was used in analyzing the *in vitro* gas production parameters. Means were separated using Tukeys at 5%. The mean and standard deviation of the nutrient composition were computed.

Result and Discussion

The analyzed nutrient composition of the leaves and seeds of the NUS are shown in Table 1.

Table 1: Mean (g/kg±SD) nutrient composition of leaf and seed fractions f neglected and underutilized species

NUS	Fraction	CP	NDF	ADF	Ash
Detarium microcarpum	Leaf	89.3±0.9	629.8±4.8	567.2±7.2	0.7±0.0
	Seed	108.6±2.6	663.7±9.0	157.7±3.8	0.6±0.1
Piliostigma thonningii	Leaf	98.5±2.2	463.3±5.0	546.1±5.7	1.3±0.1
	Seed	222.4±0.9	558.5±0.8	233.9±5.6	0.7±0.1
Icacina oliviformis	Leaf	148.3±0.4	590.0±10.0	416.9±5.2	0.3±0.0
	Seed	85.8±7.8	555.6±2.6	39.1±7.5	1.2±0.0

NUS: Neglected and underutilized species; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber

The CP concentration was higher in the seeds than the leaves of *D. microcarpum* and *P. thonningii* whereas the reverse was observed in *I. oliviofrmis*. The higher CP in seeds than leaves in two of the browse plants agrees with the reports of Martin *et al.* (2016) who found high CP in the seeds of *Moringa oleifera* than leaves. The high CP in seeds relative to leaf has been attributed to the accumulation of different enzymes and structural protein (Yang *et al.*, 2013). The relatively lower CP concentration in the seeds of *I. oliviofrmis* conforms with the findings of Kay (1987) who reported a CP of 8% but differ from Fay, (1991) who reported a CP of 14%. The relatively lower CP in seeds than leaves in *I. oliviofrmis* in the present study requires further investigation.

The CP concentration reported in all the plants and their fractions was within the minimum CP requirement (60-80 g/kg) for sustenance of microbial growth (Van Soest, 1982). This suggests that both fractions could be fed to ruminants as a source of protein. The NDF concentration was similar among the fractions of the NUS. However, the ADF showed some wide variation between the leaf and seeds. The

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lowest ADF concentration (39.1 g/kg) was reported in the seeds fraction of *I. oliviformis*. Generally, the seeds had lower ADF concentration as compared to the leaf fraction. The high ADF fraction could be due to the increased cell wall formation in the vegetative parts such as leaves and stems of plants and is often lower in the seeds. The lower ADF in the seeds could enhance its voluntary feed intake in ruminants since it has been found to be negatively correlated with intake (Riaz *et al.*, 2014; Ansah *et al.*, 2016). The ash concertation ranged from 0.3 g/kg to 1.3 g/kg with the lowest reported in the leaf fraction of *I. oliviformis*. The *in vitro* gas production parameters are shown in Table 2.

Table 2: Mean *In vitro* gas production parameters of leaf and seeds of neglected and underutilized species incubated with or without polyethylene glycol (PEG)

Species	Fraction	PEG	b	c	IVOMD (%)	ME
Icacina oliviformis	Seed	+	49.1^{d}	0.06	55.3	9.4
		-	50.0^{d}	0.06	54.2	9.3
	Leaf	+	28.8^{ab}	0.11	53.7	11.9
		-	33.1^{abcd}	0.10	51.3	11.7
Detarium microcarpum	Seed	+	44.1^{bcd}	0.04	52.0	9.4
		-	50.3^{d}	0.06	56.4	9.2
	Leaf	+	28.3^{ab}	0.20	45.7	8.5
		-	17.3^{a}	0.20	41.1	8.0
Piliostigma thonningii	Seed	+	30.8^{abc}	0.12	54.1	15.9
		-	36.6^{bcd}	0.09	56.0	16.1
	Leaf	+	48.2^{cd}	0.04	50.8	9.2
		-	29.3^{ab}	0.09	47.7	8.9
Seed			5.01	0.04	5.40	0.54
P-value	NUS		0.107	0.099	0.206	0.001
	Fraction		0.001	0.007	0.007	0.001
	PEG		0.310	0.839	0.711	0.711
	Fraction x NUS		0.001	0.002	0.289	0.001
	NUS x PEG		0.200	0.929	0.957	0.957
	Fraction x PEG		0.003	0.605	0.256	0.256
	NUS x Fraction x PEG		0.022	0.520	0.772	0.772

NUS=Neglected and underutilized Species; +=Polyethylene glycol added, - =No polyethylene glycol added, sed=standard error of difference, b=Asymptote gas production, c= Rate of gas production, IVOMD= In vitro organic matter digestibility, ME=Metabolizable energy (MJ/kg)

The asymptote gas production was significantly affected by the 3-way interaction of NUS x fraction x PEG. The highest (P=0.022) gas production was reported in the seed fraction of *I. oliviformis* and *D. microcarpum* without PEG whilst the lowest was reported in the leaf fraction of *D. microcarpum* without PEG. The higher gas production in *I. oliviformis* seed is an indication that carbohydrate fermentation of the seeds was not limited by the relatively lower concentration of CP. Rumen microbes fermenting carbohydrates requires ammonia nitrogen and peptides for the synthesis of their cell membranes and this

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is often derived from dietary protein degradation (McDonald *et al.*, 2011). The rate of gas production, IVOMD and ME were not affected by the interaction of NUS x fraction x PEG. The highest (P= 0.772) IVOMD was found in the seed fraction of *D. microcarpum* without PEG. The overall IVOMD was above 40%. The main effect of the PEG was found not to be significant suggesting that the concentrations of plant secondary metabolites such as condensed tannins did not affect the IVOMD. The ME for all the fractions was above the 4.7 MJ/kg/d required for growing lambs gaining 0-50 g/d (McDonald *et al.*, 2011).

Conclusion and Recommendation

The study revealed that the NUS investigated had potentials to be incorporated in the diet of ruminants. The seed fraction emerged as the most promising ingredient; however, considering that seeds are often used for propagation, its utilization as feed may be minimal. This can be complemented with the leaves.

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