Feed intake, growth and nutrient utilization of West African dwarf sheep fed differently processed *Gmelina arborea* Roxb. leaves based diets: performance of WAD sheep on differently processed *Gmelina arborea* leaves

Oghenesuvwe Okpara

Department of Animal Science, Delta State University, Delta State, Nigeria.
Corresponding author: O. Okpara, okparaoghenesuvwe@gmail.com

Abstract. This study was conducted to determine the effect of differently processed *Gmelina arborea* leaves (GAL) on growth and nutrient utilization of West African Dwarf (WAD) sheep. Forty WAD sheep of age 6-8 months, weighing 7-9 kg were assigned to five treatments of eight sheep per treatment in a completely randomized design. Feed and potable water were supplied daily for the 90-day period of the study. The treatments corresponded to five diets containing 50% fresh GAL: 50% elephant grass *Pennisetum purpureum* (T1), 60% chopped GAL: 40% elephant grass (T2), 60% air-dried GAL: 40% elephant grass (T3), 60% sun-dried GAL: 40% elephant grass (T4), 60% boil-dried GAL: 40% elephant grass (T5). Daily weight gain was significantly ($p < 0.05$) higher in boil-dried treated group compared to other treatments but with lower daily dry matter intake (DMI) and feed conversion ratio (FCR). Lower digestibility of DM and crude protein were observed for sheep on T3, T4, and T5 compared to T1 and T2. Sheep on T5 had higher nitrogen intake and nitrogen retention compared to others. It was concluded that boiled-dried GAL improved weight gain, feed conversion ratio and nitrogen retention when offered to sheep in combination with elephant grass.
Key Words: *Gmelina arborea* Roxb. leaves, intake, growth, nutrients utilization, processing, sheep.

Introduction. Inadequate feed supply on a year round basis is one of the single most important factors limiting livestock productivity in Nigeria. The “stop and grow” phenomenon (Crowder & Chheda 1982) is still very much prevalent in many parts of Nigeria. Ruminants gain weight during the wet season, which corresponds to the period of adequate pasture growth and abundant feed supply. However during the dry season most of the weight gained during the wet season is lost due to inadequate forage supply from pasture, thus a seasonal pattern of weight gain interrupted by weight loss during the dry season is formed. The resultant effect is that ruminants in these parts take a longer period to reach market weight or maturity than ruminants in other parts of the world (Lamidi & Ologbose 2014).

Conservation of forage as hay or silage is the major technique used in developed countries to address the deficit in forage supply to ruminants during periods of insufficient pasture growth (Vicente-Chandler 2001). However, the prevailing climatic conditions in southern Nigeria during the period of excess herbage production (high precipitation and humidity) are not conducive for successful haymaking. Silage making is not so attractive to the small farmer due to the high labour demand and machinery required to harvest, chop and store sufficient quantities of herbage to carry ruminant stock through the dry season. This, coupled with the low nutritive value of conserved tropical forage does not justify the cost of its production (Crowder & Chedda 1982; Gallaher & Pitman 2001).

Ruminants in the tropics are raised predominantly on grasses which are inherently poor in digestibility, nutritive value and unavailable in the off-season (Babayemi 2009). At this period, the performance of ruminants dependent on the native pasture is seriously impaired due to poor quality of the available pastures. This low quality is associated with the fibrous and lignified nature of the pasture which limits the intake, digestibility and utilization (Olafadehan et al 2009).

Gmelina arborea is a fast growing, non-leguminous multipurpose browse plant that produces appreciable amount of forage even at the peak of off-season. It has great potential especially as a source of high quality feed for ruminants due to its high protein, minerals and vitamins contents (Ayo-Enwerem et al 2008). These plants can boost growth performance of goats on low quality diets (Oyedele et al 2016). *G. arborea* leaf (GAL) contains phytochemicals such as tannin, alkaloid, saponin, oxalate, flavonoid, steroid (Okpara 2017). These phytochemicals have physiological effects on rumen microbes thereby modifying fermentation patterns (Faniyi et al 2016). Medicinal plants, such as *G. arborea* have the ability to improve digestibility of feedstuff in ruminants (Elghandour et al 2017) due to inherent secondary metabolites and biologically active enzymes which expedites digestion (Akanmu & Hassen 2017). The appropriate dosage use of phytochemicals could be beneficial to ruminants (Adegbeye et al 2018) as inappropriate intake resulted in weight loss (Okpara et al 2014). Better utilization efficiency and performance can be achieved with forage mixtures than with sole browse or forage (Okoruwa et al 2018) as well as heat treatment of browse plants. If GAL is properly harnessed it could be used in addressing the feed deficit challenges faced by farmers during the off- season.

Therefore, the effect of differently processed *Gmelina arborea* leaves (GAL) on growth and nutrient utilization of West African Dwarf (WAD) sheep were investigated.

Material and Method

Experimental location. This study was conducted between July 2018 to February 2019 at the sheep and goat unit of the Teaching and Research Farm and the Animal Science laboratory of the Department of Animal Science, Faculty of Agriculture, Delta State University, Asaba Campus.

Delta State falls within the humid tropics of Nigeria and Asaba precisely lies between longitudes 6^o and 8^oE and latitude 06^o and 49^oN of the Equator. Asaba has its raining season from March to September with a mean annual rainfall of 1500-1849.3 mm. It has a moderate climate with very high temperature during the dry season (October-February) with its mean annual temperature and precipitation of 28 ± 6^oC and 117 mm, respectively (NIMET 2011).

Collection and preparation of Gmelina arborea leaves. Fresh GAL was collected from Delta State University, Asaba Campus. The samples were authenticated at the Herbarium unit of the Department of Forestry and Wildlife, Delta State University, Asaba Campus.

Processing techniques of GAL samples. Two hundred and fifty grammes of GAL each were weighed and processed as fresh, chopped, air-dried, sun-dried and boil-dried samples.

Fresh: The fresh green samples were collected, crushed in a mortar (Pyrex CR), packed in a cellophane bag and stored in freezer for subsequent analysis.

Chopped: The chopped green samples were collected, chopped and crushed in a mortar (pyrex CR), packed in a cellophane bag and stored in a freezer for subsequent analysis.

Air-dried: The GAL samples meant for air-drying (i.e. indoor drying) were collected and spread in a well-ventilated laboratory.

Sun-dried: The GAL samples for sun drying (i.e. outdoor drying) were collected and spread on a special drying platform.

Boiled-dried: The GAL samples were boiled for 3 minutes and sun dried for two days (48 hours). The air dried, sundried and boil-dried processed samples of GAL were ground using hammer mill (Arthur Thomas Co. USA) to a mesh size of 2 mm. The milled samples were packed in labeled envelopes and kept in a cool and dry shelf for subsequent analysis.

Feeding and housing management of experimental animals. Forty West African Dwarf (WAD) sheep (6-8 months of age), weighing 7-9 kg were assigned into five groups of eight animals each on the basis of average body weight in a completely randomised design. Each group was offered one of the five diets containing 50% fresh GAL: 50% elephant grass (T1), 60% chopped GAL: 40% elephant grass (T2), 60% air-dried GAL: 40% elephant grass (T3), 60% sun-dried GAL: 40% elephant grass (T4), 60% boil-dried GAL: 40% elephant grass (T5). Feed and potable water was offered *ad libitum*. Sheep were housed individually in pens provided with feeder and waterer on well-ventilated, concrete-floored barns. Sheep were treated against external and internal parasites using ivomec injection and diazintol solution; administered long acting antibiotics injection; vaccinated against peste-de-petit ruminant (PPR) using Tissue Culture Rinderpest Vaccine (TCTV) at a rate of 1 mL/animal subcutaneously on the neck region (Reynolds et al 1988) and then allowed to acclimatize for a few days before the commencement of the 90 days feeding trial.

Feed intake, weight gain, digestibility, and nitrogen metabolism. Daily feed intake and weekly body weight were recorded for the 90 days of experimentation. Feed offered were adjusted weekly according to changes in body weights. Feed conversion ratio (FCR) determined from the daily feed intake and daily weight gain. At the end of the growth trial, twenty WAD sheep, four animals from each treatment, were transferred to individual metabolic cages. The modified cages with provision for feeding and watering had slated floors adapted for feacal and urine collection. After a 6-day adaptation period data were collected on total outputs (faeces and urine) and on feed intake based on daily refused feed for 8 days. Ten percent of daily total outputs per animal were preserved in a freezer (5^oC) but after the addition of few drops of concentrated H_2SO_4 to the urine. At the end of sample collection, frozen samples were thawed, properly mixed, and 10 percent aliquot sub-sampled. Feed and faecal samples were dried at 65^oC to constant weight, milled and kept in air tight containers while urine samples were kept in a deep freezer at 5^oC for nitrogen determination.

Analyses. Proximate composition of the milled samples of processed GAL was determined according to AOAC (2000). Fibre fractions (acid detergent fibre, and neutral detergent fibre) were determined by the methods of Van Soest & Robertson (1991).

Statistical analysis. Data obtained were subjected to Analysis of Variance and means were separated by Duncan's Multiple Range Tests at 5% level of probability using the procedures of SAS (2000).

Results and Discussion

Chemical composition of experimental diets. The crude protein (CP) and organic matter (OM) ranged from 16.89 to 18.51% and 92.03 to 94.36%, respectively (Table 1). The differently processed GAL contributed 58.03-67.26% of CP to the diets. The CP values are far above the 7% recommended value for tropical livestock by Minson (1990), below which there will be a deficiency in performance. This supports the findings of Okoruwa *(2019)* that browse plants have high crude protein content and could be useful feed resources to improve ruminant productivity in the tropics.

Table 1

Ingredient and chemical composition of diets consumed by sheep (g/100g DM)

Items	*T1*	*T2*	*T3*	*T4*	*T5*
Ingredients					
Fresh GAL	50.00	0.00	0.00	0.00	0.00
Chopped GAL	0.00	60.00	0.00	0.00	0.00
Sun-dried GAL	0.00	0.00	60.00	0.00	0.00
Air-dried GAL	0.00	0.00	0.00	60.00	0.00
Boiled-dried GAL	0.00	0.00	0.00	0.00	60.00
Elephant grass	50.00	40.00	40.00	40.00	40.00
Chemical composition (% DM)					
Crude protein	18.06	18.51	17.51	17.93	16.89
Organic matter	92.03	92.42	94.36	94.18	93.73

T1: diet with 50% fresh GAL; T2: diet with 60% chopped GAL; T3: diet with 60% sun-dried GAL; T4: diet with 60% air-dried GAL; T5: diet with 60% boil-dried GAL; DM: Dry matter; GAL: *Gmelina arborea* leaves.

Growth performance characteristics of WAD sheep fed differently processed GAL. Daily weight gain was higher in boil-dried treated group compared to othersbut with lower daily dry matter intake (DMI) and FCR (Table 2). This could be an indication of a better utilization of nutrient due to processing with consequent improvement in gains. Ahamufele & Udo (2010) reported that boil-drying has the potential to render feed more palatable and utilizable by WAD sheep.

Table 2

Growth performance of WAD sheep fed differently processed GAL

Parameters	*Gmelina Processing Techniques*					
	Fresh	*Chopped*	*Sun-dried*	*Air-dried*	*Boiled-dried*	*SEM*
Initial body weight (g)	7700.00	9000.00	7866.67	8500.00	8500.00	2487.80
Final body weight (g)	7833.33	9000.00	8033.33	9000.00	9333.33	4493.60
Total weight gain (g)	133.33^{c}	0.00^{d}	122.26^{c}	500.00^{b}	833.33^{a}	85.89
Daily weight gain (g)	1.59^{c}	0.00^{d}	1.98^{c}	5.95^{b}	9.92^{a}	1.02
DM intake from grass (g)	39920.00^{a}	32373.33^{b}	32066.67^{b}	32373.33^{b}	32350.0^{b}	825.18
DM intake from *Gmelina* (g)	40823.33^{b}	50066.67^{a}	37723.33^{c}	33600.00^{c}	32850.00^{c}	1774.98
Daily DM intake (g)	961.23^{a}	981.43^{a}	838.77^{ab}	785.40^{b}	776.19^{b}	24.98
DM intake as a % of body weight (%)	12.27^{a}	10.90^{b}	10.44^{b}	8.73^{c}	8.32^{c}	46.24
Feed conversion ratio	604.54^{ab}	981.43^{a}	423.62^{b}	131.95^{c}	78.25^{c}	83.21

$^{a, b, c, d}$:Means on same row with different superscripts were significantly different ($p < 0.05$); SEM: standard error of mean.

Researchers have reported that increase inclusion multipurpose trees and shrubs (MPTS) such as GAL resulted in weight loss in goats (Okagbare & Bratte 1999; Bamikole & Babayemi 2004; Okpara et al 2014) and the inability of their use as sole feed to support profitable ruminant production. The reduce gain in fresh and chopped treatments could be due to the presence and concentration of anti-nutritional factors such as saponin which according to Tadele (2015) can affect animal performance and metabolism through depression of growth rate and reduction in nutrient absorption. Akande & Fabiyi (2010) further buttress this fact that high anti-nutritional factor affects production of animals by reducing the nutrient intake, digestion, absorption and utilization. However, with processing the effect of the anti-nutritional components could be reduced resulting in gains. The present study agrees with reports by Idahor (2006); Ahamefule & Udo (2010); and Okpara et al (2014). The daily weight gain in this study were slightly higher than values of 6.95 g reported by Adamu et al (2013) who used GAL meal with maize stover diet fed to WAD rams.

Nutrient digestibility. Dry matter intake and nutrient digestibility were significantly ($p < 0.05$) affected by the different processing treatments (Table 3). The low digestibility of

CP observed for sheep on boiled-dried treatments could be associated with low rate of degradation of nutrients due to the effect of processing. The processing methods could have influenced protein digestibility through catalyzed enzymes reaction by forming an indigestible complex which reduces the digestibility of nutrients (Abdu et al 2009). Increased concentration of anti-nutritional factors such as tannins become highly detrimental as it reduces digestibility of crude protein and fibre in the rumen (Barry 1985). Smith et al (1995) reported that the CP and DM digestibility of dried leaves by WAD sheep and goats were relatively lower than fresh and wilted leaves and in all their levels of supplementation. The reduced DM obtained in this study could have been responsible for lower digestibility of other nutrients due to treatment effects. The DM digestibility values of this present study were higher than the values reported by Adamu et al (2013) but comparable with DM digestibility values reported by Okpara et al (2014). The lower crude fibre digestibility in fresh and chopped treatments could be attributed to the disruption of the activities of enzymes for degradation by phytochemicals such as tannins present in the diets (Okoruwa 2019) due to increased feed intake of the treatments. The values of crude fibre digestibility on this study are higher than the findings of Abdu et al (2013) and that of Okpara et al (2014). The digestibility of ash was similar in sun-dried, air-dried and boil-dried treatments but significantly ($p < 0.05$) higher than the fresh and chopped treatment. The values of ether extract (EE) in this study are comparable with EE values of Adamu et al (2013) and Okpara et al (2014). Water soluble constituents of plants products can be reduced by water treatment (Jack 2019). This could have affected the nitrogen free extract (NFE) content of boiled-dried GAL and responsible for lower digestibility of NFE. The values of NFE obtained in this study were higher than the values of Okpara et al (2014). Generally, lower digestibility values obtained could be as a result of the interactive effect of feed constituents and rumen microbes which negatively affects microbial activity (Okoruwa et al 2018).

Table 3

Nutrient digestibility of WAD sheep fed differently processed GAL (g/100 DM)

Parameter	*Gmelina processing techniques*					
	Fresh	*Chopped*	*Sun-dried*	*Air-dried*	*Boiled-dried*	*SEM*
Dry matter	70.41^{a}	75.83^{a}	59.94^{d}	52.49^{c}	52.70^{b}	2.52
Crude protein	89.02^{b}	90.71^{c}	84.98^{a}	80.33^{a}	79.67^{b}	1.19
Ether extract	88.08^{b}	89.23^{d}	56.47^{b}	45.56^{c}	63.82^{a}	4.64
Crude fibre	96.52^{c}	95.98^{d}	93.02^{a}	90.65^{b}	92.17^{a}	6.63
Ash	93.90^{b}	92.67^{c}	84.13^{a}	84.36^{a}	84.62^{a}	1.18
NFE	63.34^{b}	64.48^{d}	61.52^{a}	59.06^{b}	52.07^{c}	1.19

$^{a, b, c, d}$: Means on same row with different superscript were significantly different ($p < 0.05$); NFE: Nitrogen Free Extract; SEM: standard error of mean.

Nitrogen balance. Nitrogen utilization by WAD sheep fed processed GAL is shown in Table 4. The sheep on boil-dried treatment had higher nitrogen intake and nitrogen retention compared to others. Nitrogen retention is considered as the most common index of the protein nutrition status of ruminants (Abdu et al 2013). Nitrogen retention is the proportion of nitrogen utilized by farm animals from the total nitrogen intake for body processes hence the more the nitrogen consumed and digested the more the nitrogen retained (Okeniyi et al 2010). The low nitrogen retention resulting from increased nitrogen losses through faeces could probably be attributed to low nitrogen utilization as noted by Okeniyi et al (2010). However, in this study increase nitrogen loss did not adversely affect its retention. The N-retention values observed in this study were higher than the range obtained by Okoruwa et al (2013) for goats fed unripe plantain peels as replacement for *Pennisetum purpureum* but lower than the range obtained by Oduguwa & Adu (2010) for sheep fed shrimp waste meal and soya bean stover basal diets. The positive values obtained for all treatment groups suggest that the maintenance requirements of the experimental animals were adequately met by the diets and all the processing methods enhanced weight. This study confirmed that GAL can be used as supplemental feed in ruminant nutrition without toxic effect on the animal after processing as adopted in this study.

Table 4

Nitrogen balance of WAD sheep fed differently processed GAL

Parameter ($g\ day^{-1}$)	Processing techniques					
	Fresh	*Chopped*	*Sun-dried*	*Air-dried*	*Boiled-dried*	*SEM*
Feed intake (DM)	605.85[c]	733.09[a]	611.36[b]	620.12[b]	607.20[c]	2.50
Urinary nitrogen (%)	0.94[c]	0.93[c]	1.62[a]	1.58[b]	0.79[d]	0.04
Feacal output	184.76[c]	175.10[d]	242.68[b]	288.31[a]	287.67[a]	2.52
Feacal nitrogen (%)	1.68[a]	1.84[a]	1.29[b]	1.11[c]	1.10[d]	0.06
Urinary output	305.18[a]	293.00[b]	98.51[c]	95.06[c]	63.89[d]	0.98
N-intake	3.42[b]	2.96[d]	3.04[c]	3.42[b]	3.75[a]	0.03
Feacal N	0.35[b]	0.20[c]	0.11.13[d]	0.33[b]	0.80[a]	0.002
Urinary N	0.56[b]	0.29[c]	0.19[d]	0.36[b]	0.15[a]	0.04
N-retention	2.51[c]	2.47[c]	2.74[b]	2.73[b]	2.80[a]	0.03

[a, b, c, d]: Mean on same row with different superscripts were significantly different ($p < 0.05$); N: Nitrogen; SEM: standard error of mean.

Conclusions. Boiled-dried *Gmelina arborea* leaves improved weight gain, feed conversion ratio and nitrogen retention when offered to sheep in combination with elephant grass. The study revealed that processing *Gmelina arborea* leaves improved its nutritive value and therefore can serve as a potential feed resource that could sustain ruminant production.

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Author:
Oghenesuvwe Okpara, Delta State University, Department of Animal Science, Nigeria, Delta State, Asaba Campus, P.M.B 95074, e-mail: okparaoghenesuvwe@gmail.com

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