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Nutrient Intake, Digestibility and Nitrogen Balance in Yankasa Rams fed Treated Ensiled Eggplant (*Solanum melongena*) or *Digitaria smutsii* hay

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Abstract

Forty *Yankasa* breed of weaner rams weighing 9.15±3.11 $W_{kg}^{0.75}$ were used for digestibility trial to evaluate the nutritive value of treated ensiled eggplant (*Solanum melongena*) forage. Wilted, chopped eggplant forage was sprayed with 0.4% solution of urea, saline, equal proportion of urea-plus-saline, or water in a ratio of 1:4 (v: w) solution to forage. The treated forage was ensiled air-tight in black polythene bags for 21 days. Each of the treated forage constituted a treatment to which 8 animals were assigned in a randomized complete block design after balancing for weight. *Digitaria smutsii* hay was fed as control roughage in the 5th treatment. The assigned forage or hay was fed at 3% of body weight and supplemented with concentrate at 2% of body weight. The digestibility trial lasted 14 days for animals to adjust to the feed and crates, and 7 days for fecal and urine collection for laboratory chemical analysis to determine DM, CP, CF, EE, ash, NDF and ADF. Organic matter and NFE were derived from the results of the chemical analysis. Data collected for feed intakes, fecal and urine outputs, nutrient digestibility and nitrogen balance were analyzed by ANOVA using GLM procedure of SAS package, and means compared by Duncan Multiple Range Test. Crude protein in the urea-treated forage (30.13%) was more than 5 times that of the least (5.44%) in *D. smutsii* hay. Forage and total DM intakes (62.92 and 108.45g/ $W_{kg}^{0.75}$ respectively) were highest ($P<0.05$) and the correspondent values for the hay (55.25 and 99.65g/ $W_{kg}^{0.75}$ respectively) were least. Forage crude protein intakes for the treated forage ranged from 15.22 to 17.64 g/$W_{kg}^{0.75}$ and was higher ($P<0.05$) than for the hay (3.05 g/$W_{kg}^{0.75}$). The forage and total NFE intakes from the hay ((28.61 and 50.04g/$W_{kg}^{0.75}$ respectively) were higher ($P<0.05$) than the least (14.24 and 35.34 g/$W_{kg}^{0.75}$ respectively) in the saline-treated forage. The water-treated forage had the highest ($P<0.05$) digestibility for DM and OM (68.17 and 72.12% respectively). The highest ($P<0.05$) CP digestibility (81.01%) was for urea-treated forage and the least for the hay (64.55%). Nitrogen-free extract digestibility was highest ($P<0.05$) for the hay (95.83%) and least for the saline-treated (91.67%). Nitrogen intakes of the treated forage ranged from 4.23 to 4.60 g/$W_{kg}^{0.75}$ but significantly ($P<0.01$) differed from the intake in Digitaria hay (2.23 g/$W_{kg}^{0.75}$). Highest ($P<0.01$) nitrogen retention was for urea-treated (2.99 g/$W_{kg}^{0.75}$) and least for the hay (1.13 g/$W_{kg}^{0.75}$). Urea-treated forage had the highest ($P<0.01$) per cent nitrogen retention (63.59%) and saline-treated forage the least (44.95%). Ensiling eggplant (*Solanum melongena*) forage treated with 0.4% of urea, saline, equal proportion of urea-plus-saline, or water for 21 days transformed the forage from a farm waste to consumable forage with better nutrient intakes, digestibility and nitrogen retention in sheep than *Digitaria smutsii* hay.

Keywords: Eggplant nutrient intake and digestibility; nitrogen retention; *Yankasa* weaner rams

1. Introduction

The availability of feeds for small ruminants like other ruminants has become a threat to raising these species of animals in Nigeria. Grazing lands are reducing rapidly due to physical developments and environmental degradation. Nigeria has been reported to have the fastest rate of urban growth (5.3% annually) in the world (Fontem and Schippers 2004). Urbanization has reduced agricultural land (Okon et al. 2010) and because it has not been complemented with infrastructural and economic development, urban poverty and food insecurity have resulted (Cleave, 1974). As a result of the challenges posed by urbanization, urban agriculture is assuming increasing importance in ensuring food security. Animals are raised in homesteads within urban populations and around cities (Armar-Klemesu and Maxwell, 2000) and feeding them pose a big challenge.

The population of sheep is reported to be 20 million (FAOSTAT 2013). Shortage of feed for the production of the increasing sheep population has warranted research into alternative feed resource. Various crop residues are used as roughage to feed ruminants and are handy for urban and peri-urban animal production. The deployment of crop residues to feed animals does not require extra land for their production. However, many of the crop residues are not palatable and are of poor nutritional quality. Some contain anti-nutritional factors that prevent them from being consumed by ruminants. The crop residues not consumed by ruminants are usually burnt by farmers as the land is prepared for the next cropping activities.

Eggplant (*Solanum melongena*) is a commonly cultivated nightshade vegetable herb/forb in most ecologic zones of Nigeria. It is a very important vegetable crop cultivated commercially mainly by small scale farmers in most parts of the country all year round (Ozobia et al. 2013). The *Funtua* green striped variety is the most commonly cultivated in Zaria (11^o 4’ 0” North, 7^o 42’ 0” East) environ. The forage, fresh or dried is not consumed by ruminants because it is poisonous and so is burnt (All things are plants 2014). In screening some food based plants, *Solanum indicum* fruit was reported to contain the highest phytate (Aberounmand 2012).

This study was aimed at transforming eggplant (*Solanum melongena*) forage by treatment and ensiling into consumable roughage for sheep and evaluating its nutritive value in digestibility trial.

2. Materials and Methods

2.1 Location of study

The study was conducted at the National Animal Production Research Institute, Shika Zaria, Lat (DMS) 11^o 11’ 60N and Long 7^o 34’ 0E at altitude 646 meters above sea level, with mean annual precipitation of 1050 mm (Maps. Weather, Videos, and Airports for Shika, Nigeria). Individual metabolism crates were available for the metabolism trial.

2.2 Source of eggplant forage

The eggplant (*Solanum melongena*), *Funtua* green variety forage was obtained from farms in the locality after the eggplant fruit had been harvested. The fresh forage was wilted by air-drying in an open hall for 24 hours.

2.3 Feed preparation

After the eggplant (*Solanum melongena*) forage was wilted, it was manually chopped. A solution (0.4%) of urea, saline, equal proportion of urea-plus-saline, or water was sprayed to treat the chopped forage at 1: 4 ratios (v: w) of solution to forage. The treated forage was packed in black polythene bags and compressed to exclude air and then firmly tied before storing in an open sided shed for 21 days. After 21 days of ensiling, the bags were opened, the treated material evacuated and air-dried in an open room for 72 hours before storage in jute bags.

2.4 Experimental animals

Forty *Yankasa* weaner rams weighing $9.15 \pm 3.11 W_{Kg}^{0.75}$ were used for digestibility trial. The animals were blocked by body weight into four groups. They were allotted equally to five treatment groups balancing for weight in a randomized complete block design. There were 8 animals per treatment and each animal was kept in a metabolism crate. They were fed their respective diets at 3% of body weight as roughage and 2% of body weight as concentrate supplement (Table1). *Digitaria smutsii* hay which is the standard roughage used in the Institute was offered as control treatment. The ingredient composition of the concentrate is given in Table 2.

Table 1: Treatments of study

Variables	Eggplant chopped forage treatment before ensiling for 21 days				*Digitaria smutsii* hay
Treatment groups	Urea-treated	Saline-treated	Urea-plus- Saline-treated	Water-treated	(Control)
Treatment before ensiling	0.4% urea solution sprayed on chopped forage in 1:3 v:w ratio	0.4% saline sprayed on chopped forage in 1:3 v:w ratio	0.2% urea plus 0.2% saline sprayed on chopped forage in 1:3 v:w ratio	Water sprayed on chopped forage in 1:3 v:w ratio	Harvested at the end of rainy season and sun-cured before baling
Mean ram body weight ($W_{Kg}^{0.75}$)	9.15	9.11	9.08	9.07	9.32
Forage offered ($g/_{Kg}^{0.75}$)	274.5	273.3	272.4	272.1	279.6
Concentrate Offered ($g/_{Kg}^{0.75}$)	183.0	182.2	181.6	181.4	186.4
Total feed Offered ($g/_{Kg}^{0.75}$)	457.5	455.5	454.0	453.5	466.0

Table 2: Composition of concentrate

Feed ingredient	Amount (%)	Crude protein (%)	Gross Energy MJ/kg DM (Calculated)
Maize	22	11.18	18.7
Maize offal	11	16.69	19.0
Wheat offal	11.0	13.19	18.9
Cotton seed cake	52.0	33.63	21.2
Vitamin pre-mix	0.5	2.81	-
Bone meal	2.5	-	-
Salt	1.0	-	-
Total	100.0	24.26	19.30

2.5 Digestibility trial

The weaner rams in the metabolism crates was fed their respective rations for an initial 14 day period to allow them adjust to the crates and for the alimentary canal to get re-alimented. The following 7 days were used for measurement and sample collection. Each ram was fed its appropriate ration at 3% of body weight as roughage and 2% of body weight as concentrate supplement. Fresh water was provided for each animal to drink *ad libitum*. A measured volume of water was placed daily in the metabolism room to determine the loss of water due to evaporation and this was used as correction factor for water intake by the animals. Before feeding each animal in the morning at 08.00 hours, the feed leftover (ort) from the previous day was weighed and used to determine its daily intake. Samples of the feed offered daily were taken and bulked per treatment for laboratory chemical analysis. The daily fecal output was weighed before feeding each animal. About 10% of the fecal output was taken and dried to constant weight in an oven at 70^{o}C for 72 hours and then bulked for each animal awaiting chemical analysis. The urine of each animal was collected into a plastic container containing 25ml of 10% sulphuric acid to trap the ammonia in the urine into an ammonium salt. About 10% of the measured urine was sampled and stored in the refrigerator at $4^{o}C$ until bulked for each animal and analyzed for nitrogen content.

2.6 Chemical analysis

The feed samples for each treatment were bulked and analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), ash, neutral detergent fibre (NDF) and acid detergent fibre (ADF). The organic matter (OM) and nitrogen free extract (NFE) were derived from some of the results obtained from the chemical analysis. The DM, CF, EE and ash were determined by using the AOAC (1990) procedures. The nitrogen was determined by Kjeldahl method (AOAC 1990). The NDF and ADF were determined according to van Soest (1991) methods.

2.7 Statistical analysis

The design of the study was randomized complete block using body weight as blocking factor and balancing the treatments for weight (Snedecor and Cochran 1989). The data collected for feed intakes, fecal and urine outputs, nutrient digestibility and nitrogen balance were analyzed by ANOVA using the GLM procedure of SAS package (2006) and means were compared using the Duncan Multiple Range Test (1955).

3. Results:

3.1 Chemical composition

Table 3 contains the chemical composition of the concentrate supplement and basal roughage. The *Digitaria smutsii* hay used as control basal feed had the highest DM (94.53%) and OM (92.44%) while the lowest DM (93.00%) and OM (84.05) were in the saline-treated forage. The OM of the various treated ensiled eggplant forages in this study ranged from 84.05% (saline-treated) to 89.55% (water-treated).

The highest CP content in the urea-treated forage (30.13%) was more than 5 times that of the least (5.44%) in *D. smutsii* hay. The water-treated forage had the lowest CP of 24.19% compared to the other treated ensiled eggplant forages. *Digitaria smutsii* hay was highest in CF (35.70%) and ADF (40.06%). The least CF, NDF and ADF (20.52, 34.16 and 30.66% respectively) were contained in the urea-treated forage. The highest NDF (56.12%) and ADF (40.06%) were in the water-treated and *D. smutsii* hay respectively. Ether extract ranged from 1.51% (*D. smutsii*) to 2.76% (urea-plus-saline-treated forage). Of the treated forages, the saline-treated forage had the least EE (1.88%). The ash content ranged from 5.56% (*D. smutsii*) to 13.95 (saline-treated forage). The highest nitrogen free extract (NFE) was in *D. smutsii* hay (44.43%) and the least in saline-treated forage (28.33%). The CP and NFE of the concentrate mixture were 24.62 and 48.26% respectively.

Table 3: Chemical composition of concentrate and treated ensiled eggplant forage

Feed nutrient	Eggplant forage treatment with:					
	Urea	Saline	Urea-plus-Saline	Water	*D. smutsii* hay	Concentrate
Dry matter (%)	93.25	93.00	93.89	94.38	94.53	93.92
Organic matter (% DM)	85.96	84.05	87.37	89.55	92.44	86.56
Crude protein (% DM)	30.13	27.75	29.13	24.19	5.44	24.62
Crude fibre (% DM)	20.52	31.64	25.52	33.92	35.70	10.26
Ash(% DM)	12.44	13.95	10.62	8.45	5.56	13.44
Nitrogen free extract (% DM)	34.02	28.33	32.89	32.38	44.43	48.26
Ether extract (%DM)	2.42	1.88	2.76	2.56	1.51	3.42
Neutral detergent fibre (%DM)	34.16	50.33	42.72	56.12	55.86	34.61
Acid detergent fibre (%DM)	30.66	32.02	31.99	35.64	40.06	27.51

3.2 Nutrient intake

The feed DM intake by the animals is reported in Table 4. The DM intake was significant (P<0.05) across treatments. The forage DM and total DM intakes by animals given the water-treated forage (62.92 and 108.45g/ $W_{kg}^{0.75}$ respectively) were higher than those on Digitaria hay (55.25 and 99.65g/ $W_{kg}^{0.75}$ respectively) and saline-treated forage (57.44 and 101.18 g/ $W_{kg}^{0.75}$ respectively). The concentrate DM intake did not differ significantly (P>0.05) between treatments.

Table 4: Feed Dry Matter Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria Smutsii* hay	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water	(Control)		
Forage DM intake (g/ $W_{kg}^{0.75}$)	58.54^{ab}	57.44^{b}	60.39^{ab}	62.92^{a}	55.25^{b}	2.41	*
Concentrate DM intake (g/ $W_{kg}^{0.75}$)	44.16	43.74	45.44	45.54	44.40	1.26	NS
Total DM intake (g/ $W_{kg}^{0.75}$)	102.70^{ab}	101.18^{b}	105.83^{ab}	108.45^{a}	99.65^{b}	3.59	*

^{a,b} Means on the same row with different superscripts differ significantly (P<0.05)

Table 5 gives the intake of OM. Animals on water-treated forage had significantly (P<0.05) higher forage OM intake (57.60g/ $W_{kg}^{0.75}$) than those on Digitaria hay (52.18 g/ $BWkg^{0.75}$) and saline-treated forage (49.43g/ $W_{kg}^{0.75}$). The intake of concentrate OM did not differ (P>0.05) between treatment groups. The total OM intake of the animals on water-treated forage (99.39 g/ $BWkg^{0.75}$) was significantly (P<0.05) higher than those on urea-treated forage (91.79 g/ $W_{kg}^{0.75}$) and saline-treated forage (89.57 g/$W_{kg}^{0.75}$).

Table 5: Feed Organic Matter Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* hay	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water	(Control)		
Forage OM intake (g/ $W_{kg}^{0.75}$)	51.26^{bc}	49.43^{c}	53.97^{ab}	57.60^{a}	52.18^{b}	2.18	*
Concentrate OM intake (g/ $W_{kg}^{0.75}$)	40.53	40.14	41.70	41.79	40.74	1.15	NS
Total OM intake (g/ $W_{kg}^{0.75}$)	91.79^{b}	89.57^{b}	95.68^{ab}	99.39^{a}	92.92^{ab}	3.26	*

^{a,b,c} Means on the same row with different superscripts differ significantly (P<0.05)

The result in Table 6 shows that the forage CP intake by animals on all the treated forage ranged from 15.22 to 17.64 g/$W_{kg}^{0.75}$ which was significantly (P<0.01) higher than those on Digitaria hay (3.05 g/$W_{kg}^{0.75}$). The total CP intakes did not differ between the treated forages (26.43 to 28.78g/$W_{kg}^{0.75}$) but were significantly (P<0.01) higher than the intake in *Digitaria smutsii* hay (13.94g/$W_{kg}^{0.75}$). The concentrate CP intakes were similar for all treatments.

Table 6: Feed Crude Protein Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii hay*	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water	(Control)		
Forage CP intake (g/ $W_{kg}^{0.75}$)	17.64[a]	15.94[a]	17.59[a]	15.22[a]	3.05[b]	1.41	**
Concentrate CP intake (g/ $W_{kg}^{0.75}$)	10.87	10.77	11.19	11.21	10.93	0.662	NS
Total CP intake (g/ $W_{kg}^{0.75}$)	28.51[a]	26.71[a]	28.78[a]	26.43[a]	13.94[b]	5.95	**

[a,b] Means on the same row with different superscripts differ significantly (P<0.01)

In Table 7, the water-treated forage and total CF intakes (36.79 and 41.46 g/$W_{kg}^{0.75}$ respectively) were significantly (P<0.05) higher than for all others except for *D. smutsii* hay. The concentrate crude fibre intake did not differ significantly across treatments.

Table 7: Feed Crude Fibre Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* hay	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water	(Control)		
Forage CF intake (g/$W_{kg}^{0.75}$)	27.01[c]	32.01[b]	27.01[c]	36.79[a]	35.57[ab]	1.82	*
Concentrate CF intake (g/$W_{kg}^{0.75}$)	4.53	4.49	4.66	4.67	4.56	0.129	NS
Total CF intake (g/$W_{kg}^{0.75}$)	31.54[c]	36.50[b]	31.67[c]	41.46[a]	40.13[ab]	1.91	*

[a,b,c] Means on the same row with different superscripts differ significantly (P<0.05)

The feed ash intake is recorded in Table 8. The forage ash intake in Digitaria (3.07 g/$W_{kg}^{0.75}$) is significantly (P<0.05) less than those of the treated forages (5.32 to 8.01 g/$W_{kg}^{0.75}$). The ash intake from concentrate did not differ significantly (P>0.05). The highest (P<0.05) total ash intake was for the saline-treated (13.89g/$W_{kg}^{0.75}$) while the least was recorded for those on *Digitaria smutsii* hay (9.04g/$W_{kg}^{0.75}$).

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Table 8: Feed Ash Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* hay (Control)	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water			
Forage Ash intake ($g/W_{kg}^{0.75}$)	7.28^{a}	8.01^{a}	6.41^{ab}	5.32^{ab}	3.07^{b}	1.47	*
Concentrate Ash intake ($g/W_{kg}^{0.75}$)	5.94	5.88	6.11	6.12	5.97	0.169	NS
Total Ash intake ($g/W_{kg}^{0.75}$)	13.22^{ab}	13.89^{a}	12.52^{bc}	11.44^{c}	9.04^{d}	0.572	*

^{a,b,c,d} Means on the same row with different superscripts differ significantly (P<0.05)

Table 9 gives the feed EE intake which was significant (P<0.05) for forage intake and total intake. The highest forage EE intake and total EE intake were in the urea-plus-saline treated forage (1.67 and 3.22 $g/W_{kg}^{0.75}$ respectively) while the least was in Digitaria hay (0.834 and 2.35 $g/W_{kg}^{0.75}$ respectively). There was no difference in the concentrate EE intake.

Table 9: Feed Ether Extract Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* hay (Control)	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water			
Forage EE intake ($g/W_{kg}^{0.75}$)	1.42^{b}	1.08^{c}	1.67^{a}	1.61^{a}	0.834^{d}	0.09	*
Concentrate EE intake ($g/W_{kg}^{0.75}$)	1.51	1.50	1.55	1.56	1.52	0.043	NS
Total EE intake $g/W_{kg}^{0.75}$	2.93^{b}	2.58^{c}	3.22^{a}	3.17^{a}	2.35^{c}	0.121	*

^{a,b,c,d} Means on the same row with different superscripts differ significantly (P<0.05)

In Table 10, animals on *Digitaria smutsii* hay consumed the highest (P<0.05) forage NFE and total NFE (28.61 and 50.04$g/W_{kg}^{0.75}$ respectively) while the least was in the saline-treated forage (14.24 and 35.34 $g/W_{kg}^{0.75}$ respectively). The concentrate NFE intake was same for all.

Table 10: Feed Nitrogen Free Extract

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* (Control)	SEM	LOS
	Urea	Saline	Urea- plus-Saline	Water			
Forage NFE intake ($g/W_{kg}^{0.75}$)	20.19^{b}	14.24^{c}	19.31^{b}	19.43^{b}	28.61^{a}	1.36	*
Concentrate NFE intake ($g/W_{kg}^{0.75}$)	21.31	21.11	21.93	21.98	21.43	0.61	NS
Total NFE intake ($g/W^{kg0.75}$)	41.50^{b}	35.34^{c}	41.24^{b}	41.40^{b}	50.04^{a}	1.77	*

^{a,b,c,d} Means on the same row with different superscripts differ significantly (P<0.05)

The highest (P<0.05) forage NDF and total NDF intakes were for the water-treated forage (35.31 and 51.07 $g/W_{kg}^{0.75}$ respectively) and the least in the urea-treated forage (18.00 and 35.28 $g/W_{kg}^{0.75}$ respectively). All treatments had same concentrate NDF intake (Table 11).

Table 11: Feed Neutral Detergent Fibre Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria smutsii* hay	SEM	LOS
	Urea	Saline	Urea- plus-Saline	Water	(Control)		
Forage NDF intake ($g/W_{kg}^{0.75}$)	18.00^{d}	28.91^{bc}	25.80^{c}	35.31^{a}	30.86^{b}	1.60	*
Concentrate NDF intake ($g/W_{kg}^{0.75}$)	15.29	15.14	15.73	15.76	15.37	0.435	NS
Total NDF intake ($g/W_{kg}^{0.75}$)	35.28^{d}	44.05^{bc}	41.53^{c}	51.07^{a}	46.23^{b}	1.91	*

^{a,b,c,d} Means on the same row with different superscripts differ significantly (P<0.05)

The result of the ADF is given in Table 12. The forage and total ADF intakes for the water-treated (22.42 and 34.95 $g/W_{kg}^{0.75}$ respectively) and Digitaria hay (22.13 and 34.35 $g/W_{kg}^{0.75}$ respectively) were significantly higher than the other treatments. The concentrate intake did not differ (P>0.05).

Table 12: Feed Acid Detergent Fibre Intake

Feed nutrient	Eggplant forage treatment with:				*Digitaria Smutsii* hay	SEM	LOS
	Urea	Saline	Urea-plus-Saline	Water	(Control)		
Forage ADF intake ($g/W_{kg}^{0.75}$)	17.95^{b}	18.39^{b}	19.32^{b}	22.42^{a}	22.13^{a}	0.896	*
Concentrate ADF intake ($g/W_{kg}^{0.75}$)	12.15	12.03	12.50	12.53	12.21	0.346	NS
Total ADF intake ($g/W_{kg}^{0.75}$)	30.10^{b}	30.43^{b}	31.82^{b}	34.95^{a}	34.35^{a}	1.20	*

^{a,b} Means on the same row with different superscripts differ significantly (P<0.05)

3.3 Nutrient digestibility

The digestibility of all the nutrients analyzed differed significantly (P<0.05) between treatments (Table 13). The highest DM digestibility was for the water-treated forage (68.17%) and the least was for urea-treated forage (60.34%). The OM digestibility (72.12%) of the water-treated forage was significantly (P<0.05) higher than those of other treatments. The highest CP digestibility (81.01%) was recorded for the urea-treated forage while the lowest was in the Digitaria hay (64.55%).

The saline-treated forage had the highest digestibility (80.64%) of CF and this was significantly (P<0.05) higher than others with the least being for the urea-plus-saline forage (62.09%). The digestibility of ash was highest for the water-treated forage (49.83%) and least for the urea-treated (40.50%) and the urea-plus-saline treated (41.51%) forages.

The highest ($P<0.05$) NFE digestibility was obtained for the Digitaria hay (95.83%) and least in the saline-treated forage (91.67%). The EE digestibility was lowest ($P<0.05$) for urea-treated forage (23.86%) and highest for water-treated forage (56.25%). The digestibility of NDF was highest ($P<0.05$) in *Digitaria smutsii* (50.84%) compared with the urea-treated forage which was the lowest (34.62%). The ADF digestibility of *Digitaria smutsii* hay (45.59%) was significantly ($P<0.05$) higher than other treatments with the saline-treated forage being the least (33.52%).

Table 13: Nutrient digestibility

Feed nutrient	Eggplant forage treatment with:						
	Urea	Saline	Urea-plus-Saline	Water	*D. smutsii* hay	SEM	LOS
DM Digestibility (%)	60.34^{c}	65.11^{b}	63.69^{b}	68.17^{a}	65.77^{b}	1.18	*
OM Digestibility (%)	68.51^{b}	70.05^{b}	68.48^{b}	72.12^{a}	69.76^{b}	0.931	*
CP Digestibility (%)	81.01^{a}	76.30^{ab}	73.59^{b}	73.55^{b}	64.55^{c}	2.84	*
CF Digestibility (%)	66.74^{c}	80.64^{a}	62.09^{c}	72.02^{b}	72.05^{b}	2.04	*
Ash Digestibility (%)	40.50^{c}	45.72^{b}	41.51^{c}	49.83^{a}	42.78^{bc}	1.84	*
NFE Digestibility (%)	93.26^{b}	91.67^{c}	92.33^{bc}	92.93^{b}	95.83^{a}	0.47	*
EE Digestibility (%)	23.86^{c}	40.33^{b}	49.03^{a}	56.25^{a}	43.48^{b}	3.76	*
NDF Digestibility(%)	34.62^{c}	49.33^{a}	42.13^{b}	42.67^{b}	50.84^{a}	2.81	*
ADF Digestibility(%)	36.65^{c}	33.52^{c}	35.84^{c}	40.84^{b}	45.59^{a}	2.06	*

[a,b,c] Means on the same row with different superscripts differ significantly ($P<0.05$)

3.4 Nitrogen Balance

The nitrogen utilization is reported in Table 14 with significant difference ($P<0.01$). Nitrogen intakes of the treated forage ranged from 4.23 to 4.60 $g/W_{kg}^{0.75}$ but significantly differed from the intake in Digitaria hay (2.23 $g/W_{kg}^{0.75}$). The nitrogen lost in feces was highest from the urea-plus-saline treated forage (0.526 $g/W_{kg}^{0.75}$) compared with the loss from Digitaria hay (0.090 $g/W_{kg}^{0.75}$). The urea-treated forage had the highest digested nitrogen (4.19 $g/W_{kg}^{0.75}$) compared with other treatments and the least was for Digitaria hay (1.95 $g/W_{kg}^{0.75}$).The loss of nitrogen in urine was highest in the saline-treated forage (1.31 $g/W_{kg}^{0.75}$) with the animals on Digitaria hay excreting the least (0.30 $g/W_{kg}^{0.75}$). Animals on urea-treated forage had the highest nitrogen retention (2.99 $g/W_{kg}^{0.75}$) while the least (1.13 $g/W_{kg}^{0.75}$) was in those fed Digitaria hay. The per cent nitrogen retention was highest for the urea-treated forage (63.59%) but least for the saline-treated forage (44.95%).

Table 14: Nitrogen Utilization ($g/W_{kg}^{0.75}$)

Parameters	Eggplant forage treatment with:						
	Urea	Saline	Urea-plus-Saline	Water	*D. smutsii* hay	SEM	LOS
Feed nitrogen intake	4.56^{a}	4.27^{a}	4.60^{a}	4.23^{a}	2.23^{b}	0.25	**
Faecal nitrogen output	0.318^{ab}	0.322^{ab}	0.526^{a}	0.379^{ab}	0.090^{b}	0.179	**
Digested nitrogen	4.19^{a}	3.76^{b}	3.35^{b}	3.61^{b}	1.95^{c}	0.213	**
Urine nitrogen output	0.75^{c}	1.31^{a}	1.03^{b}	0.79^{c}	0.30^{d}	0.108	**
Nitrogen retention	2.99^{a}	1.98^{b}	2.28^{b}	2.33^{b}	1.13^{c}	0.197	**
% Nitrogen retention	63.59^{a}	44.95^{c}	51.51^{b}	55.02^{b}	51.13^{b}	2.89	**

[a,b,c,d] Means on the same row with different superscripts differ significantly ($P<0.01$)

4. Discussion

Eggplant (*Solanum melongena*) is a nightshade vegetable forb/herb of economic importance commonly cultivated in tropical countries (Abraham et al. 2014). Forage of eggplant is known to be unpalatable and toxic (All things are plants 2014). The *Funtua* striped green variety of eggplant is a major type cultivated in Guinea and Sudan savannas ecologic zones of Nigeria. The forage is a farm byproduct considered to be waste and usually burned because it is not consumed by animals.

4.1 Chemical composition

Chemical composition and biological attributes of feeds are indicators for feed quality. The response of an animal to feed is determined by feed factors interplaying with animal factors. The palatability, form and chemical structure of feed along with its nutrient contents affect the biological response of an animal in the intake, digestibility and nutrient utilization of the feed. Wilting forage before ensiling increases the DM of the silage (Clavero and Razz). The DM (94.53%) content in *Digitaria smutsii* hay was similar to the 94.78% reported by Malau-Aduli et al. (2003), 95.4% by Fayomi (2006) and 93.6% by Makun et al. (2008). The OM of 92.44 % was higher than the 85.7% reported by Makun et al. (2008). The OM of the Digitaria used was higher than a comparable grass, Orchard grass with 85%. In the determination of OM of wild growing forages, Khachatur (2006) reported that forbs contain OM of 89.3% which is comparable with the result of the treated eggplant forage used in this study (84.05 to 89.55%). Similar to the result in this study, Khachatur (2006) recorded higher OM in grasses (91.4 to 93.6%) than in forbs.

The CP of 5.44% in the Digitaria was higher than the 4.75% obtained by Malau-Aduli et al. (2003) but lower than the 7.7% reported by 7.88% by Fayomi (2006) and Makun et al. (2008). Crude protein content directly relates to the soluble sugars available for fermentation (Seglar 2003). The CP in the Digitaria hay was inadequate to meet the minimum microbial requirement of 7.0% CP in feed for needed ruminal microbial activity and CP required for maintenance in the host ruminant (McDonald et al. 2002). The CF (35.70%) of *D. smutsii* hay in this study was about same as 36% reported for Sudangrass hay (Preston 2007) but lower than 38% for mature Alfalfa hay (Stanton and LeValley 2010). Differences in the crude protein and crude fibre in the Digitaria hay used in this study compared to other hays cited may have been due to the stage of harvesting and curing of the hay. The values of ADF and NDF are indicative of the amount of substrate available for fermentation. The higher the values of ADF and NDF, the less free sugars available for fermentation resulting in lower silage quality (Seglar 2003). The ADF and NDF in this study are higher than reported by Seglar (2003) for Alfalfa silage.

The ash in *D. smutsii* was 5.56%, lower than the 8.0% reported by Preston, 2007 and Stanton and LeValley (2010) for mature Alfalfa hay, 10% for Sudangrass hay (Preston 2007), 15% by Forejtova et al. 2005 for some forages, and 8.47% for *Digitaria. smutsii* by Malau-Aduli et al. (2003). Ash is the inorganic fraction of plant. It comprises minerals accessed from the soil by the plant and could also be indicative of the level of soil contamination during harvest, dry matter loss due to aerobic instability or fermentation of the forage by Clostridia organism (Seglar 2003). The lower ash in this study must have been as a result of lower uptake of minerals from the soil. Urea (46%) fertilizer was applied to supply nitrogen to the Digitaria field for rapid vegetative growth of the pasture. This may be responsible for the higher organic matter and lower ash content of the Digitaria used compared with the other hays cited above. The ash content of the treated forage is higher than the 10.18% reported by Akubugwo et al. (2007) for *Solanum nigrum*. Var *virginicum*. The higher value of ash must have been as a result of species variation, and treatment and ensiling of the forage.

The EE of 1.51% obtained for Digitaria in this study is lower than the 2.40% reported by Malau-Aduli et al. (2003) but comparable with Sudangrass hay (1.8%) reported by Preston, 2007. The difference could be due to the stage of harvest and processing of the pasture to hay.

Akubugwo et al. (2007) reported crude protein content of the leaves of *Solanum nigrum* . Var *virginicum* as 24.9% which is similar to the 24.19% obtained in this study for the water-treated forage. In the study of nightshade plant (*Solanum scabrum*), Kamga et al. (2013) reported CP content of 33.02 to 38.18%. However, African eggplant (*Solanum aethiopicum)* fruit had crude protein content of 9.4 to 10.7% (Kamga et al. 2013). The treatment of eggplant forage with urea in this study increased its CP content to between 29 and 30% from 24.19% in the water-treated forage. Ensiling forage with urea has been reported to increase its crude protein content (Cardoso et al., Jianxin and Jun 2002). In the study by Magalhães et al. 2013, the CP in untreated sugarcane silage was increased from 1.15% to 14.9% in the urea-treated sugarcane silage. This study of treating ensiled eggplant confirms the reports of increase in CP content of urea-treated ensiled forage.

4.2 Feed Nutrient Intake

The DM intake of the water-treated ensiled forage was significantly higher than for the Digitaria hay and the saline-treated forage. The DM content of the water-treated forage is comparable to that of the Digitaria hay but the almost 5 times higher CP content in the treated forage induced higher DM, OM, CP and EE intakes over those of the hay. Contrary to this result, Magalhães et al.(2013) reported no difference in intakes of DM, EE, NDF, NDFap (corrected for ash and protein), total carbohydrates, hemicelluloses and TDN contained in untreated sugarcane silage compared with urea-treated sugarcane silage fed to sheep. The difference between these results may be because intake in this study was evaluated per metabolic weight (g/$W_{kg}^{0.75}$) while Magalhães et al. (2013) reported intake per day. The forage DM intake of 58.54 to 62.92 g/ $W_{kg}^{0.75}$ obtained in this study is lower than the 65.0 to 80.0 g/ $W_{kg}^{0.75}$ reported by Phillips et al.(1995) for harvested wheat forage fed to lambs. The wide range difference could be due to the stage and season of harvest of the forage, variation in forage species and stage of development of sheep fed.

The higher NFE intake over the treated forages is because of higher NFE content in the Digitaria hay than in the forages. This means that Digitaria hay contains more energy nutrients comprising carbohydrates, sugars and starches which constitute the NFE than in the treated forages. However, the deficiency of the hay in CP content inhibited nutrient intakes. The high contents of CF and ADF were responsible for the higher intakes of these nutrients in the hay than in the treated forages.

4.3 Digestibility

The digestibility values of the nutrients determined were significantly ($P<0.05$) different across treatments. It has been reported that chemical composition, DM digestibility and forage energy values differ significantly due to herbage variety, stage of growth, year of harvest and vertical belts (Givens et al.1989, Corona et al. 1995, and Stockdale 1999). The water-treated forage with the best digestibility for DM, OM, ash and EE must have been as a result of the role water plays in providing a good medium for fermentation in ensiling. Palic and Leeuw (2009) using *in vitro* methods determined OM digestibility of complete diets for ruminants to range from 68.4 to 71.6% which is comparable to the range obtained in this study. Organic matter digestibility is a means of measuring the available energy in feeds for ruminants (Barber et al. 1990) because it is very closely related to the corresponding digestibility of energy (Thomas 1990). This means that the water-treated forage contained the highest available energy for the animals. Organic matter digestibility comprises wholly digestible cell content and variously digestible cell wall content. There is a negative correlation of organic matter digestibility with NDF, ADF and hemicelluloses (Čerešnáková et. al. 1996 cited by Forejtova et.al. 2005). However, in this study the water-treated forage with the highest OM digestibility also had the highest NDF and ADF contents. This is an indication that the wholly digestible cell content in the water-treated forage may have been higher than in the other treatments with lower NDF and ADF contents.

In comparing the mean digestion coefficients of NFE and CF fractions of dry roughages, herbage and silage, Crampton and Maynard (1938) cited by Ely et al. (1952) demonstrated the variability in composition, digestibility and feeding value of CF of various sources. This variability was observed in the nutrient digestibility of the forages in this study.

4.4 Nitrogen Balance

The feed nitrogen intake and fecal nitrogen output were higher because of the higher nitrogen content in the treated forage than in the hay fed to the animals. The higher digested nitrogen for the urea-treated forage was due to the effects of higher CP intake and digestibility than in the other treatments. Loss of nitrogen in urine was highest in the saline-treated forage because the salt and the available water *ad libitum* enhanced the excretion of urea in the urine. The highest nitrogen retention and per cent nitrogen retention in the urea-treated animals must have been because there was better synchrony of dietary protein and energy than in other treatments (Longo et al. 2008).

5. Conclusion

The spraying of 0.4% solution of urea, saline, equal proportion of urea-plus-saline, or water on eggplant (*Solanum melongena*) forage at a ratio of 1:4 (v:w) before ensiling for 21 days transforms it through the process of fermentation to consumable forage for sheep production. Smallholder urban and peri-urban sheep producers can easily process eggplant forage to feed their animals instead of establishing *Digitaria smutsii* pasture for hay or grazing on land which is increasingly getting more difficult to access. Putting into consideration the obvious costs, the relative performance compared to the other study roughages in terms of intakes of CP and NFE, the digestibility of DM, OM, CP and NFE, and the nitrogen utilization, the water-treated ensiled eggplant forage is promising as a performing-forage for sheep production. Nutritional studies on the effects of anti-nutritional factors in the treated ensiled eggplant on weight response, reproductive performance and vital organs of sheep are necessary before confirmatory recommendations can be made.

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