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Research

Assessing the effect of sun-cured water hyacinth (Eichhornia crassipes Mart. Solms-Laubach) based diets on apparent digestibility and nitrogen utilization by WAD goats

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Abstract

The objective of this study was to evaluate the apparent nutrient digestibility and nitrogen utilization by goats fed water hyacinth (WH) based diets. The chemical composition of experimental diets was determined. Apparent nutrient digestibility, nitrogen utilization and total digestible nutrients by WAD goats were also determined. Twenty (20) female WAD goats between the ages of 1- 1.5 years months weighing 9.18 – 11.8 kg were used for the digestibility trial. Four animals were allotted to each of 5 treatments in a completely randomized design. Parameters measured include: apparent digestibility of dry matter and crude protein, nitrogen intake, urinary nitrogen, nitrogen balance and retention, total digestible nutrients.

Results revealed that the apparent digestibility of dry matter and crude protein decreased with increasing level of WH in the diets, however the apparent digestibility of dry matter and crude protein were similar for goats on 0% and 30% WH diets, while there were significant variations among 45%, 60% and 90% WH diets. Same trend was observed for nitrogen intake, urinary nitrogen, nitrogen balance and retention, total digestible nutrients.

It is concluded that in diets based on Guinea grass the maximum level of sun-cured water hyacinth in diets for growing goats is 30%.

KEY WORDS: apparent digestibility, chemical composition, nitrogen balance, nitrogen retention, total digestible

Introduction

One of the major problems of ruminant production in Nigeria is the scarcity of forages all year round. Livestock have abundance of pasture to take in the first six months of the rainy season during which animals are relatively well fattened. The other six months are always followed by scarcity of forages as a consequence of the dry period, resulting in standing hay and low quality feed that eventually culminates in the growth retardation of the animals (Babayemi et al., 2003).

Although certain tree legumes had been proved for supporting and sustaining ruminants as supplements in the dry season (Rogers, 2002), there are also aquatic plants yet unexplored as feedstuff for ruminants in Nigeria. Rivers, streams, brooks, swamps dams and lakes where many varieties of water plants (e.g. *Eichhornia crassipes, Nephrolepis biserrata, Spirodela polyrhiza, and Lemna perpusila*) to mention a few are located, surround almost all the regions of Nigeria. The reproductive efficiency of these water plants is high (Khan et al., 2002) and therefore, frequently block navigable waters, irrigation canals and aquaculture. Water hyacinth (*Eichhornia crassipes*) is the most common amongst these water plants in the tropics.

Water hyacinth *(Eichhornia crassipes* {*Mart.*} *Solms - Laubach)* is a water plant that grows wildly in uncultivated aquatic vegetation with no agronomic care. The growth rate is aggressive. The annual productivity of water hyacinth in the tropical region was put at 33.20 tons DM/ha/yr (Akinwande et al., 2013), while temperate region put it at 168 t/ha / year (Bates and Hentages, 1976).

The potential of this water weed as fodder for ruminants in the tropics had been reported (Mako and Akinwande 2012; Mako, 2013), however, there is need to study the digestibility and utilization of nutrients of this weed by ruminants.

This study was therefore designed to evaluate the effects of sun-cured water hyacinth with Guinea grass and concentrates on the apparent digestibility and nitrogen utilization by WAD goats.

Material and methods

Experimental site

The experiment was carried out at the goat unit of the Teaching and Research Farm Tai Solarin University of Education, Ijagun, Ijebu-Ode (7^0 15^1 N to 7^0 40^1 E)

The animal pen was made of low walls of 1 m by 1.5 m in size and each pen was about 220 cm long and 121 cm wide. The floor of the pen was made of concrete and the roof of the goat unit which housed the pens was made of corrugated iron sheets. The pens were dusted and washed thoroughly with warm detergent to remove dirt. The pens were further disinfected with broad spectrum insecticide, acaricides and larvicides (diasuntol).

Experimental animals

Twenty (20) adult female West African dwarf goats used for this experiment were randomly selected from the thirty (30) animals that were previously used for growth studies. They were 1-1.5 years of age weighing 9.18 – 11.8kg.They had adapted to the diets. The digestibility study lasted 14 days.

Collection of water hyacinth and Guinea grass

Water hyacinth was collected from river Ogun (Odogbolu Local Government area in Ogun State), the roots were discarded and the foliage was sun dried and bagged until needed. A six week re-growth Guinea grass as established (Bamikole et al; 2004) was harvested from a pasture land of the Teaching

and Research Farm, Tai Solarin University of Education, Ijagun, Ijebu-Ode and sun-cured. Known weights of sun-cured Water hyacinth and Guinea grass were oven dried at 105 ^{0}C and kept for dry matter determination**.**

Digestibility trials

Twenty female goats from the thirty used for the growth studies were randomly selected for determining the digestibility and N-balance of the diets. The goats were confined in individual modified (Akinsoyinu, 1974) metabolism cages for a separate collection of faeces and urine in a completely randomized design. The goats were offered the feed during seven days adaptation period prior to 7 days collection period; water and salt lick were accessible throughout the metabolic period. Water hyacinth was fed at 0800 h, while Guinea grass was fed at 1600 h and concentrate was fed at 1800 h each day. Refusals were weighed the following morning at 0700 h and deducted from the total amount served for the determination of feed intake. Daily feeds were served to meet 5 % of goats body weight (1 % of CC, 4 % WH and GG) and this was frequently adjusted to ensure that each animal receive about 20 % of feed above its previous days consumption. Feed refusal was sampled daily and mixed for the entire collection period on an individual basis using an air tight plastic bag. Samples from refusals were taken for proximate composition analysis. Fresh water was served each day; salt lick was placed permanently in each cage

The animals were weighed at the beginning and end of the digestibility trials. During seven days of collection period, total faeces were collected and weighed daily. A 10 % sample of total faeces was stored in a freezer at –10 ^{0}C. After 7 day collection period, the sample from each day was bulked, mixed and dried in the oven at 60 ^{0}C for chemical analysis. All urine was collected and weighed daily in the morning using measuring plastic containers. At collection, 2 ml of 10 % sulphuric acid was added to each container to prevent microbial growth and loss of nitrogen. Ten percent of total urine was sampled daily and stored at -4 ^{0}C for nitrogen analysis.

Composition of experimental diet

Treatment 1 ---- 0WH + 90GG + 10CC
Treatment 2 ----- 30WH + 60GG + 10CC
Treatment 3 ------ 45WH + 45GG + 10CC
Treatment 4 ------ 60WH + 30GG + 10CC
Treatment 5 ----- 90WH + 0GG + 10CC

Chemical analysis

The supplemental feeds and residues or refusal and dried faeces were ground separately through a 1 mm mesh screen for analysis. Two grammes each of milled samples in duplicate were used for proximate chemical analysis. Crude protein determination was by Kjeldahl technique which involved the digestion of the samples in concentrated sulphuric acid which converted the sample nitrogen to ammonium sulphate. After digestion, the digest was cooled, diluted to mark with distilled water in 250 ml volumetric flasks. The digest was distilled with weak acid (boric acid) and titrated in a Kjeldhal apparatus with 60 % sodium hydroxide which changed the sample nitrogen into ionized ammonium. The solution was then distilled, and the distillate containing the ammonium was automatically titrated with hydrochloric acid. The percent CP was obtained by multiplying the percent nitrogen content obtained by 6.25 (AOAC, 1995). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) content of the feed and faeces were determined as prescribed by Van Soest et al. (1994).

Results

The amount of crude protein content (11.6 %) in sun-cured water hyacinth was higher than that of Guinea grass (8.41 %), but lower than the concentrate (18.1 %) (Table1). Both sun-

cured water hyacinth, dried Guinea grass and concentrate had similar levels of DM. Lignin was higher in Guinea grass but it had lower contents of ash (13.9 g /100 g DM) than Water hyacinth (18.2 g/100 g DM). However, the concentrate supplement had the lowest content of ash (7.68 g/100 g DM). Highest (71.5 %) and lowest (39.7 %) neutral detergent fibre contents were obtained in Guinea grass and concentrate respectively. The DM of experimental diets followed the same trend with the ingredients. Crude protein was highest for the diet 90% WH and lowest for the diet 0%WH, while the NDF values followed a reverse order.

Table 1: Chemical composition of ingredients and experimental diets (g/100 g DM)

Diets	Dry matter	Organic matter	Crude protein	Crude fibre	Ash	Ether extract	NDF	ADF
WH	89.00	81.80	11.63	21.30	18.20	1.27	66.32	43.33
GG	90.10	86.09	8.41	34.01	13.91	1.81	71.52	48.32
CC	89.80	92.32	18.10	13.71	7.68	3.88	39.71	21.10
0%WH	89.77	87.20	10.33	29.29	12.80	2.22	66.86	43.27
30%WH	89.66	86.49	11.12	27.34	13.51	2.10	63.48	40.81
45%WH	89.57	85.77	11.81	24.15	14.23	2.04	61.78	38.91
60%WH	89.62	84.77	12.43	22.28	15.23	1.94	58.41	35.85
90%WH	89.54	83.88	13.04	19.79	16.12	1.80	55.86	33.31

Apparent digestibility by WAD goats fed sun-cured Water hyacinth

Apparent digestibility (%) of dry matter (ADDM), organic matter (ADOM), crude protein (ADCP), neutral detergent fibre (ADNDF), by goats are presented in Table 2. The digestibility values of ADDM, ADOM and ADCP ranged from 66.45 - 80.94 %, 63.88 – 79.29 % and 67.89 – 80.13 % respectively in 90 % WH to 0 % WH diets. There were significant differences in the apparent digestibility among treatment means of goats fed 45%, 60% and 90% WH inclusion, but no significant variations was observed among treatment means of goats on 0% and 30% WH diets, however no significant variation occurred in the ADNDF of all diets it ranged from75.95 – 86.26% in 90% and 0% WH diets respectively.

Table 2: Apparent nutrient digestibility (g/100 g DM) by WAD goats fed sun-cured Water hyacinth with Guinea grass and concentrate

	0%WH	30%WH	45%WH	60%WH	90%WH	SEM
Dry Matter	80.94^{a}	76.12^{ab}	76.03^{ab}	73.23^{ab}	66.45^{b}	**2.043**
Crude Protein	80.13^{a}	78.88^{a}	75.15^{ab}	71.20^{ab}	67.89^{b}	**1.924**
Organic Matter	79.29^{a}	74.83^{a}	74.36^{ab}	70.25^{ab}	63.88^{b}	**2.114**
Crude Fibre	84.47^{a}	79.51^{ab}	75.21^{abc}	71.97^{bc}	68.64^{c}	**1.848**
Ether Extract	88.95^{a}	88.76^{a}	85.01^{ab}	83.62^{ab}	80.23^{b}	**1.165**
Neutral Detergent Fibre	86.26	80.03	80.88	76.20	75.95	**2.335**
Acid Detergent Fibre	**83.84^{a}**	**80.54^{ab}**	**77.48^{ab}**	**75.59^{ab}**	**71.90^{b}**	**1.790**

a,b,c, = Means on the same row with different superscripts are significant (P<0.05)
WH = water hyacinth, GG = Guinea grass, CC = concentrate

Nitrogen utilization by WAD goats fed sun-cured Water hyacinth

Table 3 shows N- utilization by WAD goats. N-intake, faecal-N, urinary-N, N-excreted, N-Balance, and N- retention, which ranged from 3.73-6.51 g/d, 0.46- 0.63, 2.32 – 2.57, 1.41 – 4.15, 37.7 - 63.95 % respectively. Significant variations were observed in N-intake, urinary –N, total N excreted, N-balance and N-retention. Variations observed in faecal –N (g/d) as affected by treatments were not significant. Intake of goats on 0 % WH was not significantly different from N-intake of goats on 30 %, but was significantly different from goats on 45 %, 60 % and 90 % WH diets. Total N-excreted (g/d) was significantly lowest (2.32 g /d) for goats on 90% WH diet and highest (2.57 g/d) for goats on 60 % WH diet. The highest (4.15 g/d) and least (1.41 g/d) N-balance were observed for goats on 0% and 90% WH diets respectively. The same trend was observed for the N-retention (%).

Total digestible nutrients by WAD goats fed sun-cured water hyacinth

Digestible crude protein (DCP), crude fibre (DCF), ether extract (DEE), nitrogen free extract (DNFE) and total digestible nutrients (TDN) presented in Table 4 ranged from 9.54-11.91, 12.52-20.11, 4.35-4.88, 29.46-37.77 and 58.02-73.30 respectively. DCP and DNFE by goats on 0% and 90 % WH diets did not differ significantly, but significant variations were observed from goats on 45 %, 60 % and 90 % WH diets. DCF, DEE and TDN differ significantly among treatment means. The least (58.02) and highest (73.3) were observed in goats on 90 % and 0 % WH diets respectively.

Table 3: Nitrogen utilization by WAD goats fed different combinations (%) of water hyacinth and guinea grass with concentrate

	Diet composition					
Parameter	0WH	30WH	45WH	60WH	90WH	SEM
N-intake (g/g)	6.51^{a}	6.68^{a}	5.96^{ab}	4.68^{bc}	3.37^{c}	0.43
Faecal-N (g/d)	1.87	1.80	1.94	1.95	1.86	0.04
Urinary-N (g/d)	0.49^{bc}	0.50^{bc}	0.57^{ab}	0.63^{a}	0.46^{c}	0.02
Total-N excreted (g/d)	2.36^{b}	2.38^{b}	2.50^{ab}	2.57^{a}	2.32^{b}	0.04
N-Balance (g/d)	4.15^{a}	4.30^{a}	3.46^{ab}	2.11^{bc}	1.41^{c}	0.27
N-Retention (%)	63.60^{a}	63.95^{a}	58.05^{ab}	44.39^{b}	37.69^{c}	1.68

a,b,c,: means along the same row with different superscripts are significant ($P < 0.05$)
WH = water hyacinth

Table 4: Total digestible nutrients (%) by WAD goats fed sun-cured water hyacinth with Guinea grass and concentrate mixtures

	Diet composition					
Parameters	0WH	30WH	45WH	60WH	90WH	SEM
Crude protein	11.03^{a}	9.45^{b}	9.23^{b}	8.65^{b}	11.91^{a}	0.26
Crude fibre	20.11^{a}	18.39^{ab}	17.25^{bc}	15.75^{c}	12.82^{d}	0.37
Ether Extract	4.71^{ab}	4.45^{b}	4.35^{c}	4.17^{c}	4.88^{a}	0.05
Nitrogen free extract	37.55^{a}	37.34^{a}	32.31^{ab}	29.46^{b}	37.77^{a}	1.13
Total digestible nutrients	73.30^{a}	67.38^{ab}	67.07^{ab}	61.65^{b}	58.02^{c}	2.02

a,b,c,d = means along the same row with different superscripts are significant ($p<0.05$), WH = water hyacinth

Discussion

It was observed that the digestibility of nutrients had an inverse relationship with increasing level of water hyacinth in the diets. This progressive decrease in digestibility of nutrients with increasing level of water hyacinth might be due to the reduction in the buildup of rumen micro-organisms responsible for the breakdown of crude fibre (Kane et al., 1959). Highest values of digestibility of nutrients were recorded for 0 % WH and 30 % WH inclusion diets, while the lowest digestibility values of nutrients were recorded in the diet of 90 % WH inclusion. The DMI is a basic limiting factor in feed utilization since this will affect the overall performance of the farm animals.

It has to be emphasized that in the present study the nutritive value of water hyacinth appeared to be higher than that of Guinea grass, as assessed by higher crude protein and lower cell wall contents. An earlier study also predicted a relatively high nutritive value for water hyacinth as indicated by *in vitro* digestibility data (Mako et al., 2011). However the reduced digestibility of WH could be attributed to the physical nature of water hyacinth and presence of anti-nutritional factors.

The high total digestible nutrients (TDN) and apparent digestibility of dry matter (ADDM), organic matter (ADOM), crude protein (ADCP), and positive N- balance obtained in this study for 0WH, 30WH and 45WH may be indicative of proper utilization of the feedstuffs. These results are higher than previous studies involving Guinea grass with *Leuceana lucocephala* (Adejumo, 1987) and *Panicum* maximum with *Ficus religiosa* (Bamikole et al., 2003). The nitrogen retention obtained here was higher than the value obtained for rabbits fed water hyacinth leaf meal (Dairo, 1999). The ADCP by WAD goats on 0 % WH and 30 % WH inclusion levels are similar, this suggests that at 30 % level of inclusion water hyacinth can replace *Panicum maximum* without deleterious effect on the digestibility and nitrogen utilization by WAD goats fed water hyacinth based diet.

Conclusion

The estimated chemical composition of water hyacinth was a proof of its potential of sustaining dry season animal production. Although the moisture content of the forage was very high resulting in very low dry matter, it has been proved in this study that sun-curing improved the dry matter of the forage considerably. The results revealed that the highest crude protein and dry matter digestibility, nitrogen balance and retention, total digestible nutrients were recorded for goats fed 30% water hyacinth level of inclusion.

It can be concluded that optimal digestibility of nutrients and nitrogen utilization by the West African dwarf goat were attained when 30% of the conventional Guinea grass was replaced with sun - cured water hyacinth.

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