NUTRITIONAL QUALITY AND UTILIZATION OF WATER HYACINTH -CASSAVA PEELS SILAGE BY WEST AFRICAN DWARF (WAD) GOATS

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Abstract

Twenty West African Dwarf goats aged between 1-1.5 years and balanced for sex, weighing between 11kg–12kg were fed variable levels of Water hyacinth (E*ichhornia crassipes*) in cassava peels silage. The aim was to investigate the nutritional value and utilization of water hyacinth (E*ichhornia crassipes*) in cassava peels silage. A completely randomized design with five treatments and four replicates was used as water hyacinth replaced cassava peels at 0% (control), 15%, 30%, 45% and 60% in the formulated diets designated as WH0, WH15, WH30, WH45 and WH60 respectively with 20% *Panicum maximum* and 20% sundried poultry droppings added to make up complete diets. At the end of the study; the observed dry matter intake, crude protein intake and average live weight gain values were significantly (P<0.05) different and were influenced by the treatment diets. The best performance indices were seen in the goats fed treatment (WH0) at significant (P<0.05) levels while goats fed treatment WH15 compared favourably with the control. Goats fed higher water hyacinth levels in WH30, WH45 and WH60 presented relatively lower performance indices. Hence 15% water hyacinth inclusion (WH15) in West African Dwarf goat's diet would be a good source of nutrient and a valuable alternative feedstuff for ruminant animals during the dry seasons and food scarcity periods.

Keywords: water hyacinth, digestibility, goats, silage, growth.

Introduction

The livestock sector is reputable for being a significant contributor of economic and social benefits to the rural population by the delivery of animal protein, income, foreign exchange, employment, and sustainable agricultural products (Alders *et al*. 2021). Livestock accounts for approximately 17 percent of total calorie consumption and 33 percent of human protein consumption (FAO 2018). Nutrition has a significant impact on livestock animals' survival, growth rate, health status, product quality, profitability, and sustainability. (Fernandez 2017). Ruminants in the tropics rely primarily on natural pastures for feed; however, their productivity is hampered during the dry seasons, when grasses lose nutrients while consumers' demand for livestock products rises (Duguma and Janssens 2021, Henchion *et al*. 2021). In view of these; cheap, readily available but healthy agro-industrial by-products like sundried cassava peels, reported to be of high potential as a feed source could reduce production cost. Ingredients including water hyacinth, cassava peels, corn cobs, abattoir waste, poultry droppings are used to supplement some feed constituents, lowering feed costs and decreasing feed-food competition (Godoy*et al*. 2021, Singh *et al*. 2021) especially in the dry seasons.

Water hyacinth (*Eichhornia crassipes*) is adjudged to be one of the most intrusive aquatic plants and a danger to biodiversity. It is locally prevalent in sloughs, ponds, and water ways (Indulekha and Thomas 2019). It lowers water oxygen levels, hinders water flow and access to sunlight and endangers aquatic organisms' survival. (Madikizela 2021). Despite being considered detrimental, water hyacinth has high crude protein content (25.6-30.60%), and compares well with soybean meal (Hontiveros*et al*. 2015; Enyi *et al*. 2020). It may therefore may be harnessed into leaf protein feed resource for animals, reducing feed cost and facilitating animal growth, while its harvesting contributes to its control in the waterways (Harun *et al*. 2021, Teye*et al*. 2021). Through this study, the performance of growing WAD goats fed variable levels of water hyacinth in cassava peels silage was evaluated.

Problem Statement

The menace caused by water hyacinth been an invasive plant but rich in crude protein could be reduced to the barest minimum if it is exploited as a component of ruminants' diet especially in the dry seasons when pastures diminish in nutrients and could not sufficiently supply all the nutritional needs of the animals.

Materials and Methods

Experimental Site

The project was carried out at the small ruminant unit of the Teaching and Research Farm, of the Federal University Oye-Ekiti. Nigeria The laboratory analysis was done at the Diagnostic and Nutrition Laboratory of the Department of Animal Production and Health, Federal University Oye-Ekiti, Nigeria. The project location lies within Longitudes E 005° 29.573 and Latitudes N 07° 48.308, at an elevation of 548.4 meters above the sea levels and with an annual rainfall of 1778mm.

Feed Preparation

Fresh water hyacinths were harvested from the River Niger, at Lokoja in Nigeria. The plants' roots were cut off and the shoots were further lacerated, and wilted under shade for 48 hours on polythene sheets. Cassava peels and Poultry dropping collected from the "garri" production factory and the University Teaching and Research Farm respectively were sun-dried for 7 days to reduce their moisture contents. *Panicum maximum* was obtained from within the University environment.

The cassava peels were replaced with the water hyacinth at 0, 15, 30, 45, and 60 percent levels in diets labeled as WH0, WH15, WH30, WH45, and WH60, respectively, with 20 percent *Panicum maximum* and 20 percent sundried poultry droppings added to make up complete diets (Table 1). These diets were designed to have 12% crude protein. Plastic drums (100 liter capacity) were used as silos. Ensiling was done by rapid compaction of water hyacinth, cassava peels,sundried poultry droppings and *Panicum maximum*in various proportion into large polythene bags placed inside the plastic silos; samples with no water hyacinthwas also ensiled as the control. Sealing of the silos was done and the prepared silage samples were left to ferment for 21 days. Immediately after opening the silos, 0.5kg sample of each diet was taken from the bulk by drawing portions from different depths of the silos and mixed up to ensure homogeneity of the sample. The pH values and the physical properties such as moldiness, texture, aroma, colour and moistness of the silage were evaluated with the help of some volunteers. The silage products were then removed from the silos and air dried for 10 days, to reduce moisture content, inhibit further microbial activities and to enhance feed acceptability by the experimental animals.

Management of experimental animals

Twenty young West African Dwarf goats weighing 11kg-12kg and aged 1-1.5 years were obtained from a neighboring village in a bid to assess the nutritional quality and its utilization of water hyacinth-cassava peels silage. Dentition and information from the goat owners were used to estimate the age of the animals. The animals were brought in after cleaning and disinfecting the semi-open sheds pen (2m x 3m dimension). The animals were kept in isolation for a total of two weeks at the experiment site in order to monitor any illnesses and promote adaptation. The animals were treated with antibiotics (Oxytetracyclin 200LA, 0.6ml) to enhance their immunity against infections during the adaption phase in addition to an ectoparasite treatment using Cypermethrin "Ectocyp Pour on" (0.7ml) and an endoparasite treatment using ivermectin ("Tectin") (0.15ml). The Pestes *de petit Ruminate* (P.P.R) vaccine was later given. The 70-day experiment included a 56-day growth trial and a 14-day digestibility trial. The pens were cleaned every day and the wood shavings used as the beddings were changed fortnightly. No mortality was recorded during the trial.

Growth trial

The growth trial was a completely randomized design (CRD), with five treatments of four replicates and goats randomly assigned based on their initial body weights and balanced for sex. Fresh water and mineral-salt lick were provided *ad libitum* daily in individual pens. Feed offered and refused was collected, weighed, and recorded daily before fresh feeds were given in the mornings. The experimental diets were given at 3% body weight at 0700h and 1600h during the 56-day trial. Each goat was weighed (non-shrunk) at the start of the experiment and at weekly intervals before early morning feeding using a 50kg electronic digital hanging scale to track any weight changes (WeiHeng brand). The feed constituents and experimental diets were dried, ground, bulked, and analyzed for dry matter (residue after drying to constant weight at 100°C), ash (residue after ignition at 500°C), crude protein (Kjeldahl N x 6.25), ether extract or fat extract (dry sample with ether for about 4 hours), and crude fibre (Goering and Van Soest 1970; AOAC 2012). The average daily feed intake, dry matter intake, weekly weight gain, average daily gain, and feed conversion ratio were all assessed. There was no recorded mortality.

Digestibility Trial:

Three goats from each treatment were transferred to the metabolic cages with facilities for collecting urine and faeces separately at the conclusion of the growth trial for the commencement of the digestibility trial. The same feed used for the growth trial was also used in the digestibility trial. The first four days were used to acclimatize the animals to the metabolic cages. The separate collection of faeces and urine for analysis was done over the course of the final ten days of the digestibility trial. The average daily feed intake, weekly weight gain, and average daily gain and apparent digestibility coefficient were determined.

Data collection and Chemical Analysis

The total faeces voided were collected, weighed and thoroughly mixed, and then 10% aliquot samples were taken and oven-dried at 60°C for 48 hours to a constant weight. Prior to chemical analysis, the dried fecal samples were milled using a laboratory hammer mill to pass through a 2mm sieve. Results obtained were used to determine the apparent digestibility co-efficient and percentages of the digestible nutrients. To prevent nitrogen escape, urine was collected daily into a graduated plastic container laced with 2-3 drops of H_2SO_4. Standard methods were used to determine the dry matter, crude protein, crude fiber, and ether extract of the faeces (AOAC 2012).

Statistical analysis

The analysis of variance (ANOVA) of data recorded was run with the General linear model technique of SAS (2008). The standard deviation and coefficient of variation were calculated, and where significant differences were found, the Duncan's Multiple Range Test (Duncan 1955) was used to separate treatment means. For all statistical analyses, significance was accepted at $P < 0.05$.

Ethical Statement

The authors confirm that ethical approval was obtained from the appropriate local ethics committee at the commencement of this study.

Results and Discussions

Nutritional Constituents of the Experimental Feed

Chemical composition of the experimental feedstuffs that comprised the treatment diets was presented in Table 1. The high crude protein content of the feeds indicated that the diets contained adequate dietary nitrogen and were suitable for feeding small ruminant animals. According to Mina (2018) and (Lareo and Bressani, 2019), water hyacinth leaves can be utilized as ruminant fodder because they contain up to 20% or 38% crude protein which correlates with the observed CP (33%) of the water hyacinth used in this study.Water hyacinth has also been considered a good nutritional supplement due to its ability to supply nutrients all year round in livestock feeds and reportedly compares favorably in terms of nutrients to other conventional feed resources (Adeyemi and Osubor 2016). It has been used with success in feeding rabbits (Teye*et al*. 2021), Cattle (Sophal *et al.* 2010), does (Fitrihidajati 2017; Olanrewaju *et al*. 2021;Yusuf *et al*. 2021), Piglet (Tiwari *et al.* 2020) and Ducks**,** (Agnetwest 2020). Cassava peels are rich in soluble protein and gross energy (19 MJ/kg) and useful as animal feed (Hindawi 2019).

Table 1: Gross and Nutrient Composition of Water Hyacinthin Cassava Peels Silage Diets (g/100g).

Components	Diets				
	WH0	**WH15**	**WH30**	**WH45**	**WH60**
Cassava peels	60.00	45.00	30.00	15.00	--
Eichhonia crassipes	--	15.00	30.00	45.00	60.00
DriedPoultry droppings	20.00	20.00	20.00	20.00	20.00
Panicum maximum	20.00	20.00	20.00	20.00	20.00
Total	100	100	100	100	100
Proximate composition					
Dry matter	94.06	92.24	89.80	86.10	84.00
Crude protein	24.70	24.62	21.84	19.91	17.16
Crude fibre	17.14	19.78	20.19	22.85	23.65
Ether extract	6.95	6.75	6.45	5.79	4.96
Ash	16.52	14.05	11.59	9.70	10.40
Nitrogen free extract	34.69	34.80	39.93	41.75	43.83

WH0, WH15, WH30, WH45,WH60: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets.

The physical properties and the pH of the silages

The physical properties and the pH of the silages were presented in Table 2. The observed absence of mold, non-sticky texture, acceptable pH and the pleasant aroma in all the treatment samples signifies absence of harmful microorganisms and its safety as a feed for the experimental animals (Thomas 2008). According to reports, fermented feed may be able to keep gastrointestinal micro flora in a state of balance and sustain intestinal health. (Toppo 2021). Water hyacinth are reported to be high in crude fibre, cellulose and hemicellulose content (Punitha *et al.* 2015), this could account for the observed rise in crude fiber content with increasing levels of water hyacinth inclusion in the treatment diets. The ash content of the diets was within the recommended values indicating that the goats were supplied adequate minerals and micronutrients (NRC 1981).

Table 2: Physical Properties and pH of the Water hyacinthin Cassava Peels Silage.

PROPERTIES	WH0	WH15	WH30	WH45	WH60
pH	3.66	3.62	3.91	4.10	3.75
Mouldiness	No mould	No mould	No mould	No mould	No mould
Odour	Slightly Pungent	Pleasant	Pleasant	Choking	Pungent
Colour	Dark brown	Brown	Greenish	Brownish green	Greenish
Moistness	Slightly moist	Moist	Moist	Moist	Highly moist

WH0, WH15, WH30, WH45,WH60: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets.

Feed and nutrient intake in the experimental animals

Findings from this study indicated that dry matter intake (DMI) were significantly (P<0.05) influenced by the treatment diets (Table 3), treatments WH0 and WH15 had higher dry matter intake values than other treatment diets; this supports the findings of Yusuf *et al*. (2021), who reported significantly (P <0.05) higher nutrient intake in goats fed 0% and 5% water hyacinth than others fed higher values. Generally in this study, ensiling the treatment diets may have contributed to the consistent DM intake, which corroborates previous reports by Heuze *et al*. (2015), and Indulekha and Thomas (2019) that ensiling water hyacinth improves palatability and preservation. In this study, the observed DM intake decreased as the water hyacinth inclusion level increased; in that goats fed WH60 had the least DM intake and this agrees with reports of Dada (2001) that the inclusion of water hyacinth at levels more than 25% in goats' diet reduces feed intake and causes poor performance. The DM intake observed also resonates with the findings of Abdelhamid and Gabr (2007) that increasing proportions of water hyacinth cause a linear decrease in dry matter intake, especially when water hyacinth was gradually increased to 100% in diets of sheep fed rice straw and concentrates

Table 3:Nutrient Intake in Experimental Animals fed Varying Levels of Water Hyacinth (g/kgW$^{0.75}$)

Nutrients	WH0	WH15	WH30	WH45	WH60	SEM
Dry Matter	153.24^{a}	141.88^{b}	121.24^{c}	100.82^{d}	88.45^{e}	1.15
Crude Protein	53.69^{a}	49.59^{b}	38.73^{c}	29.15^{d}	18.24^{e}	1.04
Crude Fibre	40.82^{a}	42.08^{a}	36.52^{b}	32.32^{c}	23.20^{d}	0.11
Ether Extract	20.73^{a}	18.86^{b}	15.5^{c}	11.52^{d}	10.19^{d}	0.94
Ash	33.71^{a}	32.55^{a}	24.08^{b}	16.99^{c}	12.51^{d}	0.47
Nitrogen Free Extract	69.26^{a}	64.23^{b}	60.9^{c}	50.81^{d}	26.87^{e}	1.73

*a, b, Mean values with different superscripts within a row differ significantly (P<0.05), SEM: Standard error of means; WH0, WH15, WH30, WH45,WH60: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets.

Apparent nutrients digestibility co-efficient of experimental animals

The apparent digestibility co-efficient of the various experimental diets is shown in Table 4, and it was calculated as the difference between nutrients consumed and nutrients excreted in faeces expressed as a percentage of nutrient intake (Bello and Tsado 2013). Digestion and palatability of the experimental diets was perceived to be enhanced by ensiling. Higher feed digestibility was observed in treatments WH0 and WH15 having 77.63% and 75.42% digestibility levels than observed in other treatments. Fermentation of feeds is said to increase palatability, digestibility, maintain intestinal health, homeostasis in gastrointestinal micro flora, nutrient absorbance level, immunomodulation through diet manipulation and lowers the pH level in stomach, which suppresses growth of pathogenic microbes, particularly those carried in by feedstuffs (Missotten *et al.* 2015; Isnawati *et al*. 2021). Fitrihidajati *et al*. (2017) also discovered that goats fed fermented water hyacinth had higher digestibility and bodyweight.

Table 4: Apparent Nutrient Digestibility Coefficient in Experimental Animals fed the Experimental Diets (%

Nutrients	WH0	WH15	WH30	WH45	WH60	SEM
Dry Matter	77.63^{a}	75.42^{b}	67.35^{c}	59.97^{d}	51.87^{e}	0.54
Crude Protein	74.2^{a}	71.74^{b}	62.82^{c}	56.63^{d}	52.93^{e}	0.16
Crude Fibre	70.09^{a}	67.42^{b}	62.40^{c}	60.75^{c}	50.76^{d}	1.20
Ether Extract	71.65^{a}	68.35^{b}	64.61^{c}	52.20^{d}	51.79^{d}	0.62
Ash	70.00^{a}	72.10^{a}	61.30^{b}	55.45^{c}	49.80^{d}	0.44
Nitrogen Free Extract	72.58^{a}	70.36^{b}	60.71^{c}	58.00^{d}	48.60^{e}	0.15

*a, b, Mean values with different superscripts within a row differ significantly (P<0.05),
SEM: Standard error of means; WH0, WH15, WH30, WH45,WH60: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets

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Performance evaluation of the experimental animals

The treatment diets had a significant (P<0.05) influence on the performance of the experimental animals as shown in (Table 5). Goats served the control diet (WH0) and the treatment WH15 both experienced the leading weight gains; this agrees with reports by Fitrihidajati *et al*. (2017) who reported higher weight gain in goats fed water hyacinth feed formulas over animals fed the conventional feeds. The feed conversion ratio of WH0 and W15 were not significantly different (P>0.05), nor were treatments WH30 and WH45; however, treatment WH60 showed a significant difference (P<0.05); the results showed that any of these prepared diets might support goats' growth except treatment WH60; this agrees with reports by Moselhy *et al.* (2022) and Thepyothin *et al*. (2021) that urea increases the nutritional value and quality of water hyacinth silage, and that ensiling preserves feed energy, lowers microbial populations, and maintains the nutritional value of excreta-based feeds. The experimental goats fed diets WH0 and WH15 converted their feed to flesh (4.60, 4.97) well and performed better than the other treatments, this agrees with Mani (2018) who reported higher growth performance of Awassi lambs; when water hyacinth leaves were used to substitute for maize at 10% inclusion level in formulated diets. In comparison to goats fed greater percentages, Yusuf *et al*. (2021) established that goats fed diets containing 0% and 5% of sun-dried water hyacinth had higher mean weight gains, maximum performance, and feed conversion ratios. This was contrary to reports by DADA (2002) who reported the best performance at higher inclusion level of 40% of sundried water hyacinth in growing goats; and the report of Shigdaf *et al.* (2018) opined that withered water hyacinth leaves could effectively replace concentrate mix for Washera sheep at levels between 50% and 75%. No toxicity was observed from the animals and this aligns with reports that water hyacinth silage can be used in ruminant diets with huge acceptance, dry matter, and protein digestibility outcomes without threat of toxicity (Lareo and Bressani, 2019).

Table 5: Performance of Experimental Animals fed Varying Levels of Water Hyacinth.

Parameters	WH0	WH15	WH30	WH45	WH60	SEM
Dry Matter Intake	153.24^{a}	141.88^{b}	121.24^{c}	100.82^{d}	88.45^{e}	0.11
Initial Liveweight(kg)	11.05	11.33	12.00	11.7	11.68	1.07
Final Liveweight(kg)	13.38^{a}	13.33^{a}	13.42^{a}	12.74^{b}	12.18^{b}	0.80
Liveweight Gain (kg)	2.33^{a}	2.00^{a}	1.42^{b}	1.04^{bc}	0.65^{c}	0.77
Liveweight Gain(g/d)	33.29^{a}	28.57^{b}	20.29^{c}	14.86^{d}	9.29^{e}	0.59
Feed Conversion Ratio	4.6	4.97	5.98	6.79	9.52	1.40

*a, b, Mean values with different superscripts within a row differ significantly (P<0.05),
SEM: Standard error of means; WH0, WH15, WH30, WH45,WH60: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets.

Conclusions

The assessment of nutritional quality and utilization of water hyacinth-cassava peels silage through the West African Dwarf goats in this study indicated that values observed exhibited significant (P<0.05) differences among the treatment means which was due to the treatment effect. West African Dwarf goats fed the control diet (WH0)) had the highest feed intake, apparent nutrient digestibility coefficient, average weight increase and feed

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conversion ratio; closely followed by treatment WH15 at significant ($P<0.05$) levels. Experimental animals on treatment WH0 recorded the highest values and consequently best utilization and performance indices among the treatment means; however, experimental animals on treatment WH15 compared favourably well with WH0. Hence, 15% water hyacinth inclusion in West African Dwarf goats' diet would be a valuable alternative feedstuffs and a good source of nutrients for ruminant animals during the dry season and times of food scarcity.

Acknowledgement

The authors are grateful to the Federal University Oye-Ekiti for the facility provided for undertaking this study.

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