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GROWTH PERFORMANCE, NITROGEN UTILIZATION AND ECONOMICS OF RED SOKOTO BUCKS FED *Saccharomyces cerevisiae*-TREATED GROUNDNUT HAULM AND DRIED CASSAVA PEEL-BASED DIETS

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ABSTRACT. This study investigated the growth performance, nitrogen balance, and economics of production of Red Sokoto bucks (RSBs) fed *Saccharomyces cerevisiae*-treated, biodegradable groundnut haulms (SCGH) and dried cassava peels (DCP). Four dietary treatments were formulated including a control diet (T1; 0% SCGH:DCP) and DCP in combination with SCGH at the different proportions of 275:695 (T2), 375:595 (T3), and 475:495 (T4) g/kg of dry matter (DM). A combination of 5 g and 50 g of yeast as a probiotic and molasses, respectively, were added to 1 kg of GH after been dissolved in 1 L of water. Twelve healthy RSBs weighing 9.5 ± 0.40 kg of body weight (BW) and aged 7 to 8 months were exposed to four treatments. This was replicated three times in a completely randomized design (CRD). The experiment lasted for 90 days. The average final weight, average daily weight gain (gram/day), nitrogen intake, and nitrogen balance were significantly influenced by the inclusion of DCP and SCGH in the diets. There was no significant difference ($p > 0.05$) between the ADG of T1 (58.20 g/d) and the T4 (58.89 g/d) groups. Feed conversion ratio and feed-cost saving ($630.80) increased with the inclusion of DCP and SCGH in the goats' diets. In conclusion, T4 (SCGH: 475g, DCP: 495g) had a better chemical composition, ADG, nitrogen balance, and feed-cost saving; therefore, SCGH are recommended and are readily available agricultural wastes that can be fed to RSBs to improve performance and nitrogen utilization in a cost-effective way, especially during dry season.

Keywords: bucks; cassava peels; nitrogen balance; probiotics; yeast.

INTRODUCTION

Feed is the main factor restricting livestock productivity, particularly in developing nations. This has forced researchers to look for readily available and affordable feed sources for goats such as agricultural wastes and agro-industrial by-products (FAOSTAT, 2013). In Nigeria, cassava is a staple crop that is frequently planted as a substitute for dietary carbohydrates. The processing of cassava generates a large quantity of waste, which includes cassava peels, roots, and foliage. Peels from cassava are widely available, and their inappropriate disposal is still causing environmental issues that require attention.

The presence of hydrogen cyanide (HCN) in cassava peels and leaves in ruminant diets has restricted farmers in utilizing it as a feeding ruminant. If cassava peels are adequately dried and treated, this HCN can be reduced to tolerable levels (Tewe, 1991). In developing nations, cassava peels have the potential to replace other energy sources in animal rations (Omoike, 2006).

It has been reported that agricultural by-products such as cassava peels are widely available in rural areas and could be a significant source of nutrition for small ruminants (Kalio *et al.*, 2013). After post-harvest processing, the majority of the waste from cassava is the peel. The stem, leaves, peel, and other tuber by-products can be fed to ruminants (Fajemisin *et al.*, 2017, 2018), thus, the delicate stems and leaves of the plant are now being studied for use in animal feed (Akinfala and Tewe, 2004).

Based on the nutritional value of cassava peels, some of the studies suggested that it can be incorporated into the diets of goats, which could subsequently reduce feed costs (Fajemisin *et al.*, 2017, 2018). Adebowale and Taiwo, (1996) fed sheep diets containing 20% fermented cassava peels, and this resulted in growth rates that were comparable to those fed maize bran-based diets. It has been discovered that supplementing ruminant diets with probiotics (bacteria and fungus) enhances feed intake, growth performance, digestibility, and rumen microbial activity; therefore, it was thought that dried cassava peels (DCP) and *Saccharomyces cerevisiae*-treated groundnut haulms (SCGH) could be used to feed goats during dry season. This study investigated the growth performance, nitrogen balance, and economics of growing of feeding Red Sokoto bucks (RSBs) graded levels of DCP and SCGH.

MATERIALS AND METHODS

Study area

The study was conducted at Federal University, Gashua, Yobe State in Nigeria's Ruminant Unit of the Teaching and Research Farm of the Department of Animal Science. March and April are the hottest months, with average highs of 38-41.5°C, and June through September is considered the rainy season. The experiment was conducted between February and April with a temperature range of 33-41.5°C and a relative humidity of 25-35%, respectively (CLIMATEMP, 2020).

Silage-preparation procedures

Groundnut haulms (GH) were purchased from Yobe State's Garin Alkali Livestock Market. Subsequently, in accordance with the protocols of Musa *et al.* (2020), a 1 L mixture of water with 5g of yeast and 50 g of molasses was prepared and then added to 1 kg of groundnut haulm. After, the mixture was carefully packaged for anaerobic fermentation within thick polythene bags, was sealed tightly, and was squeezed to remove and minimize air. To get rid of the volatile ammonia gas, the silage was opened and allowed to aerate overnight in the shade following 90 days of ensiling (Olafadehan *et al.*, 2016).

Measurement, source and formulation of experimental diets

Four test diets were compounded and labelled as T_1, T_2, T_3, and T_4. The four dietary treatments included the control diet (T1) and the biodegradable SCGH at varying ratios of 275:695 (T2), 375:595 (T3), and 475:495 (T4) g/kg of dry matter (DM). T1 was a typical diet without SCGH and DCP. The entire mixed meal was given to each animal at a proportion of 5% of their body weight. The yeast, *Saccharomyces cerevisiae*, was acquired from M-delight Pharmaceutical Centre in Kano. GH, dried cassava peels, and other feed components were purchased from the Gashua Agro-commodity market in Yobe State. *Table 1* presents the experimental diets in g/1,000g.

Experimental procedure, design and management of experimental animals

For the experiment, twelve RSBs in good health and weighing 9.5 ± 0.40 kg of body weight (BW) were bought at the Garin-alkali market in Gashua, Yobe State. Following a veterinarian examination, the animals were divided into four nutritional regimens using a completely randomized design (CRD), with three replicates for each treatment. Each buck serve as an experimental unit. To protect them from inclement weather, each animal was kept individually in a 1.2 m × 0.9 m open-sided ruminant pen that had good ventilation. Two weeks prior to the experiment, all of the bucks received antibiotic treatments (ivermectin at 1 mL/50 kg of BW and oxytetracycline at 1 mL/10 kg of BW). The total mixed ration (TMR) provided to the animals was around 900 g per day per head (DM) at 5% of their BW. The animals were given the same amount of feed two times a day, at 8:00 and 13:00. Water was given without restriction. The test animals received their experimental diets in plastic rubbers. The animals' initial weights were determined prior to the experiment. Weekly weight measurements were then recorded. Every day, uneaten feed was removed before new feed was given. The feed conversion ratio, dry matter, and nutrient intakes were calculated. After a two-week preliminary adaption period, the experiment was conducted for 90 days.

Chemical analysis

Samples from the four experimental diets consisting of SCGH and DCP were brought to the lab and were dried individually in an air-draft oven at 60°C for 96 hours. The samples were then ground separately in a Wiley mill, were passed through a 1 mm sieve, and were sampled for chemical analysis using the Association of Official Analytical Chemists' standard procedures (AOAC, 2006). Three copies of each analysis were completed. The samples were oven-dried for 24 hours at 100°C to assess the dry matter content. The Ankom fibre analyser was used to perform fibre fraction analysis, including neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL), as reported by Van Soest *et al.* (1991). The formula presented by Robinson *et al.* (2004) yields the gross energy (MJ/Kg DM) as follows: gross energy = % Crude Protein x 16.7 + %Ether Extract x 37.7 + % carbohydrate x 16.7 (Ekaneyake *et al.*, 1999). The samples were kept at -20°C until analysis. Hemicellulose was calculated as the difference between ADF and NDF, while cellulose was the difference between ADF and ADL.

Nitrogen balance study

Following the feeding trial, the RSBs were exposed to a nitrogen-balance investigation, in which each animal was housed individually in a metabolic cage with provisions for quantitative faeces and urine collection. The goats were adapted for seven days before samples were collected and frozen at -5°C for examination. The efficiency of nitrogen utilization was measured as nitrogen balance ÷ nitrogen intake. Daily feed intake was measured during the collection period. Every morning, the orts, faeces, and urine were gathered. To avoid nitrogen loss from urine due to volatilization, 200 mL of sulphuric acid solution (100 mL/L) was added to the urine collection containers.

Table 1 - Gross composition of experimental diets (g/1,000g DM)

Ingredients	T1	T2	T3	T4
Dried cassava peels	0	275	375	475
Yeast-treated groundnut haulms	0	695	595	495
Wheat offal	200	0	0	0
Rice husk	200	0	0	0
Palm kernel cake	370	0	0	0
Balanite eagyptiaca leaf meal	200	0	0	0
Sulphur	10	10	10	10
Bone meal	10	10	10	10
Salt	5	5	5	5
Ruminant premix	5	5	5	5
TOTAL	1000g	1000g	1000g	1000g
Calculated analysis				
Crude protein (%)	13.02	13.51	13.40	13.39
GE (KJ/100g DM)	8.40	8.51	8.62	8.57

GE: Gross energy

Economic analysis

An economic analysis was conducted to assess the profitability of providing growing RSBs with control diets or DCP and SCGH-based diets, taking into account both the primary costs and additional factors. The total cost of feed provided during the feeding trial was determined by factoring in the cost of the feed ingredients. The average weight gain, feed cost per kg gained, and amount of feed used per kg gained were calculated. The calculation of feed-cost savings in naira involved deducting the feed cost per kg gained of the control diet from the amount of DCP and SCGH-based diets (Ramatu and Abdulmumin, 2020).

Data analysis

Using the Statistical Analysis Software (SAS, 2015), the data were subjected to analysis of variance (ANOVA) for a CRD with a model that included the diet as a treatment effect. The Least Significant Difference was used to separate the means at the $p < 0.05$ level.

The following statistical model was applied (*Equation 1*):

$$Yij = \mu + TS_i + eij \quad (1)$$

where Yij = Individual observation; μ = population mean; TS_i = effect of i^{th} DCP: Yeast-treated GHM based diets; eij = random error.

RESULTS

The chemical composition of the control and SCGH/DCP-based diets is shown in *Table 2*. The DM obtained in this study ranged from 91.11-93.81%. A higher DM value was obtained in T4, while T3 had the lowest DM value. The CP value ranged from 16.81-17.50. A higher CP value was obtained in T3, while T1 had the lowest CP value. DCP had a CP value of 5.95%, while SCGH had a CP value of 16.13%. The ether extract value obtained ranged from 3.91-4.17%. A higher EE value was obtained in T2, while T3 had the lowest EE value. DCP had an EE value of 3.92%, while SCGH had an EE value of 3.51%. The crude fibre value ranged from 20.55-23.77. A higher CF value was obtained in T2, while T3 had the lowest CF value. DCP had a CF value of 23.77%, while SCGH had a C value of 9.76%. The nitrogen free extract value ranged from 49.45-52.68. Higher nitrogen free extract (NFE), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), hemicellulose, and cellulose values were obtained in T4, while T1 had the lowest values for these parameters. DCP had an NFE value of 49.45%, while SCGH had an NFE value of 74.28%. The ash value ranged from 5.2-6.50. A higher ash value was obtained in T1, while T3 had the lowest ash value. DCP had an ash value of 6.50%, while SCGH had an ash value of 6.45%. The NDF value ranged from 27.60-37.11. DCP had an NDF value of 38.01, while SCGH had an NDF value of 23.56. The ADF value ranged from 21.11-26.43. DCP had an ADF value of 26.00, while SCGH had an ADF value of 19.07. The ADL value ranged from 16.07-18.42. DCP had an ADL value of 14.32, while SCGH had an ADL value of 8.63. The hemicellulose value ranged from 9.36-9.88. DCP had a hemicellulose value of 9.90, while SCGH had a hemicellulose value of 8.32. The cellulose value ranged from 5.04-8.01. DCP had a cellulose value of 11.68, while SCGH had a cellulose value of 7.65. The GE value ranged from 13.00-13.17. A higher GE value was obtained in T3, while T1 had the lowest GE value. DCP had a GE value of 13.20, while SCGH had a GE value of 13.06 KJ/100g of DM.

The growth performance of RSBs fed DCP and SCGH at graded levels in their diets is shown in *Table 3*. The average final weight (AFW) was significantly ($p < 0.05$) different across the treatments. Higher AFW were recorded in T1 and T4, and T1 had the lowest AFW (13.17kg). Similarly, the weight gained at the end of the experiment was higher in T1 and T4, with the values of 5.24kg and 5.30kg, respectively. The average daily weight gain (g/d) was significantly ($p < 0.05$) different among T1, T2, and T3, but there was no significant difference between T1 (58.20 g/d) and T4 (58.89 g/d). A better FCR was obtained in T1 (8.84) and T4 (9.61). There was no significant ($p > 0.05$) difference in the FCR of animals in T2 and T3.

Table 2 - Nutritional and HCN content of the control and experimental diets (in g/100g), unless otherwise stated

Parameters	T1	T2	T3	T4	DCP	Y-GH
Dry matter	92.61	92.21	91.55	93.81	91.11	88.12
CP	17.50	16.91	16.88	16.81	5.95	16.13
EE	4.00	4.17	3.91	4.08	3.92	3.51
CF	22.13	21.16	20.55	20.83	23.77	9.76
NFE	50.22	52.68	51.99	52.57	49.45	74.28
ASH	6.15	5.34	5.26	5.71	6.50	6.45
HCN (mg/kg DM)	ND	ND	ND	ND	26.54	ND
NDF	27.60	35.40	36.66	37.11	38.01	25.56
ADF	21.11	24.21	25.00	26.43	26.00	19.07
ADL	16.07	17.54	17.99	18.42	14.32	8.43
Hemicellulose	9.36	9.69	9.88	9.78	9.90	8.32
Cellulose	5.04	6.67	7.01	8.01	11.68	7.65
*Gross energy (KJ/100g DM)	13.06	13.16	13.17	13.13	13.00	13.20

ND; Not done, NFE; Nitrogen free extract, HCN; Hydro cyanide, NDF; Neutral detergent fibre, ADF; Acid detergent fibre, ADL; Acid detergent lignin, SEM; Standard error of the mean, DCP; dry cassava peels, SCGH; *Saccharomyces cerevisiae* -treated groundnut haulms. T1: control diet, T2: DCP 275, groundnut haulms 695g, T3: DCP 375g, groundnut haulms 595g, T4: DCP 475g, groundnut haulms 495g

Table 3 - Growth performance of Red Sokoto bucks fed a control diet or a mixture of *Saccharomyces cerevisiae*-treated groundnut haulms and dried cassava peel based-diets

Parameters	Diets					
	T1	T2	T3	T4	SEM	P-Value
Initial weight (kg)	9.83	9.10	9.60	9.40		0.03NS
Average final weight (kg)	15.07^{ab}	13.17^{d}	14.10^{c}	14.70^{ab}	0.66	0.71*
Average weight gain (kg)	5.24^{ab}	4.07^{c}	4.50^{d}	5.30^{ab}	0.21	0.62*
Average daily gain (g/d)	58.20^{ab}	46.00^{cd}	50.00^{cd}	58.89^{ab}	4.42	0.82*
Total feed intake (kg)	46.31	48.71	50.53	50.91	3.94	0.003NS
Average daily feed intake (g/d)	514.55	541.17	561.40	565.70	23.12	0.04NS
Feed conversion ratio	8.84^{cd}	11.77^{ab}	11.22^{ab}	9.61^{cd}	1.48	0.32*

^{abc} = means on the same column with different superscripts are significantly varied ($p < 0.05$). SEM; Standard error of the mean. T1: control diet, T2: DCP 275, groundnut haulms 695g, T3: DCP 375g, groundnut haulms 595g, T4: DCP 475g, groundnut haulms 495g.

The economics of production using SCGH and DCP-based diets to feed RSBs is shown in *Table 4*. The cost of feed ($/kg) was $ 0.23, $ 0.15, $ 0.13 and $ 0.12 in T1, T2, T3, and T4, respectively. T1 was more expensive than the other treatment diets. It is noteworthy that as the DCP increased, the cost of the diets decreases across the treatments.

The kg of feed consumed per kg gained was better in T1 compared to other treatments, followed by T2. T3 had the highest kg of feed consumed per kg gained. The average weight gained (kg) was higher in T1 and T4, while it was lower in T2. The feed cost/kg gained in dollar ($) was significantly higher ($p < 0.05$) in T1 and decreased progressively in T2, T3, and T4 as DCP increased. The feed-cost saving ($) was higher in T4 ($0.84), followed by T2 ($0.64). The lowest feed-cost saving ($) was recorded in T3 ($0.57).

Nitrogen intake (g/day) was significantly ($p < 0.05$) different across the treatments. The higher nitrogen intake was recorded in T3, followed by T4, while T1 had the lowest nitrogen intake. Similarly, nitrogen excretion in faeces was higher ($p < 0.05$) in T3, while T1 had the lowest nitrogen loss in faeces. The urinary nitrogen loss was higher in T1, followed by T3 and T4, while T2 had the lowest urinary nitrogen loss. The total nitrogen loss was similar among T2, T3, and T4, with the exception of T1, which had the lowest total nitrogen loss. The nitrogen absorbed was also similar among all the treatments, except for T1.

The nitrogen retained and the percent nitrogen retained was not significantly ($p < 0.05$) different across the treatments.

DISCUSSION

The study's DM and ash levels matched those of a previous study (Ramatu and Abdulmumin, 2020) that fed RSBs diets consisting of variously processed DCP. The CP levels were greater than those reported by Asaolu *et al.* (2012), who fed goats with biodegradable DCP. The diets' CP contents are adequate to satisfy the developing goats' nutritional needs. The EE and CF values that were obtained were lower than those found by Asaolu *et al.* (2012) in which West Africa Dwarf goats were supplemented diets containing DCP.

After feeding goats with diets containing on DCP and SCGH. The study's results for CP, HCN, NFE, and ADL were consistent with those published by Abatan *et al.* (2015); however, the NDF, hemicellulose, and cellulose were lower. For the study by Asaolu *et al.* (2012), the DCP had an HCN value of 26.54 mg/kg, which falls within the recommended level for feeding small ruminants.

This study made use of air-dried DCP and the addition of sulphur to lower the peels' HCN content. This was supported by Niayale *et al.* (2020) assessment of the impact of DCP silage on various fermentation parameters and the growth characteristics of sheep raised on farms.

The ADF was less than that stated by Ukanwoko *et al.* (2013), whose study involved feeding oil palm leaf meal and diets based on DCP to WAD goats. The GE found in this study was greater than what Abatan *et al.* (2015) stated.

The ADG recorded by Ramatu and Abdulmumin (2020) after feeding RSBs diets that included variously processed DCP was 30.03g. The ADG acquired by animals in both the control and other treatments (46g-58.89g) was greater. The animals in T2 (46.0 g/day) that were fed a mixture of CSP: 275 g + GH: 675 g may have had a lower ADG value because there was less CSP in the mixture, which provided insufficient energy for the RSBs to grow to their full potential.

The ADG of 46-58.89 g/day observed in this experiment is similar to that reported by Bawala *et al.* (2007), where they fed sabara (*Guiera senegalensis*) leaf meal (32-50 g/day) to RSBs. The results of this study's analysis of AFW, WG, and ADG were higher than those published by Abatan *et al.* (2015), where WAD goats were given a ration containing DCP and foliage. This might be because the goats used in the research were of different breeds and it has been documented that breeds differ in both their birth weight and growth rate (Ramatu and Abdulmumin, 2020).

The addition of DCP and SCGH to the RSBs' meals did not significantly alter the TFI or ADFI values, but they were higher than those found in a study by Ramatu and Abdulmumin (2020) that fed RSBs diets that included variously processed DCP. This may be explained by the fact that each animal is unique, as well as the type of feed that the test animals were given.

It was observed that FCR in this study was comparable to that reported by Bawala *et al.* (2007), wherein WAD sheep were fed a diet consisting of rumen epithelial waste and DCP.

The study's results for feed cost and feed cost savings ($0.57 - $0.84) were less than those reported by Ramatu and Abdulmumin (2020). The lower cost might result from the period of the purchase, the sourcing of feed ingredients, and the larger percentage of DCP utilized in the study (47%).

The nitrogen intake and percentage nitrogen retained were comparable to those found in a study by Bawala *et al.* (2007), in which West African dwarf sheep were fed diets consisting of rumen epithelial waste and DCP. The levels of nitrogen found in the faeces and urine and total nitrogen, nitrogen absorbed, and nitrogen retained were all higher than those found in the study by Bawala *et al.* (2007), in which WAD sheep were fed diets containing rumen epithelial waste and DCP.

Table 4 - Economic analysis of Red Sokoto bucks fed a control diet or a mixture of *Saccharomyces cerevisiae*-treated groundnut haulms and dried cassava peel-based diets

Parameters	Diets			
	T1: CON	T2	T3	T4
Cost of feed ($/kg)	0.23	0.15	0.13	0.12
Kg feed consumed per kg gained	8.84	9.31	11.23	9.61
Average weight gained (kg)	5.24	4.07^{c}	4.50	5.30
Feed cost/kg gained ($)	2.00	1.37	1.43	1.15
Feed cost saving ($)	-	0.64	0.57	0.84

T1: control diet, T2: DCP 275, groundnut haulms 695g,
T3: DCP 375g, groundnut haulms 595g, T4: DCP 475g, groundnut haulms 495g.

Table 5 - Nitrogen balance of Red Sokoto bucks fed a control diet or a mixture of *Saccharomyces cerevisiae*-treated groundnut haulms and dried cassava peel-based diets

Parameters	Diets					
	T1: CON	T2	T3	T4	SEM	P-Value
Nitrogen intake (g/day)	11.84^{d}	15.37^{c}	17.43^{a}	16.18^{b}	2.12	0.041*
Nitrogen excretion						
Faecal	5.69^{cd}	7.77^{b}	9.08^{a}	7.2^{b}	1.5	0.034*
Urinary	0.78^{a}	0.46^{c}	0.52^{b}	0.61^{b}	0.34	0.021*
Total nitrogen	6.47^{c}	8.23^{ab}	9.61^{ab}	7.81^{ab}	2.56	0.034*
Nitrogen absorbed	6.15^{c}	7.60^{ab}	8.35^{ab}	8.98^{ab}	2.71	0.012*
Nitrogen retained	5.37	7.14	7.83	8.37	3.24	0.22^{NS}
Nitrogen retained %	45.40	46.50	44.90	51.7	6.50	0.33^{NS}

^{abc} = means on the same column with different superscripts are significantly varied ($p < 0.05$), SEM; Standard error of the mean. T1: control diet, T2: DCP 275, groundnut haulms 695g, T3: DCP 375g, groundnut haulms 595g, T4: DCP 475g, groundnut haulms 495g

CONCLUSIONS

The findings showed that adding more SCGH and DCP to RSBs' diets improved the growth rate and nitrogen retention of goats and lowers feed costs. Goats given T4 exhibited the best performance and nitrogen utilization (SCGH: 475g, CSP: 495g). Additionally, the findings showed that the growth performance and nitrogen balance of RSBs is not adversely affected by DCP or SCGH.

RECOMMENDATION

Goats can be sustainably fed DCP and SCGH, especially when forage is scarce and conventional feed is expensive. DCP can be utilized as a dry season substitute to support animal growth in an affordable way.

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