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FEED INTAKE, GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY OF RED SOKOTO BUCKS FED *Pseudomonas putida* TREATED SUGARCANE BAGASSE

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ABSTRACT

This study was conducted to evaluate the growth performance of Red Sokoto Bucks fed *Pseudomonas putida* treated sugarcane bagasse. The experiment lasted 90days and a total of 27 Red Sokoto bucks aged 8-10 months and weighing an average of 10.5kg were randomly assigned into three dietary treatments with three replicates per treatment and Three (3) goats per replicate in a completely randomized design. The diets contained 0%, 5% and 10% level of Bacteria treated bagasse fed as T1, T2 and T3 respectively. Feed and water were provided *ad-libitum* and standard management practices were followed. Data collected were subjected to analysis of variance using SPSS computer application and mean were separated using Duncan multiple-range test. The result showed that final weight gain, daily weight gain and total weight gain increased significantly (P<0.05) across the treatments as the levels of Bacteria treated Sugarcane bagasse increased in the diet. The final weight was 15.93 kg, 17.13 kg and 19.10 kg for T_1, T_2 and T_3, respectively, similarly the average daily weight gain calculated which increased significantly across the treatments was 61.89g/day, 73.67g/day and 97.45g/day for T_1, T_2 and T_3 respectively, while the highest daily feed intake value of 409.56g/day was recorded in T_3, increased feed intake was observed with the Bacteria treated bagasse, this showed high acceptance and palatability of the treated bagasse. The best FCR of 4.20 was recorded in the highest inclusion level of treated bagasse. There was no significant difference in the protein digestibility, however there were significant (P<0.05) increase in the dry matter, crude fibre, neutral detergent fibre, acid detergent fibre, acid detergent lignin and cellulose digestibility, in bacteria treated diets. It was concluded that *Pseudomonas* treated sugarcane bagasse improved weight gain and feed intake without adverse effect on performance and digestibility coefficient of Red Sokoto Bucks.

Key words: Sugarcane bagasse, Red Sokoto goats, *Pseudomonas putida*, digestibility coefficient, feed intake, weight gain

INTRODUCTION

In terms of providing food, raw resources, and foreign exchange, small ruminant animals continue to significantly contribute to Nigeria's economy (Yousuf and Adeloye, 2010). According to Oni (2002), sheep and goats make up roughly 36% of the nation's overall meat supply and have enormous development potential. Goat also features prominently in the economic and social lives of Nigerians. In Nigeria, livestock production accounts for less than 8% of the country's GDP and for 10% of its agricultural activity (Adeyemi *et al.,* 2017). Due to the fast geometric growth of the current human population and the desire for animal protein consumption by humans in Nigeria, this livestock production rate needs to be enhanced (Yahya *et al.,* 2020). Tropical livestock production is severely hampered by insufficient animal feed supplies, especially during the dry season. How to provide the animals with adequate year-round nutrition is the main challenge facing small ruminant animal farmers (Wuanor and Ayoade, 2017). Energy and protein availability are crucial for animal nutrition and are frequently the main factors limiting the production of ruminants in many tropical climates (including Nigeria). Given the shortage and high cost of conventional feed resources, research is on indigenous alternative feed sources produced in the tropical climate nations like Nigeria (Balagopalan, 2014). According to Venkata *et al*. (2018), integrating livestock production systems with crop production has significant importance for maximizing returns from the same land by generating additional income through the use of crop wastes or readily accessible agro-industrial by-products to the farmer. In light of this new situation, more in-depth nutritional details regarding the usage of such waste in ruminant feed are required (Barros *et al.,* 2009).

Sugarcane bagasse is the fibrous by-product of crushing and juice extraction from the cane stalk. Bagasse is a good supply of fiber that could be used to feed animals (Tosh and Yada, 2010). Mahala *et al.* (2007) stated that if bagasse is utilized as a base diet, it is crucial to provide the right supplements to get the best possible physical and financial results. Bagasse has a limited application as animal feed because of its high fibre content (43%) and low nitrogen content (0.2%) Ramli *et al.* (2005). Like most agricultural and industrial by-products, sugarcane bagasse is fibrous and low in nutrients, necessitating some sort of processing.

During biological treatment, microorganisms and their enzymatic machinery break down lignin and modify lignocelulose structures. By using bacteria like *Pseudomonas putida,* which metabolize lignocelluloses, there is a potential to improve the nutritional value of lignocellulose agricultural and industrial wastes, such as sugarcane bagasses. As opposed to feeding untreated roughage, providing biologically treated roughage enhanced feed intake, improved digestibility, and boosted feed conversion efficiency, according to the majority of research findings (Abdel-Azim *et al.,* 2011; El-Bordeny *et al.,* 2015).

Pseudomonas putida is a Gram-negative, rod-shaped, non-fermenting bacterium that is ubiquitously encountered in the environment. *P. putida* is a safe strain of bacteria which is not pathogenic, unlike *P. aeruginosa*, a human pathogen (Yeoh, 2006). It is known for its ability to degrade organic solvents. These solvents include toluene, in Gasoline. This ability has been put to use in bioremediation, or the use of microorganisms to biodegrade oil. Continuous oxidative enzymes that might be involved in lignin break down processes are identified consistently in *Pseudomonas putida*. Screening studies reported P. putida secreted ligninolytic enzymes such as laccase, Mn^{2+}-independent peroxidase (Ahmad *et al.,* 2010). According to Loc *et al*. (2010), feed is a crucial part of the livestock industry and is typically held accountable for between 70 and 80% of the overall cost of production. In many developing countries, the livestock industries still rely heavily on the expensive importation of conventional basic materials like grains, legumes, and oil seed cakes. As a result, non-conventional feed materials, such as crop leftovers and other agro-industrial by-products like sugarcane bagasse, which are more readily available and less expensive are needed.

Agricultural by-products and crop waste are a major component of Nigeria's goat production; this system is typically characterized by restrictions brought on by the lack of year-round feed resources as a result of the extended dry season in northern Nigeria and high cost of grains and other conventional feed. However, due to their poor nutritional value and high fiber content, non-conventional feedstuffs like sugarcane bagasse have a clearly limited usage.

According to Anwar *et al.,* (2014), lignocellulosic materials are the most promising feedstuff as natural and renewable resources essential for the functioning of modern industrial societies. In addition to industrial extraction several tonnes of sugarcane are consumed annually in Nigeria which has resulted to a large quantity of waste blocking waterways both in urban and rural parts of the country resulting into land pollution. Incorporating bagasse into livestock feeds can reduce environmental problems caused by the waste (Maidala *et al*., 2016). However, due to their poor nutritional value and high fiber content, non-conventional feedstuffs like sugarcane bagasse have a clearly limited usage.

The findings of the study will have theoretical and practical significance. Results from the study will shed more light on the potentials of *Pseudomonas* as biological treatment for the fibrous agro-industrial by-products such as sugarcane bagasse in solving the problems of high feed cost and scarcity and its overall effect in the performance of goats in particular.

The study will be a beneficial guide on the use of *Pseudomonas putida* bacteria as biological treatment of fibrous by-products to policy makers, stakeholders, farmers and as well the general public who are interested in improving goat production. Furthermore, future researchers who wish to carry out similar research will find this study as a reference material to start their research.

The objective of this study was to determine the effect of *Pseudomonas putida* treated Sugarcane bagasse on the performance characteristics of Red Sokoto Goat.

MATERIALS AND METHOD

Study Area:

This experiment was conducted at Red Goat farm Kuje, Kuje Area council Abuja. Kuje Area Council is located between latitude 8°40′ and 9°00′ north of the equator and longitude 7°00′ and 7°40′ east of the Greenwich meridian on the map of the world. It lies adjacent to Gwagwalada and is about 40km South West of Abuja, and has a population of 97 367 according to the 2006 Nigerian census report (Federal Government of Nigeria Official Gazette, 2007).

Sources of Experimental Materials:

Sugarcane bagasse was collected from Sugarcane juice outlets within Abuja. *Pseudomonas putida* was sourced from University of Abuja Teaching Hospital Laboratory Gwagwalada. The bacterial suspension was obtained by culture in nutrient medium (liquid MH) for 24 hours at 30°C and sub-culture for further usage. After 24 h incubation at 30°C, the cultures were adjusted to a microbial concentration of approximately $1x10^8$ CFU/ml (OD 0.45 at 610 nm) with a spectrophotometer according to the method described by Govindappa *et al*. (2011).

Treatment and inoculation of Sugarcane Bagasse:

The collected bagasse was sundried to reduce the moisture content and milled into a smaller size using a hammer mill. The bagasse was tied in a sack and autoclaved at 121^{o}C, for 15minutes, it was later cooled in a clean environment before inoculation. The *Pseudomonas puida* inoculum was washed mixed homogeneously into measured distilled water then sprinkled evenly with the bagasse. Using a haemocytometer, about 10^7 spores per ml was used to inoculate the oven-dried bagasse and tied in a black polythene bag for about nine (9) days so as to enhance the bacteria growth. After the enveloping of the substrate by the inoculum it was then oven dried at 70^{o}C for 24hrs so as to terminate its growth before its inclusion in the experimental diets.

Experimental Diets:

Diets was formulated to meet the nutrient requirements of grower goats. Three (3) experimental diets were formulated using Cassava waste, Rice husk, Soya bean meal, Premix, salt and varying levels of Pseudomonas treated and untreated Sugarcane bagasse as shown on the Table 1.

Experimental Design:

Twenty-seven (27) Red Sokoto bucks (age between 8 and 10 months old) were obtained from Red goat farm in Kuje area of Abuja. The goats were randomized against the experimental diets in a Completely Randomized design model (CRD). The goats were randomly distributed into three (3) treatment groups with three (3) replicate per treatment and three (3) goats per replicate.

Experimental Animals and Management:

The bucks were housed in well-ventilated raised pens within a common house. Prior to the experiment the bucks were dewormed using Abendazole ® suspension and dipped in acaricide (Amitix®) solution one week before the commencement of the feeding trial to control endo and ecto-parasites.

Table 1: Experimental Diets Containing Varying Levels of Pseudomonas treated and untreated Sugarcane bagasse.

Ingredients	T1	T2	T3
Untreated Sugarcane Bagasse	10.00	5.00	0.00
Pseudomonas Treated Bagasse	0.00	5.00	10.00
Cassava Waste	60.00	60.00	60.00
Rice Husk	10.00	10.00	10.00
Soya Bean meal	18.00	18.00	18.00
Vitamin -mineral premix	1.00	1.00	1.00
Common salt	1.00	1.00	1.00

Data Collection

Weight Gain:

The bucks were weighed on weekly basis, Weight changes was recorded as the difference between weight of the previous week and the current. Weight gain was recorded as the final weight minus initial weight.

Feed Intake:

Daily feed intake was recorded as the quantity of feed offered minus the quantity of left over collected the next day before serving new feed.

Faecal Sample Collection:

During the last 10 days, three bucks per treatment were moved to a metabolic cage to facilitate collection of feaces. The faecal samples were collected each morning just before feeding. Daily total faecal samples were weighed, sub-sampled and then oven dried at 70^{o}C. At the end of the 7-days collection period, the faecal samples were bulked, mixed thoroughly and sub-sampled for each replicate while dry matter was determined at 100^{0}C for 24hrs. The samples were then taken to the laboratory for chemical analysis.

Digestibility:

Nutrient digestibility was calculated as the portion of nutrient intake not recovered in faeces

$$\textbf{Apparent digestibility} = \frac{\text{(Nutrient Intake-Nutrient output)}}{\text{(Nutrient intake)}} \times 100$$

Where; Nutrient intake (g) = Feed intake × Nutrient in diet; Nutrient output (g) = Faecal output × Nutrient in faeces.

Chemical Analysis:

Feed and faecal samples were collected and dried in an oven at 70°C for 24 hours. For analysis, all dried materials were milled. The samples were analyzed for dry matter (DM), nitrogen (N), crude protein (CP) following the AOAC (2000) approved procedures.

Metabolizable energy of the diets and faeces was estimated using the method of AOAC (2000).

Statistical Analysis:
All data collected was analyzed using one-way analysis of variance (ANOVA) of a completely randomized design. Treatment means were separated using Duncan multiple range test SPSS (2013) version 22.

RESULT AND DISCUSSION
Proximate compositions of the experimental diets used in this study is shown in (Table 2) showed that the dry matter content ranged from 92.17 – 94.74%, indicating high content of dry matter. The crude protein recorded in the experimental diets ranged from 14.11% to 17.85%, with T3 recording the highest value while the lowest CP value was observed in T1. The crude fibre (30.83 to 34.22%) of the diets decreased as the level of treated sugarcane bagasse increased in the diets. The dry matter content of the diets ranged between 90.74 and 94.12%, indicating a longer shelf life and the potential to retain more nutrients. The results revealed increasing crude protein content as the inclusion levels of Pseudomonas treated bagasse increased in the diet. The crude protein content of all the diets ranged between 15.83% and 16.91% which was higher than the minimum of 8% prescribed as adequate by Norton (1994) and Gatemby (2002) for meeting the nutritional needs for moderate weight increase in goats (NRC 2007). The CP values were higher than the 14.90 – 15.85% CP values reported by Yahya *et al.* (2020) for Red Sokoto goats fed graded levels of probiotic supplemented sugarcane bagasse. The crude fibre values observed in this study decreased as the level of Pseudomonas treated bagasse increased in the diet.

The decrease in crude fiber content observed in Treatments 2 and 3, as compared to Treatment 1, could be attributed to the action of the *Pseudomonas putida* treatment on the sugarcane bagasse. The microbial treatment might have facilitated the breakdown of complex fibrous components, resulting in a reduction of crude fiber. This corroborates with the result of Salvedia and Supungco (2017) which demonstrated the efficacy of microbial treatments in enhancing the digestibility of fibrous feed components. The values ranged from 30.83 to 34.22%. The CF values found in this study were higher than 26.6 – 28.93% reported by Mijinyawa *et al*. (2016) for Red Sokoto bucks fed treated and untreated sugarcane bagasse with or without enzyme supplementation in total mixed ration. Ether extract (EE) values was between 3.42 and 4.20%.

The EE value was lower than the 5.50 – 7.16% reported by Yahya *et al.* (2020) for Red Sokoto goats fed graded levels of probiotic supplemented sugarcane bagasse. These values were however higher than 2.09 – 2.73% ether extract values reported by Mijinyawa *et al.*, (2016) for Red Sokoto bucks fed treated and untreated sugarcane bagasse with or without enzyme supplementation in total mixed ration. The ash values found in this study ranged from 9.59 – 11.29%, which is an indication that the diets contained a significant amount of minerals. Ash values in the diets were comparable with the 7.50 – 12.73% reported by Yahya *et al.* (2020) for Red Sokoto goats fed graded levels of probiotic supplemented sugarcane bagasse, but were higher than 1.08 – 4.45% range reported by Gado *et al.* (2007) for Baladi goats fed biologically treated sugarcane bagasse. The NDF values ranged from 58.51–62.73%.

David (2012) observed that ruminant diets should contain at least 20% NDF on a DM basis to maintain optimal roughage digestion. The neutral detergent fibre fraction contains hemicellulose, cellulose, and lignin, resulting in enhanced fibre that aids in rumen motility stimulation. The values obtained in this study were slightly lower than the 68.30 – 69.04% values reported by Mijinyawa *et al*. (2016) for Red Sokoto bucks fed treated and untreated sugarcane bagasse with or without enzyme supplementation in total mixed ration. The nutritional superiority of the Pseudomonas treated bagasse was shown by the reduction in ADF. David (2012), in a previous study reported that diets with lower ADF values are of good nutritional value. The ADF value reduced as the level of Pseudomonas treated bagasse increased in the diet. The values ranged from 25.7 – 32.54%.

Table 2: Proximate Composition of the Experimental Diets

Parameters	**T_1 (0%)**	**T_2 (5%)**	**T_3 (10)**
DM	93.12	92.17	90.74
CP	14.11	15.93	17.85
CF	34.22	31.23	30.83
EE	3.42	3.51	4.2
Ash	11.29	10.12	9.59
NDF	62.73	60.2	58.51
ADF	32.54	27.4	25.7
ADL	12.6	12.2	13.9
C	8.56	9.31	8.19
HC	21.61	21.09	18.98

DM=Dry Matter; CP= Crude Protein; CF=Crude Fibre; EE=Ether Extract; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre; ADL=Acid Detergent Lignin; HI=Hemicellulose

The result on the performance of Red Sokoto goats fed graded levels of *Pseudomonas* treated sugarcane bagasse is shown in Table 3. The initial weight of T_1, T_2 and T_3 were recorded to be 10.36, 10.33 and 10.50 kg, respectively which was statistically not significant ($P>0.05$). The study showed that there was significant ($P<0.05$) in the final weight, total feed intake, daily feed intake, daily weight gain and feed conversion ratio across the treatments. Final weight was 15.93 kg, 17.13 kg and 19.10 kg for T_1, T_2 and T_3, respectively. Average daily feed intake was significantly ($P<0.05$) higher in T_3 while T_1 and T_2 were statistically similar ($P>0.05$). The average daily feed intake values recorded were 368.89 g/day, 379.00 g/day and 409.56 g/day for T_1, T_2 and T_3, respectively. The total weight gain values observed in the study were 5.57 kg, 6.63 kg and 8.77 kg for T_1, T_2 and T_3, respectively. The mean Average daily weight gain during the trial period was 61.89 g/day, 73.67 g/day and 97.45 g/day for T_1, T_2 and T_3, respectively. Feed conversion ratio values ranged from 4.20 in T_3 to 5.96 in T_1. The significant increase in average daily weight gain with the increase in the levels of treated bagasse in this study agreed with the report of Salvedia and Supungco (2017) in which bagasse treated with probiotics was fed to crossbred dairy goat kids and the control had lowest weight gain compared to the probiotic treated group. Similarly, the average daily feed intake was significantly affected by the experimental diet. Increased feed intake was recorded with the highest level of treated bagasse, the significant increase in weight might be due to high dry matter intake and consequently leading to enhance performance.

Table 3: Performance of Red Sokoto goats fed graded levels of *Pseudomonas* treated sugarcane bagasse

Parameters	T1	T2	T3	±SEM
Initial weight (kg)	10.36	10.33	10.5	0.26
Final weight (kg)	15.93^{c}	17.13^{b}	19.10^{a}	1.22
Total feed intake (g)	33200^{c}	34110^{b}	36860^{a}	24.53
Average daily feed intake (g/day)	368.89^{b}	379.00^{b}	409.56^{a}	11.48
Total weight gain (kg)	5.57^{c}	6.63^{b}	8.77^{a}	0.37
Average daily weight gain (g/day)	61.89^{c}	73.67^{b}	97.45^{a}	1.24
FCR	5.96^{c}	5.15^{b}	4.20^{a}	0.78

Means with different superscripts in a row differ significantly (P<0.05), FCR = Feed conversion ratio

The effect of *Pseudomonas* treated sugarcane bagasse on nutrient digestibility of Red Sokoto goats is presented in Table 4. The result showed that there was a significant (p<0.05) difference in nutrient digestibility of Dry matter, with T_1 (79.86%) recording the least value and T_3 recorded the highest value of (89.16%). There was no significant difference (p>0.05) for nutrient digestibility values for CP between treatment means. The CP digestibility values ranged from 77.80% and 78.98%. However, there was a significant (p<0.05) difference in nutrient digestibility of Crude fibre. Crude fibre digestibility was highest in T_3 (71.69%), T_2 recorded a value of 71.38% and T_1 recorded the least value of 62.36%. Ether extract digestibility was highest in T_2 (75.75%), while T_1 recorded the least ether extract digestibility value of 76.07%. Neutral detergent fibre digestibility increased with increasing level of treated sugarcane bagasse in the diet, T_2 (79.68%) and T_3 recorded a significantly (<0.05) higher neutral detergent fibre digestibility, while T_1 had lowest (74.81%) neutral detergent fibre digestibility value. Acid detergent fibre digestibility increased as the level of Pseudomonas treated bagasse increased in the diet. T_1 recorded the least value (73.23%) while T_3 recorded the highest (82.53%) (P<0.05) digestibility value.

The result on nutrient digestibility also showed significant difference (p<0.05) in ADL digestibility across treatment means. The values increased with increasing level of Treated sugarcane bagasse in the diet. The values ranged from between 46.73% in $T_1$and 57.67% in T_3. Higher digestibility values for DM, ADF, NDF, and Lignin obtained in bacteria treated diet can be explained as a result of direct fibre degradation by the bacteria, enhanced microbial attachment, and complementary actions with ruminal enzymes. This agreed with previous studies that showed an increase on NDF and ADF digestibility with the use of exogenous enzymes (Feng *et al*., 1996). Kung *et al*. (2000) reported that treatment of feeds with enzymes prior to feeding can improve digestibility via a number of different mechanisms. Rode *et al*. (1999) found that enzymes significantly increased DM, OM, NDF, ADF, and CP digestibility in dairy cows. Ajayi *et al.* (2012) accorded dry matter digestibility as one of the determining factors in feed utilization, energy intake, and overall performance of ruminants. The higher DM digestibility of T_3 compared to other treatment groups is consistent with lower CF content of the experimental diet, this agreed with Olafadehan and Okunade, (2018) who submitted that fiber has a negative relationship with voluntary feed intake and digestibility. Also, the significantly (P<0.05) higher dry matter intake and digestibility observed in animal on Treatment 3 could be that the animals found the ration more palatable, this agreed with Abdu *et al* (2012).

Table 4: Apparent digestibility of Red Sokoto Goats fed graded levels of Pseudomonas treated sugarcane bagasse

Parameter (%)	TREATMENTS T1	T2	T3	±SEM
DM	79.86^{c}	86.85^{b}	89.16^{a}	0.80
Crude Protein	77.80	78.98	78.01	1.68
Crude Fibre	62.36^{b}	71.38^{a}	71.69^{a}	0.55
Ether Extract	71.23^{c}	75.75^{a}	73.29^{b}	1.51
Neutral Detergent Fibre	74.81^{c}	79.68^{a}	78.24^{a}	1.48
Acid Detergent Fibre	73.23^{b}	79.01^{a}	82.53^{a}	0.87
Acid Detergent Lignin	46.73^{c}	57.10^{b}	57.67^{a}	0.35
Cellulose	67.57^{b}	70.14^{a}	67.64^{b}	0.58
Hemicellulose	75.53^{c}	79.07^{a}	78.27^{b}	0.42

Means with different superscripts in a row differ significantly (P<0.05)

CONCLUSION

It could be concluded that goats fed *Pseudomonas putida* treated bagasse performed better than those fed untreated bagasse. Treating sugarcane bagasse with bacteria significantly increase and decreased the crude protein and crude fibre content respectively. This signifies that incorporating *Peudomonas putida* treated bagasse in the diet of goats significantly improved their performance in terms of feed intake, digestibility and weight gain.

Pseudomonas putida treated sugarcane bagasse could be used as feed for growing goats at 10% inclusion.

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