DIETARY EVALUATION AND PARTIAL BUDGET ANALYSIS OF *ASPERGILLUS NIGER* TREATED SUGARCANE SCRAPS ON THE PERFORMANCE CHARACTERISTICS OF RED SOKOTO GOATS

***Belewu, M.A., Ajayi, A.M., Adeleke, R.A., Olusanmi, J.O., Adelodun, G.T. and Jimoh R.B.**
Department of Animal Science University of Abuja
Microbial Biotechnology and Dairy Science Laboratory
Tel: +234 803 581 7941; +234 802 125 1967
*Corresponding author e-mail: moshood.belewu@uniabuja.edu.ng
milkyinka@yahoo.com,
ORCID: https://orcid.org/ooo-0003-3553-7652
Researcher ID: www.researcher-id.com/rid/C9724-2018
Google Scholar: https/bit.ly/3z56LXO)

ABSTRACT

The Study which was conducted at the Teaching and Research Farm, University of Abuja, was aimed at evaluating the effect of feeding Aspergillus treated Sugarcane scraps on feed intake, weight gain, digestibility and partial budget analysis of Red Sokoto goats. Nine mixed sexes Red Sokoto goats with an average initial weight of between 13.37 and 13.60kg (±SEM=0,07) used for the study were acclimatized to the experimental diets for two weeks. The study consisted of 56 days feeding trial and 7 days of digestibility period in a Complete Randomised design model . The dietary treatments were T1 (0% Aspergillus treated Sugarcane scraps); T2 (12.50% Aspergillus treated Sugarcane scraps) and T3 (25% Aspergillus treated Sugarcane scraps). The results revealed significant variations (P< 0.05) in the average dry matter intake {500g/day (T1); 450g/day (T2); and 750g/day (T3)}. Crude Protein intake, ether extract intake, metabolizable energy intake and ash intake were highest for T3 compared to other dietary treatments. The significant (P<0.05) weight gain noted was highest for T3 and lowest for T1. Feed Conversion Ratio (FRC) was best for T2 and T3. Digestibility of all parameters were significantly different (P<0.05) with the highest value recorded for T3. Feed cost per kilogram was N267.03 (T1); N287.67 (T2) and N308.69 (T3) while feed cost/g weight gain was economical for T3 (N0.39) compared with N0.54 (T2) and N2.05 (T3). The study concluded that feeding Aspergillus treated Sugarcane scraps to Red Sokoto goats holds a positive effect on the performance and economically feasible

Keywords: Feed intake, weight gain, digestibility coefficient, feed conversion ratio, partial budget analysis

INTRODUCTION

The world's increasing human population and the resultant change in the environment in the last few years have resulted in an increasing need for food. It is noteworthy that feed resources that were abundant in the past no longer exist on many farms due to urbanization. Additionally, the consequence of season on forages and feed ingredients is another problem that leads to feed shortages since feeds are abundant only during the wet season of the year, and weight gain during the wet season is wholly or partially lost in the dry season The seasonal weight loss has vital consequences on animal performance and health status (Alemayehu, 2004., Parreira *et al.,* 2020). Hence, researchers are now searching for alternative feed ingredients that are readily available, affordable, and rich in some nutrients without compromising the quality. According to the Federal Ministry of Environment, Nigeria generated some 32 million tonnes of waste per year, which was among the highest in Africa with only about 20 -30% collected and managed correctly while the remaining are dumped in unauthorized places or burnt thereby contributing to environmental hazard and health implications (www.aqmd.gov> compliance> open-burn). The tremendous quantities of agricultural waste residues generated in Nigeria can play a vital role in meeting energy and unconventional feed ingredients demand for livestock.

Agricultural waste residues include left over after harvesting from farms and leftovers from processing industries. Some examples are Maize cobs, husk and stalks, Cassava stalks and wastes, Sugarcane bagasse, top and sugarcane scraps, falling leaves, stovers, straws, and sea pods (Mottet *et al.*, 2017), and many more

Sugarcane: It is a source of several foods and favourite dishes in several countries (Brazil, India, China, Thailand, Pakistan, Mexico, Colombia, Indonesia, Philippines, United States of America, Laos, Myanmar, and Nigeria) where the crop is cultivated. In Nigeria, the crop is cultivated on a commercial scale in states like Katsina, Taraba, Kano, Adamawa, Jigawa, Kaduna, Kebbi, Kwara and Sokoto (www.finelib.com).

Sugarcane bagasse is the fibrous materials left after the extraction of the juice for numerous dishes and foods while Sugarcane scraps are the scrapping of the outer coat of the stock, which contains little or no juice, and it constitutes an environmental nuisance in most states where sugarcane is produced on commercial scale.

Sugarcane scrap has a good techno-economical prospect due to the presence of phytochemicals found in the rinds which are anticancer, antitumor, and antifibrotic tumors (Chu *et al.,* 2016., Wang *et al.*, 2018). Sugarcane scraps have low protein content (2-6% dry matter basis) and high fibre content (30-50%) (Silva *et al.*, 2019). It has poor ash content while the fat content is negligible (Bhatia *et al.*, 2021). The existence of anti-nutritional factors also limits its utilization in livestock nutrition (Silva *et al.*, 2012)

Fig 1: Dumping site of Sugarcane scraps

With progress in Biotechnology and Bioengineering, most of the waste agricultural residues now is increasingly becoming essential and form the basis of energy production, enzymes, vitamins, minerals, livestock feed, antioxidants, antibiotics, and chemicals through solid state fermentation (SSF) process using beneficial microorganisms like *Aspergillus niger*

Aspergillus niger:

The fungus has specific features that make it precious for the production of citric acid, proteins, and bioactive compounds. It produces numerous extracellular enzymes such as cellulase, lipase, oxidase, pectinase, α-amylase, and glucoamylase (Gofrey and West, 1996 ;, Taketaka *et al*., 2020., www.isnff-jfb.com 2023.) which are vital in the detoxification and degradation of fibrous substances. Hence, the thrust of this study was to evaluate the efficacy of feeding *Aspergillus niger-treated* Sugarcane scraps on feed intake, weight gain, apparent digestibility, and partial budget analysis of Red Sokoto goats.

MATERIALS AND METHODS

Study Area:

The study was carried out at the Ruminant Unit, Teaching and Research Farm, University of Abuja, Permanent site. The study site is located between latitude 8.9807^{0}N and longitude 7.1805$^{E.}$ The rainy period of the year lasted for 8.2 months from March to November with humidity of 55%. The temperature ranges from 17^{0}C to 35^{0}C C (http://www.accuweather,com).

COLLECTION AND PROCESSING OF SUGARCANE SCRAPS

Sugarcane scraps:

Sugarcane scrap (it is the scrapping of the outer coat of a sugarcane stem and it contains no juice) which is an act of dressing sugar cane stem before selling to consumers and it is very common in all sugarcane producing States among the Sugarcane farmers and sellers

Sugarcane scraps that constitute environmental pollution were collected at the Giri area of Abuja, the dumping site in appreciable quantities at a time to prevent variations in composition and later autoclave at 220^{O}C for 15 minutes and 15psi pressure at the Soil Science

Department, Faculty of Agriculture, University of Abuja. After, cooling it was inoculated with spores of *Aspergillus niger.*

INOCULATION AND INCUBATION OF AUTOCLAVED SUGAR CANE SCRAPS

Aspergillus niger which was collected in Petri dishes from the Department of Microbiology, University of Abuja was used to inoculate the warm autoclave Sugarcane scraps contained in plastic bowl {*Aspergillus nige*r (10^7 spores per ml)} in layers and later incubated for 7-10 days when the fungus enveloped the substrate (Sugarcane scrap)

FORMULATION OF THE EXPERIMENTAL DIETS

The dietary treatments (Table 1) consist of fixed ingredients (Cassava waste , Rice husk, Groundnut cake, Salt and Vitamin-mineral premix) while fungus treated Sugarcane scraps was included at various levels {0% fungus treated sugarcane scraps(Control diet, A) ; 12.5% fungus treated Sugarcane scraps (Diet B) and 25% fungus treated Sugarcane scraps (C)}.

Table 1: Composition of the Experimental Diets

INGREDIENTS	A (%)	B (50%)	C (100%)
Cassava waste(kg)	54.00	54.00	54.00
Rice husk(kg)	25.00	12.50	0.00
Fungus treated Sugarcane scrap (kg)	0.00	12.50	25.00
Groundnut cake (kg)	20.00	20.00	20.00
Salt (kg)	0.50	0.50	0.50
Vitamin premix (kg)	0.50	0.50	0.50
Total	100	100	100

ANIMALS AND MANAGEMENT

Nine Red Sokoto Goats (mean initial body weight =13.45±0.07 kg body weight) about 8 weeks old were used in a completely randomized design with three animals replicated per treatment. The animals were randomized against the three dietary treatment groups as follows: Dietary treatment 1 (control) (0% inclusion of fungus-treated Sugarcane; Dietary treatment 2 (inclusion of 12.50% fungus treated Sugarcane scraps) and Dietary treatment 3 (25 % fungus-treated Sugarcane scraps). Each treatment consisted of three (3) animals that were housed in pens throughout the study period.

Feed Intake and Digestibility Coefficient:

Experimental diets were offered daily at 0800 h and water was provided *ad libitum* during the study period. The goats were adapted for 10 days to the experimental diets before actual data collection commenced. The orts for each animal were weighed and recorded every morning before giving fresh diets.

Goats were weighed weekly and their weight gain was determined. At the end of the trial period, there was a 7-day total day collection period of daily faeces from each goat in addition to diets offered and orts for the determination of the digestibility coefficient.

$$\textbf{ADWG} = \frac{FBW \quad IBW}{TNFD}$$

Where: ADWG= Average Daily Weight Gain, IBWG= Initial Body Weight Gain and TNFD= Total Number of Feeding Days, FBW =Final Body Weight

Apparent digestibility coefficient

$$= \frac{\text{Total nutrient consumed} - \text{Total nutrient in faeces}}{\text{Total nutrient}} * 100$$

$$\textbf{Feed Conversion Ratio} = \frac{\text{Total Drymatter intake}}{\text{Daily weight gain}}$$

Analytical Methods:

Diet samples were milled in a hammer mill to pass through 1 mm mesh sieve for proximate analysis determination according to the methods described by (AOAC, 2005) Crude protein was calculated from N x 6.25. Samples of faeces were dried at 70^{o}C for 48 h, later milled to pass through 1 mm diameter screen and were analyzed for proximate composition (AOAC, 2005). Gross energy of the diets and faeces were measured by bomb calorimetry using benzoic acid as a standard (26437 J/g).

Statistical Analysis:

Data collected were subjected to Analysis of Variance of a completely randomized design (CRD) (Steel and Torrie, 1980). Means were separated using Duncan's multiple range test (Duncan, 1955).

Results

The chemical composition and metabolizable energy content of the experimental diets are presented in Table 1. The crude protein, dry matter, and ether extract content were higher in dietary treatment 3 than in other nutritional treatments. Feed intake and weight gain are shown in Table 2. There were significant differences (P < 0.01) in all the nutrient intakes (Dry matter, Crude protein, Crude fibre, Ether extract, ash, and Metabolizable energy), weight gain, and feed conversion ratio (FCR) among the Dietary treatments.

Goats on dietary treatments 1 and 3 had significantly (P < 0.05) higher DMI than goats on Dietary treatment 2, which recorded a low DMI. The Crude protein intake (CPI) was higher for dietary treatment 3 compared with Dietary treatments 1 and 2 which are similar. Crude fibre intake and Ash intake followed a similar trend as the CPI. The ether extract intake was higher for *Aspergillus niger*-treated Sugarcane scrap-based diets (Diets 2 and 3). Contrarily, the highest metabolizable energy intake was recorded for T3 >T1>T2 in that order. Additionally, weight gain was significantly higher (P<0.05) for the fungus treated Sugarcane scraps based diets 2 and 3 compared with the Control.

A lower (P <0.05) Feed conversion Ratio was observed with goats on the control diet compared with dietary treatments 2 and 3. The partial budget analysis showed no variation in the feed cost/final live weight among the dietary treatments (N19.78, N20.68 and N21.44 for dietary treatments 1, 2, and 3 respectively). However, the feed cost/kg was numerically higher for dietary treatment 3>2>1. Additionally, feed cost per kg of weight gain was significantly less for dietary treatment 3, followed by 2 and the least for dietary treatment 1.

Dry matter, crude protein, crude fibre and ether extract digestibility were higher (P < 0.05) in the fungus-treated sugarcane-based diets compared with the control diet.

Table 2: Proximate composition (%) of experimental diets fed to Red Sokoto goats

Parameters (%)	T1	T2	T3
Dry matter	80.50	80.73	79.00
Crude Protein	14.74	15.01	15.03
Crude Ffibre	10.38	10.90	10.57
Ether extract	5.96	6.09	6.43
TOTAL ASH	8.17	8.77	8.70
Metabolizale energy(Kcal/kg)	2,509.70	2,547.40	2,567.00
NFE%	60.75	59.23	59.27

Table 3. Feed Intake of the Experimental Animals

Parameters (g/d)	T1	T2	T3
Dry matter intake	500.00^{b}	450.00^{c}	750.00^{a}
Crude Protein intake	70.00^{b}	70.00^{b}	110.00^{a}
Crude fibre intake	50.00^{b}	50.00^{b}	80.00^{a}
Ether extract intake	20.00^{c}	30.00^{b}	50.00^{a}
Metabolizable intake (kcal/g)	1254.85^{b}	11460.33^{c}	19250.25^{a}
Ash intake	40.85^{b}	40.00^{b}	70.00^{a}

a, b ,c Means in a row with common letter(s) superscript do not differ (P > 0.05).

Table 4. Weight gain and Partial Budget Analysis

Parameters	T1	T2	T3	SEM
Initial weight (kg)	13.37	13.38	13.60	0.07NS
Final Weight(kg)	13.50^{a}	13.91^{a}	14.40^{b}	0.26
Weight gain (g)	130.00^{c}	530.00^{b}	800.00^{a}	190.00
Feed cost/ kg (Naira)	267.03^{c}	287.67^{b}	308.69^{a}	50.23
Feed cost /final live weight (Naira)	19.78	20.68	21.44	5.14NS
Feed cost/kg weight gain (Naira)	2.05^{a}	0.54^{b}	0.39^{c}	0.78

a, b ,c Means in a row with common letter(s) superscript do not differ (P > 0.05).

Table 5: Digestibility coefficient of the Experimental Animal

%	T_1 (%)	T_2 (%)	$_3$ (%)	±SEM
Dry matter digestibility	72.00^b	68.83^c	78.60^a	11.36
Crude protein digestibility	77.14^b	84.21^a	85.43^a	13.15
Ether extract digestibility	60.00^c	70.00^b	78.00^a	10.78
Crude fibre digestibility	64.00^c	68.00^b	72.51^a	1.90

a, b ,c Means in a row with common letter(s) superscript do not differ (P > 0.05).

DISCUSSION

Treatment 1 showed crude protein content of between 14.74 and 15.03%, providing an adequate protein level for goat growth and development. The observed values are consistent with acceptable ranges for goat diets (NRC, 2007). Dry matter content in the dietary Treatment ranged from 79.00% to 80.73%, indicating a relatively high dry matter concentration. This is beneficial for nutrient intake and digestion in goats. Crude fiber content in the dietary Treatment varied

from 10.38% to 10.90% which was slightly lower than the minimum level of 12% recommended by NRC(2007). The reduction may probably be due to the enzymatic action of *Aspergillus niger* on the Sugarcane scraps. Ether extract content in the Treatments ranged from 5.96% to 6.43%, indicating a moderate fat level in the diet. Fat serves as a concentrated source of energy and aids in the absorption of fat-soluble vitamins. Total ash content in the Treatment ranged from 8.17% to 8.77% indicating the presence of essential minerals necessary for goats' overall health and well-being.

The Treatment exhibited a range of metabolizable energy content of between 2509.70 and 2567.00 Kcal/kg suggesting its potential as an energy-dense diet. This higher metabolizable energy may contribute to improved feed intake and weight gain in goats.

Nitrogen-free extract content in the Treatment ranged from 59.23% to 60.75%, representing a moderate carbohydrate content. The carbohydrates serve as a readily available energy source for goats.

The results presented on the feed intake and weight gain provide valuable insights into the feeding behaviour and growth performance of the animals in different treatments. The differences observed in feed intake and weight gain parameters can be attributed to variations in the composition of the diets and the nutritional requirements of the animals. However, Treatment 3 showed the highest dry matter intake (DMI) of 750 grams, indicating that the animals consumed a larger quantity of feed compared to other treatments. This might be due to the palatability and nutrient composition of the diet, as animals tend to consume more when the feed is highly palatable and nutritionally balanced (McDonald *et al*., 2002). The high daily dry matter intake observed herein was in agreement with the report of Haque *et al.* (1997). It would appear that the fungus-based diet was probably more palatable and more acceptable to goats than the Control diet. Additionally, the total DM intake based on percent body weight (%BW) was not significantly different (P>0.05) among the dietary treatments. The daily DM intake based on the % BW of goats in this experiment was within the range of 3.0 to 5.0% reported needed for goats (www.wrightfeeds.ca)

The significance of protein intake as the determinant of performance in ruminants is well elicited in literature (Preston and Leng, 1987). However, crude protein intake (CPI) values of between 70g and 110g were noted for dietary treatments 1- 3 which was above the 7% minimum recommended by NRC (2007). This suggested that the diets provided adequate protein content to meet the animals' requirements for growth and maintenance (NRC, 2007). Similarly, the crude fiber intake (CFI) values were comparable across the treatments, indicating consistent fiber content in the diets. Adequate fiber intake is important for proper rumen function and overall digestive health in ruminants (Van Soest, 1994).

Treatment 3 had the highest intake of ether extract (EEI) at 50g, indicating a higher consumption of dietary fat compared to the other treatments. This could be attributed to the fermentation of Sugarcane scraps with *Aspergillus niger* which is a good lipase producer with high lipolytic activity (pubmed.ncbi.nlm.nih.gov 2023) and or the inclusion of fat-rich ingredients in the diet, which may have contributed to increased energy intake. Fat is a concentrated source of energy and can positively influence growth and performance in livestock (Chilliard *et al*., 2007).

Treatment 3 had the highest value of Metabolizable energy (19,250.25 kcal/kg). This suggested that the diet provided a higher amount of energy to the animals, potentially contributing to improved growth performance. Energy is a critical component of the diet, and meeting the energy requirements is essential for optimal growth and development in animals (NRC, 2007) as noted in this study.

Dietary treatment 3 showed the highest final weight of 14.40 kg, indicating better weight gain compared to dietary treatments 1 and 2. This was consistent with the higher feed intake and energy intake observed in Treatment 3, suggesting that the animals received more nutrients and energy to support growth.

Dietary Treatment 2 also exhibited significant (P<0.05) weight gain, with a final weight of 13.91 kg, while Treatment 1 had the lowest weight gain of 13.50 kg. These differences might be attributed to variations in the nutritional composition and digestibility of the diets. The results suggested that Treatment 3, with higher feed intake and energy intake, promoted better growth compared to the other treatments.

The higher Feed Conversion Ratio of dietary treatment 2 (0.85) and dietary treatment 3 (0.94) compared with the control (3.85) was a reflection of the higher weight gain observed in diets 2 and 3 (fungus-based dietary treatments) compared with the control. Nevertheless, there was a marginal increase of 6.67 % and 3.04 % in the final body weight of dietary treatments 3 and 2 respectively when compared with the control. Fungus-based diets appeared to increase the appetite of the goats from 50% replacement to 100% of Sugarcane scraps and this could have led to the increase in weight gain and improvement in feed conversion ratio observed respectively at 50 % (dietary treatment (2) and 100% (dietary treatment 3) levels of inclusion.

Partial Budget Analysis

The result of economic analysis indicated that feed cost/ kilogram weight gain of the goat was higher for goats fed with T2 and T3 diets which was due to the higher final body weight noted. But, T1 had a low rate of feed cost/kg of feed due to its high variable cost.

Digestibility coefficient

The nutrient digestibility indicated that the digestibility values of dry matter, crude protein, crude fibre, and ether extract were significantly different (P<0.05) among the dietary treatments (1-3). This observation supported the submission of Abo-Donia *et al.* (2014) and Nguyen *et al.(*2019) who noted increasing apparent nutrient digestibility when fungal-treated peanut hulls and rice straw respectively were fed to sheep. The apparent digestibility of dry matter in the current study was slightly higher than the reported value of Dereje (2014) within the value of (68.4-71.3). Variations may be due to the species and nutrient composition and intakes.

Crude fibre digestibility was significantly lower in the Control compared with other dietary treatments. This finding agreed with the earlier report of Lowry (1995) that fungus-treated ingredients had a high digestibility but noted that most of the rumen fermentation occurred very rapidly within the first 24 hrs. Lascano and Palacios (1993) observed that the intake and digestibility of tropical dry season grasses by goats and sheep tend to be low due to high fibre and low crude protein concentration in these forages but its incubation with fungus enhanced the intake and digestibility in this study. This observation implies that *Aspergillus niger* treated waste agricultural residues when included in a complete diet of ruminant animals have improved the nutrient intake and digestibility in the diets of ruminant animals.

Conclusion

This study noted that there was a great potential for improving the nutrient intake, weight gain, and digestibility coefficients of Red Sokoto goats fed Aspergillus-treated Sugarcane scraps-based diets. Hence, the results of the present experiment have shown that the inclusion of fungus-treated Sugarcane scraps at 25 % and 50% in the diet of Red Sokoto goats gave the optimum performance. However, dietary treatment 3 gave the best performance in terms of weight gain, apparent digestibility, cost of /kg weight gain, and FCR. The utilization of such diets holds a good promise for farmers due to the declining nutritive value of available grass species during the dry season and therefore reduced the characteristic weight loss during this period.

Conflicts of interest

The authors declared no conflict of interest regarding the publication of this paper

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