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Energy and protein values and economic efficiency of Red Sokoto goats fed *Zymomonas mobilis* treated sawdust in the diet

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The availability of ruminant animal feeds is among the main constraints to the expansion of the livestock industry in the Southeast of Nigeria. Anigbogu (2000) and Anigbogu and Okocha (2003) noted that the major limitation to ruminant production in this area is poor nutrition. Chemical treatment of fibrous feedstuffs, the supplementation of tropical roughages with leguminous fodder trees and shrubs (FTS), addition of low-cost nitrogenous sources and use of agricultural by-products are among the promising methods to alleviate nutrient deficiencies associated with these diets (Chesson *et al*. 1983, Morgavi *et al*. 2006) but are highly cost effective. To avoid the product of fermentative digestion, the enhancement of the digestibility of fibrous feeds through the improvement of the organisms in *in-vivo* and *in-vitro* is currently acknowledged as the most powerful tool for improving the rate and extent of digestion of low quality and lignocellolistic feeds (Anigbogu and Anigbogu 1999, Anigbogu *et al*. 2009a).

Recent studies suggested that *Zymomonas mobilis* a bacterium from palm sap, can improve nutrient in lignocellolistic materials for animal nutrition, when the end product *(Zymomonas mobilis* degraded material) is added to the diets of ruminant animals (Sprenger 1996, Ichita 2006, Anigbogu *et al*. 2009b). The supplementation of digestive enzymes is essential to ruminant animals, because complex feeds such as palm kernel residues, sawdust, rice hull etc. are not readily absorbed by the digestive tract unless these are broken down to simple molecules (Anigbogu *et al*. 2003a, Anigbogu and Ibe 2005, Ichita 2006). In view of the above findings, the conversion of sawdust into proteolytic enzyme residues becomes important for the nutrition of ruminant animal industry generally.

Sawdust was biologically treated in the traditional setting using 40 kg sawdust placed in the fermentation vat (volume, 100 liters) with 80 litres of water added to 4 kg previously fermented dough containing *Z. mobilis*, which acted as starter inoculum. The samples were homogenously mixed at 48 h intervals until the end of the fermentation period of 10 days at the temperature of about 23.95°C. The fermented product was sun-dried, analyzed and stored as treated sawdust for the experiment. Red Sokoto goats of both sexes (12 females and 6 males), average body weight of 9.0 kg, 4–5 months of age, were divided into 3 groups and fed 15% untreated sawdust (T_1), 15% treated sawdust (T_2) and 20% treated sawdust (T_3) and other ingredients (Table 1). For adaptation, the experimental rations were fed to the animals for 3 weeks, before the actual study, which lasted for 42 days.

The initial body weights of the animals were recorded at the beginning of the study and subsequently at weekly

Table 1. Experimental diets and their composition (kg)

Feedstuffs	T_1	T_2	T_3
Maize offal	49	49	44
Untreated sawdust	15	-	-
Treated sawdust	-	15	20
Palm kernel cake	33	33	33
Bone meal	1.25	1.25	1.25
Oyster shell	1.25	1.25	1.25
Salt	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25
Total	100.00 kg	100.00 kg	100.00 kg
Chemical composition (%)			
Crude protein	12.04	12.74	13.02
Ether extract	6.20	6.17	6.18
Crude fiber	18.35	17.86	20.80
Ash	5.35	5.52	5.59
Calcium	0.90	1.18	1.28
Phosphorus	0.65	0.67	0.68
Salt	0.41	0.48	0.50
MER/MJ/kg	11.24	11.29	11.73

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interval till the end of the experiment. The diets offered were adjusted on weekly basis depending on the body weight without altering the diets. The determinations of the energy needs were based on the TDN required for gain as followed: Pounds gain × 3.53; and TDN equivalent to loss: Pounds lost × 2.73 (Ranjhan 1993, Maynard *et al*. 2002). The protein intake was based on% crude protein in feed × g of feed taken/ 100. The digestible protein of the feed was based on: crude protein of the feed/average biological value of 0.775. The digestible protein for growth was based on: body protein concentration × g of gain/day/0.45. Protein replacement value = N balance$_{ST}$ - N balance $_T$×100/N intake; and net protein retention (NPR) = gain on text protein (g) + loss on protein free diet (g)/protein intake (g) (Lassiter and Edwards 2002). The economic benefit analysis was calculated in Nigeria naira (N), but was based on Lopez (1985), while the return on investment (ROI) was based as net profit/production cost × 100 (Anigbogu 2000). The economic efficiency was obtained as net revenue/feed cost. The relative economic efficiency was with the assumption that the control treatment is equal to 100. The data were analyzed as analysis of variance. The differences between the treatments mean when found significant (P< 0.05, P< 0.01) were treated by Duncan's new Multiple Range Test (Gomez and Gomez 2005) at an alpha level of 0.05% significance.

There was significant increase (P<0.01) in weight gain ($W^{0.75}$) with the inclusion of *Z. mobilis* treated saw dust (Table 2); values increased from –15.90 g day (T_1) to 31.86 g day^{-1} (T_2) (Anigbogu *et al*. 2009a). There was significant increase (P<0.01) in DMI based on feed intake ($W^{0.75}$) on T_1 to T_3 which was similar to the observation made by Classen (1996). The efficiency of feed utilization was significant (P<0.01) better in T_2 (3.47) and T_3 (6.08) than that of T_1 (–5.42). Our results are in line with those of Anigbogu *et al*. (2009b), Anigbogu *et al*. (2009a).

The protein intake (PI) was low (P<0.01) in T_1 as compared to T_2 and T_3 but similar to the observations of Beauchemin and Rode (1996), Hirstov *et al*. (1998). The digestible protein of the feed (DPF) improved (P>0.05) on DPF in T_3 (0.17) and T_2 (0.16) than 0 in T_1 (0.15). The digestible protein for growth (DPG) improved significantly (P<0.01) with the highest value (35.91) recorded for the T_2, which is in line with the works of Colombatto *et al*. (2002), whereas the protein replacement value (PRV) exhibited improvement (P<0.01) in T_3 (0.08) as reported by Newbold (1995). The highest value on net protein retention (NPR) was observed on T_2 (0.90) (Beauchemin and Rode 1996, Firkins 1996). The total digestible nutrient (TDN) required for gain followed the same trend (P<0.01) as recorded for net protein retention by Brown and Johnson (1991). There was significant effect (P<0.01) on the return on investment (ROI), the values increased from –3.66% head^{-1} (T_1) to 46.68%/head (T_2) as in the studies of Classen (1996) and Bosthast *et al*. (1999). The economic efficiency was significant (P<0.01) better in T_2 (189.42) and T_3 (69.31) than that of T_1 (–7.52). The relative economic efficiency was generally poor (P<0.01) in diet T_1 as compared to T_2 and T_3, this is similar to the work of Williams *et al*. (1991), Feng *et al*. (1992) and Lewis *et al*. (1996).

The protein values studied were consistently better as noted in diets B and C with *Z. mobilis* treated sawdust which indicates efficient utilization of nitrogen in rumen. As noted

Table 2. Data on protein, and energy values and economic efficiency of Red Sokoto goats fed life-enzyme (Z. mobilis treated sawdust) in diet

	Treatment diets			±SD	CV	Sig.
	T_1	T_2	T_3			
Initial weight (kg)	7.8	10.5	8.3			
Final weight (kg)	7.7	14.7	10.6			
Final Wt. gain kg $^{(W0.75\ kg)}$	4.62	7.51	5.88	1.45	0.48	**
Daily Wt. gain g $^{(W0.75\ g)}$	–15.90	31.86	20.20	24.90	8.30	**
Ave. total intake g $^{(W0.75\ g)}$	86.10	110.46	122.72	18.64	6.21	**
Efficiency of feed utilization	–5.42	3.47	6.08	6.03	2.01	**
Protein intake (PI) (g d^{-1})	45.75	67.52	79.42	13.37	4.46	**
Digestible protein of feed (DPF)	0.15	0.16	0.17	0.06	0.02	ns
Digestible protein for growth (g d^{-1})	–14.22	35.91	19.56	25.57	8.52	**
Protein replacement value (PRV)	0.00	0.05	0.08	0.11	0.04	**
Net protein retention (NPR)	0.00	0.90	0.19	0.40	0.13	**
Determination of energy needs						
TDN required for gain	0.00	162.06	88.25	55.70	18.57	**
TDN equivalent to loss	–49.64	0.00	0.00	23.31	7.77	**
Return on investment (ROI) (%)	–3.66	46.68	22.50	35.61	11.87	**
Economic efficiency (EE)	–7.52	189.42	69.31	99.26	33.09	**
Relative economic efficiency (REE):	0.00	1.04	1.11	0.35	0.12	**
	100.00	104.04	111.00	0.35	0.12	**

in this study for an effective rumen digestion of poor degradability wastes and other low quality feeds, not only that a level of nitrogen be improved to poor quality feeds like sawdust, also that continuous supply of nitrogen may be necessary to maintain effective fermentation in the rumen. The results of the present study showed that the incorporation of *Z. mobilis* treated sawdust at 15 and 20% in the goat diets improved the weight gain ($W^{0.75}$), feed intake ($W^{0.75}$), efficiency of feed utilization, TDN required for gain, protein values, and economic benefit analyses studied as compared to those fed untreated sawdust alone without *Z. mobilis* treated sawdust. The results of the present study revealed that diets containing 15 and 20% *Z. mobilis* treated sawdust could be used as component of formulated diet for Red Sokoto goats.

SUMMARY

Sawdust was incubated with *Zymomonas mobilis*. Eighteen growing Red Sokoto goats (4–5 months of age, 12 females and 6 males) were divided into 3 groups and fed diets containing T_1 (0%), T_2 (15%) and T_3 (20%) *Z. mobilis* treated sawdust, respectively, which replaced maize offal a conversional energy source and fed/day/head. There was increase on the body weight gain better on the T_2 and T_1 over that of diet T_1. The total intake increased on T_2 and T_3. The efficiency of feed utilization improved on T_2. Protein intake of T_2 and T_3 were consistently higher than T_1. The values for digestible protein for growth and net protein retention were generally high among the goats fed diets T_2 and T_3. The total digestible nutrient required for gain was consistently high on diets T_2 and T_3. Return on investment of T_2 and T_3 diets were consistently higher than –3.66% found on T_1.

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