NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 49 Number 2, October 2018. Pp. 218-227
Available online at: http://www.ajol.info/index.php/naj

VALUES OF SAWDUST DEGRADED DIASTIC MICROBES of Achatina fulica FED GOATS AS PART OF FORMULATED DIETS: AN ALTERNATIVE MUNICIPAL ORGANIC WASTE MANAGEMENT

[1&2]Anigbogu, N.M., [2]Afam-Ibezim, E.M. and [3]Ukweni, I.A.
[1&2]Coordinator: Life-Enzyme and Fine Chemical Research (Waste Management, Utilization & Pollution Control); [2]Department of Animal Nutrition and Forage Science; [3]Department of Veterinary Physiology & Pharmacology; Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria.
Corresponding Authors' email: nmanigbogu@gmail.com

ABSTRACT
Experiment was conducted to evaluate the utilization of sawdust degraded diastic microbes (SDDM) (of *Achatina fulica*) as feed component for Red Sokoto goats. Thirty-six Red Sokoto goats of mixed sexes (18 females and 18 males), average bodyweight 4kg, between 4-5months of ages were used. Goats were randomized into 3 groups of 12 goats per group, consisting of 3 goats per replicate, which replicated 4 times. Groups were assigned to each of the 3 diets (T1 with 15% undegraded sawdust, T2 with 15% SDDM and T3 with 25% SDDM). Investigations revealed the chemical composition of the organic matter, ash, and the energy generally were low on the SDDM ($P>0.05$) when the sawdust was degraded with the diastic microbes. The SDDM protein, crude fibre, ether extract, nitrogen free extract as well as the nitrogen followed a different dive with great increment over the untreated sawdust. This could be due to the efficiency of the diastic microbes in the degradation of the sawdust to make the nutrients available for the efficient farm animals' utilization; which is an indication of quality sawdust produced (SDDM). The daily feed intake and weight gain values (435.87g) (79.37g) and (308.25g) (15.87g) differed ($P<0.01$) as against the values in T1. However the efficiency of feed utilization values (T3 and T2; 19.42, 5.49) differed ($P<0.01$) over T1. The cost of feed/kg and cost of production/goat showed better values on the T3 ($P<0.05$) over of T2 and T1; while the gross and net profits were generally better ($P<0.01$) in T2 followed by T3 and T1. Similar trends were observed on carcass values, wholesale cuts, lean/bone values and pelts, respectively. It was concluded that, the inclusion of SDDM at 15% and 25% as part of formulated concentrate diets for growing goats gave the best results, over the undegraded sawdust.

Keywords: Weight gain, sawdust, cost benefits, goats, and diastic microbes

Introduction

Fear about the future availability of conventional feed for use in the farm animal production has been evident of discussions at various meetings and conferences recently (Best, 2006; Anigbogu and Onyejekwe, 2012). Most concentrates for goats are grain-based, and are used to meet their energy requirement, which helps to improve their feed efficiency (Pramote, 2011). Grimes (2006) forecasted an increase in the price of conventional feeds such as maize over the next 10 years because of competition for grains from industrial processes. Similarly, worthy of note is the fact that there exists a high level of competition between man and animals for conventional feed such as maize, for it is a major staple food for human (Anigbogu, 2011a). In Africa, annual quantity of fibrous agricultural residues available sawdust inclusive was put at about 340 million tonnes as observed by Belewu *et al*., (2007). In Nigeria, large amount of sawdust are produced annually which was estimated to be 30,064, 323m^2 (Babayemi and Dauda, 2009), and are not utilized for farm animal feed. This contributes to poor waste disposal; which in itself contributes to environmental pollution and constitutes public nuisance and eyesore (Oladeji, 2010). These enormous amounts of sawdust represent potential valuable feed materials for future biotechnological exploitation as noted by Anigbogu (2011b). If this huge amount of sawdust could be converted to feedstuff as farm animal feeds, our environment could be cleared of pollution, and with improved health (Belewu *et al*., 2007, Anigbogu and Ezekwem, 2013). According to Anigbogu and Ibe (2005), scarcity of feed for farm animals has been a problem hindering animal husbandry in the Southern Nigeria; where there is abundance of sawdust from the wood-milling industry that serves as waste causing health harzard. There have been calls for research on the use of sawdust as suitable feed in the nutrition of farm animals, so as to help control our environment of pollution (Anigbogu *et al*., 2009a, Anigbogu and Adekul-Agbale, 2013).

According to Anigbogu (2011b), the major limitation in the use of sawdust as feed (which constitute about 62.10% lignocellulosic plant materials) is the crystalline nature of the cellulose and recalcitrance of lignin; he further revealed that, lignin constitutes a physical barrier to the utilization of sawdust in the farm animals' feeding system. As in Anigbogu (2011b), this physical barrier of lignin could be broken either by physical, chemical or in biological treatments. This biological treatment of fibrous materials is not entirely new, and is currently being introduced in the field of animal nutrition and production throughout the globe as noted by Anigbogu (2011b), Anigbogu *et al*., (2011c). The recent microbial technology using efficient micro organisms and Innovation Solid-state Fermentation (SSF) technology (Anigbogu *et al*., 2009b; Anigbogu *et al*., 2011b) may be particularly appropriate for the biological conversion of sawdust to valuable feed to make enzymic hydrolysis more accessible in the rumen. Diastic microbes, a specialized crop of symbiotic micro-organisms [found in the digestive system of Giant African Snail (*Achatina fulica*), an omnivorous animal], that help in the breakdown of the complex carbohydrates (polysaccharide/complex cellulose) into simple sugars could be used in the bio-conversion of sawdust into valuable feed for farm animals. These microbes comprise of bacteria, fungi, protozoa, yeasts, etc; which could produce arrays of enzymes as decompositors, including a cytase (cellulose-splitting enzyme), which digests plant cellwalls and liberates their contents, thus this study.

Materials and Methods

Experimental Site

The experiment was carried out at the Sheep and Goat Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The site lies between latitude of 05^0 - 29^0 North and longitude of 7^0 – 32^0 East, and at an altitude of 123m above the sea level. It is ecologically situated in the rainforest Zone of Southeast of Nigeria (Keay, 1959) with annual rainfall of 2177mm, temperature of 22^0C - 36^0C, and relative humidity of 50% to 90%.

Materials Used

About 200kg of sawdust was obtained at Timber Milling Industries, Umuahia, Abia State, Nigeria. The chemical compositions of the materials used are as in Tables 1 and 2, respectively.

Preparation of Starter Inoculum

The starter inoculum was prepared under the laboratory condition (Anigbogu *et al*., 2009b) using fermentation vat (Volume = 3.5 litres). Five hundred grams of sawdust as substrate, 100 ml diastic microbe suspensions, 2 liters of water were measured and placed in the vat.

Preparation of Life-enzyme (Sawdust Degraded Diastic Microbes [SDDM])

The life-enzyme was prepared as in Anigbogu *et al*., (2009b) using 20kg of sawdust placed in the fermentation vat (Volume = 100 liters), 40 liters of water added with 2kg previously fermented dough (containing diastic microbes) which acted as starter inoculum. Then, stirred to obtain a homogenous mixture, and allowed to degrade at the room temperature of 23.1°C to 24.6°C for 10 days. After that, the fermented product was sun-dried, analyzed and stored as Life-enzyme [sawdust degraded diastic microbes (SDDM)] for the experiment (Roman et al. 2006, Anigbogu 2011a).

Experimental Animals

Thirty-six Red Sokoto goats of both sexes (18 females and 18 males) with average body weight of 4kg, aged between 4 - 5 months were used for the experiment and were housed on a floor space of 0.5 - 0.75 square meters, with 4 - 5 linear inches feeding space, on well ventilated, cemented, floored pens. To prevent accumulation of excreta and wetness of the pens, they were spread with wood shaven as bedding material. Goats were quarantined for 3 weeks to observe the health condition, treated against helminthes and ectoparasites using IVOMEC, during which they were fed the experimental rations (Anigbogu *et al*., 2009b).

Feeding and Watering

Diets consisted of T1 = 15% UDS, T2 = 15% SDDM, and T3 = 25% SDDM, where maize offal, palm kernel cake, 3.5% ruminant concentrate-mix were used to balance the diets, as in Table 3. Water and feeds were provided *ad libitum* to the goats; first at 09.00 hrs and later at 16.00 hrs/day. Diet intake was measured by difference each time before the next feeding, as described by Anigbogu *et al*., (2009a).

Chemical Analysis and Data Collection

All samples including the feeding materials were chemically analyzed based on the AOAC (1990). Other data were gathered as weekly weight of the goats and daily feed intake, from where the daily weight gain, daily feed intake, and efficiency of feed utilization (Anigbogu, 2003).

$$\text{Efficiency of feed utilization} = \frac{\text{Daily feed intake}}{\text{Daily weight gain}}$$

Data on Cost Benefits

The cost benefit analysis was based on the method as applied by Anigbogu (2003). The cost/kg of dietary ingredient was used to calculate the cost/kg of each diet; from which the cost of feed consumed, cost of production, gross profit, profit, return on investment and economic efficiency were determined.

Slaughter Technique and Carcass Evaluation

At the end of the experimental trial of 63 days, 3 goats each were selected for the slaughter experiment from each of the treatments, to study the carcass yield characteristics, organometry, proportions of the wholesale cuts (legs, loins, hotel ranks, breast and shoulder), lean, bone and fat. A day prior to slaughter all animals to be slaughtered were weighed to obtain their live weight. They were subjected to 18 hours fast, weighed, slaughtered, dressed and dissected according to the standard wholesale cuts groups based on Gerrand (1964) and Anigbogu (2003).

Determination of Pelt

By calibrated gauze

Three goats were selected for pelt study in each of the treatments. They were slaughtered and skinned. After which the pelt was placed on wooden boards and fastened on all sides with thumb nails, and the circumference of the pelts determined using the calibrated gauze material.

By weighing scale

The weight of the pelts was obtained using weighing scale, after skinning.

Determination of Feed Quality in Relation to Fat Marbling of Goats

In each of the treatments, 3 goats were selected for study on shrinking-ability. The initial bodyweight of the goats were taken using a weighing scale, after which the goats were starved for the first 4hrs, then followed by another 24hrs starvation, after which weighed and data recorded.

Design and Statistical Analysis

Thirty-six goats were randomized in a completely randomized design, with 12 goats per group of 3 that consisted of 3 animals that replicated 4 times. Each group was assigned one of the diets as in the Table 3. Data collected were subjected to analysis of variance procedure of the Completely Randomized Design as described by Steel and Torries (2000). The mean separation for significant effect was done using Duncan's New Multiple Range Test as described by Gomez and Gomez (2006), where significance occurred.

Results and Discussion

Chemical Composition of Sawdust Used

As in Table 1, the chemical composition as studied revealed that the organic matter was low on the SDDM by about 2.52% ($P>0.05$) when the sawdust was degraded with the diastic microbes. The SDDM protein as well as the nitrogen followed a similar dive with an increment of about 660% over the untreated sawdust. Further, the crude fiber followed a similar partan with an improvement of about 26.25% ($P<0.01$), where the ether extract and nitrogen free extract generally increased ($P<0.01$) by 25% and 28.38%, respectively all in favor of the SDDM over the untreated sawdust. The ash and the energy values took a negative dimension ($P>0.05$) on the SDDM. This study falls in line with the works of Anigbogu and Adeku-Agbole (2013), Anigbogu *et al.*(2011b), this could be an indication on the efficiency of the diastic microbes in the degradation of the sawdust to make the nutrients available for the efficient farm animals utilization. It's an indication of quality sawdust produced (SDDM). This was observed by Anigbogu (2015), when the *Zymomonas mobilis* treated sawdust was evaluated of protein, effective fibre and fats.

Weight Changes, Feed Intake and Efficiency of Feed Utilization Parameters

The results for daily feed intake, liveweight changes and efficiency of feed utilization of goats fed with SDDM as component of diets are presented in Table 3. The feed intake values as recorded in this study were 435.87g (T2) and 308.25g (T3) were better ($P<0.01$) than the value obtained on the T1, this supported the findings of Anigbogu *et al.* (2009a). While the liveweight change value as observed was better ($P<0.01$) among goats fed T2 (79.37g) and T3 (15.87g) over those of T1 (-23.80g) that revealed significant lost in weight. For the efficiency of feed utilization, the goats when fed the SDDM diets (T2 and T3) recorded the best values as in 5.49 and 19.42 ($P<0.01$), respectively over the goats fed T1 (-10.85) diet.

On the feed intake: The value obtained is an indication that the SDDM was palatable and acceptable to the goats as component of formulated diets. This could be attributed to the more metabolizable content of the SDDM that is as a result of the action of diastic microbes on the sawdust. Furthermore, it could be due to the action, and the detoxification subsequent removal of inhibitory/toxic substances contained in undegraded/raw sawdust by the action of the microbes (Anigbogu *et al.*, 2011b).

On liveweight change: The significant liveweight change found among the goats fed the diets (T2 and T3) could be as a result of higher feed intake of the goats fed the SDDM diets, as well as the breakdown of the glucosidic bonds in the cellulose and hemicellulose (Belewu & Ademilola, 2002) by cellulolytic enzymes produced by the diastic microbes, and the subsequent release of the metabolites in form of D-glucose, soluble cellulodextrins, xylose, arabinose, galactose, true proteins, essential fats and mannose which were utilized by the goats. This finding is in line with observations made by Anigbogu (2001b) in similar studies. It also confirms the assertion of Belewu and Ademilola (2002) who revealed that, pre-treatment of dry grass with fibrolytic enzymes improved the *in vitro* ruminal fibre digestion and utilization in farm animals.

On the efficiency of feed utilization: The better efficiency of feed utilization as noted in this study could be attributed as a result of the availability of the nutrilites from the SDDM, which resulted in better metabolism/utilization by the goats as in the T2 and T3 diets fed goats. This is in line with observations made by Belewu *et al*. (2004) who reported an improved feed intake , weight gain and better feed efficiency of goat fed sawdust/cassava waste diet incubated with *Saccharomyces cerevisiae.* The poor result obtained in T1 could be due to the presence of lignin, phytotoxins and other inhibitory factors as observed in the raw sawdust which made the nutrients in T1 inaccessible to the goats' microbial system, and which reflected in the daily loss in weight as also noted by Anigbogu and Adeku-Agbole (2013) in related study.

Cost Benefit analyses

The results for feed cost/kg, cost of production, gross and net profits, return on investment and economic efficiency of goats fed SDDM in the diets are as presented in Table 4. Based on economic benefits studied, the feed cost/kg was better **(**P<0.05) in T3 (₦36.43), when compared to T1 (₦40.27) and T2 (₦40.43). The cost of production/goat was generally better in T3 (₦5386.46) (P<0.05) over the T2 (₦6257.1) and T1 (₦6503.93), which was due to the use and the effects of the degraded sawdust as feed in the goats' diets. While the gross and net profits of the goats were observed to increased, and were generally profitable (P<0.01) in T2 (₦8,286.4) (₦2029.3) over those of T3 (₦5, 696.9) (₦310.44), and T1 (₦5,696.9) (-₦807.03) respectively. Based on the return on investment, it was observed (P<0.01) that T2 recorded the higher value at 32.43% over those of T3 (5.76%) and T1 (-12.4%). Where the economic efficiency value studied was found higher (P<0.05) on T2 (1.83) SDDM diet fed goats, than those of the T3 (0.44) and T1 (-1.23) goats.

Feed cost/kg: This is an indication that, when the sawdust is degraded with diastic microbes and added in high level in the diet has a great effect to the cost benefit despite the additional costs due to the treatment. Further, had great bearing when fed to the goats in relation to the cost of production, and profits as revealed by Anigbogu (2011a), Anigbogu and Onyejekwe (2010) in some previous studies using *Zymomonas mobilis* in the degradation of sawdust and as feed for Maradi goats. Therefore, used in degradation of sawdust with diastic microbes become important in the goat feeding nutritional system.

Cost of production: It validates the fact that, the inclusion of SDDM resulted to better cost of production as noted by Anigbogu *et al.* (2009a) in previous studies where sawdust was treated with *Z. mobilis.* The degradation of sawdust with diastic microbes has improved the cost of feed/kg by increasing the growth as well as the efficiency of feed utilization, which was the contributing factor that helped improve the cost of production as revealed by Anigbogu and Anosike (2010a) in a related study.

Gross and net profits: The poor result as noted in T1 was as a result of change in weight, which was as a result of poor feed intake, poor efficiency of feed utilization, which in turn attributed to poor cost of production, poor return on investment as well as poor economic efficiency as recorded in this study. Further, this poor performance could be as a result of the negative nutritional impact of the undegraded sawdust on the goats (Anigbogu *et al*., 2009a, Anigbogu *et al*.., 2011a). Therefore, it is invariably an indication that, it is highly profitable to feed goats with SDDM as component of formulated diet as observed in this study and as revealed by Anigbogu and Adeku-Ogbole (2013) and Anigbogu *et al.* (2011a), in similar studies using *Z. mbilis* treated sawdust.

Return on investment: This could be attributed to the better daily weight gain, efficiency of feed utilization, better profit, better cost of production and cost of feed/kg as recorded among the goats fed SDDM. This is justifiable because, the best profits were made on feeding goats with T2 and T3 at inclusion rates of 15% and 25% in the diets. It further revealed that, feeding goats with undegraded sawdust as feed ingredient in formulated diet will only result to poor productivities/losses as noted by Anigbogu (2011a) in similar study, but with improved results when *Zymomonas* degraded sawdust was fed to the goats.

Economic efficiency: The highest value on the economic efficiency obtained in T2 and T3 is an indication of maximizing profits in this study with the inclusion of SDDM at 15% and 25% as part of goats' formulated diets. It further revealed that, it is good to feed goats with SDDM as part of formulated diet for the goats as previously noted by Anigbogu (2011a), Anigbogu *et al*. (2010a) in similar studies.

Carcass Characteristics

The Table 5 summarizes the carcass yield characteristics of goats as in this study. The corresponding values for warm carcass (kg) differed (P<0.01) and was better 6.05 (T2) followed in T2 (3.43) and then T1 (3.20). The T2 produced better warm carcass when compared to the other treatments. The dressing percentage was high (P<0.01) in the T2 over those of T1 and T3, respectively. The leg and lion cuts differed (P<0.01) among the treatment groups. The T2 had the highest value, followed by T3, while the poorest value was noted in T1. In this study, the rib, shoulder and breast values for goats fed the T2 diets had the highest value (P<0.01) over those of T3 and T1 diets. The lean meat and bone values were observed favorably better on the T1 and T3 (P<0.01) over the T3. Then, it was observed that the T1 had the highest bone value (P<0.01) when compared to these of the other treatments. High abdominal and pelvic fat values were recorded (P<0.01) among the goats fed the degraded sawdust (T2 and T3) over these fed T1 with the values of 12 and 2. The pelt values based on weight and circumference measurements were generally higher (P<0.01) among the goats fed the degraded sawdust over the goats fed T1.

Warm carcass value: This could be attributed to the better efficiency of feed utilization as recorded in T2 as compared to T1 and T3. This is in line with observations made by Belewu & Popoola (2007) who concluded that, feeding of *Rhizopus* treated sawdust for WAD goat improved the body weight gain of the experimental animals than those of the control with non fungal treatment. Their observation had a great bearing to carcass quality as also noted by Anigbogu (2003), who also fed goat with *Z. mobilis* treated sawdust and had similar observation.

Dress percentage: The values obtained for all treatment groups fall within the range of 32-52% as reported for goats (World Bank 1983; Steele 1996; Prinkerton 2003; Attah *et al*. 2004). Though, the goats fed the SDDM diets had the best results.

Leg and lion cuts: The result indicates that, the inclusion of SDDM in the diets for the goats favorably improved the leg cuts than those fed with the control diet, as also noted by Anigbogu (2003) in a similar work, who revealed that, gain in weight in farm animals is an index for the carcass cuts. There was a great improvement on the loin cuts, with the T2 and T3 having the highest values, which is an indication of high carcass yield. This could be traced to better quality feed as a result of the inclusion of SDDM in the goats' diets. This is in line with the results of Anigbogu *et al*. (2010b) in a similar study, where cassava peels were treated with organic microbes for Life-enzyme production, and was fed to goats.

Ribs, shoulder and breast: Similar observation was made for the shoulders, breasts and flanks, where higher values were observed in T2 which indicate better quality feed and higher efficiency of feed utilization, when the SDDM was made part of the goats' diet, which was as observed by Anigbogu (2011a) in a similar work. The goats fed T2 and T3 diets had the most favorable values for the lean cuts, this differed (P<0.01) over the T1 fed goats. This indication was as a result of better efficiency of feed utilization by the goats fed with SDDM diets. The result further revealed that, feeding goats with SDDM diets yielded better lean cuts than on goats fed undegraded sawdust (Anigbogu and Onyejekwe, 2010).

Lean and bone: These improvements as noted as in the lean and bone values are as an indication of the degraded sawdust as part of the formulated diets for the goats. The high level of the bone as noted in the T1 could be as a result of poor quality feed that was as a composite of the undegraded sawdust. The poor lean cut as noted in T1 resulted to the poor weight gain that resulted to high skeletal formation, which could be attributed to poor feed intake and poor metabolism and poor utilization of the undegraded sawdust by the goats, as found by Anigbogu *et al*. (2011a), Anigbogu (2011b) in a related study when sawdust was treated by *Z. mobilis*. Goats fed T2 and T3 diets had the most favorable values for bone lean ratio which differed (P<0.01) among the treatments. The high bone lean ratio observed for goats fed T2 and T3 diets supports the facts previously noted that, the efficiency of feed utilization of the goats fed the SDDM diets were generally positive. This was confirmed by the higher dressing percentage (40.33), (34.30) found on T2 and T3 respectively, over the T1 fed goats, which was due to the addition of the degraded sawdust in the diets of goats, as previously noted by Anigbogu (2011a).

Abdominal and pelvic fats: This increase could be attributed to the fact that, goats in T1 were unable to utilize the complex carbohydrate of undegraded sawdust, coupled with the anti-nutritional factors present in the sawdust. Further, this could be as a result of high complex bound nutrients in T1 diet that resulted to the poor metabolism of undegraded sawdust in the diet, and poor energy production for the goats. Similar observations were made by Anigbogu and Associates as previously cited in this study, which is in line with the findings of Williams *et al*. (1991) and Lewis *et al*. (1996). The higher values for pelt based on weight and circumference measured were observed in T2 and T3 which differed (P<0.01) over the T1. This could be attributed to the better growth on the goats fed the SDDM diet as compared to those fed the control. This could lead to the conclusion that, since pelt from Red Sokoto goat is of high economic value, feeding goats with SDDM diet will be beneficial for high monetary value/recovery. The values obtained for the various parts that constitute the offal revealed that T2 had higher offal value, and the pelt respectively. This is in line with the work of Classen (1996), Colombatto *et al.* (2002), due to better growth and feed consumption as noted in this study.

Conclusion

The results of this study revealed that, sawdust when degraded with diastic microbes (SDDM) could serve as good feed for the goats. This is because there were better performances in all parameters studied, when the goats were fed with the SDDM diets. It is therefore recommended that, where sawdust is cheap, they should be treated with diastic microbes before feeding to goats at 15% - 25% in formulated concentrate diets for optimum performance. Also, more studies should be conducted on use of above 25% SDDM in the diets for goats, and other ruminant animals.

Acknowledgements

The recognition of 1st position in Sample Records for *Zymomonas mobilis* Cells in the world by the WorldWideScience.org, and the commendation of the Michael Okpara University of Agriculture Umudike on the above achievement to the 1st author, Prof. N. M. Anigbogu is gratefully acknowledged. The material assistance and expertise on the use of "*An Alternative Municipal Organic Waste Management: Exploitation of Nutrients of Sawdust Degraded Diastic Microbes as Feed For Goats"* provided by him is well appreciated. The authors also extend many thanks to referenced authors whose works were sighted in this study.

References

Association of Official and Analytical chemists. (1990). Official Methods of Analysis. Washington D.C. U.S.A.

Abdel-Sater, M.A., EL-Said, A.H.M. (2001). Xylan-decomposing fungi and xylanolytic Activity in agricultural and industrial wastes. *Int. biodeterioration Biodegrad.* doi:10.1016/S0964-8305(00)00113-x.47(1):15-21.

Agosin, D., Jarpa, S., Rojas, E. and Espejo, E. (1989). Solid State Fermentation on pine sawdust By brown-rot Fungi-Enzyme and Microbial Technology 11: 511-517.

Akuyuz, M., Yildiz, A. (2008). Evaluation of cellulosic wastes for the cultivation of *Pleurotuseryngii* (DC ex Fr.) Quel. *Afr. J. Biotechnol*. 7(10):1494-1499.

Anigbogu, N.M., Ezekwem, E.P. and Ugwuene, M.C. (2011a). Potentials of WAD Goats Fed Life-Enzyme (*Zymomonas mobilis* Degraded Sawdust/Poultry Litter) Sweetened Cake. *Nigerian Agricultural Journal 42: 233-239*.

Anigbogu N.M. and Ezekwem E.P. (2013). Effect of *Zymomonas mobilis* Degraded Sawdust/Poultry Litter (Life-Enzyme) on the Fiber Values (eNDF) of WAD Goats. *Nigerian Agricultural Journal* 44 (Nos. 1 & 2): 217-225.

Anigbogu, N.M. (2011a). Energy and Protein Values and Economic Efficiency of Red Sokoto Goats fed *Zymomonas mobilis* Treated Sawdust in the Diet. *Indian Journal of Animal Sciences.* 81(1):87-90.

Anigbogu, N.M. (2011b). Bio-Remediation: *Zymomonas mobilis* for Life-Enzyme Production As Farm Animal Feed. *Proceeding, 36th Conference, Nigerian Society for Animal Production, 13-16 March, University of Abuja Nigeria, pgs. 755-757.*

Anigbogu, N.M. and Adekule-Agbale, O.I.L. (2013). Performance and Economic Benefits of *Zymomonas mobilis* or in Combination with *Asparagus oryzae* Treated Sawdust Fed Goats as Feed. *Nigerian Agricultural Journal 44(Nos. 1& 2): 189-197.*

Anigbogu, N.M. and Anosike, J.C. (2010a). Economic Benefits of Life-Enzyme (*Zymomonas mobilis*) Degraded Sawdust Sweetened Cake as Feed for Maradi Goats. *Proceeding, 15th Conference, ASAN, 13-15 Sept, University of Uyo, Nigeria, pgs. 82-84.*

Anigbogu, N.M. and Anosike, J.C. (2010b). *Zymomonas mobilis* Degraded and Sweetened Sawdust (Life-Enzyme) Cake as Feed for the Goats. *Indian Journal of Animal Sciences 81(1):87-90.*

Anigbogu, N. M., and Ibe, S. N. (2005). The effect of crude enzyme residue of sawdust/poultry litter in the nutrition of West African Dwarf goats. In: Proceedings of the 30th Annualconference of the Nigerian Society for Animal Production, 30, 175-178.

Anigbogu, N.M. and Onyejekwe, I.E. (2010). Direct-fed Microbe (*Zymomonas mobilis* Degraded Rice Hull) as Feed for Maradi Goats. *Proceedings of the 15th Annual Conference of Animal Science Association of Nigeria, Sept. 13th-15th University of Uyo, Nigeria. 15:88-90.*

Anigbogu, N.M. and Onyejekwe, I.E. (2012). Environmental Minimal Total Discomfort and Production Efficiency Factors of Goats Fed *Zymomonas mobilis* Degraded Rice Hulls Under Confined Condition. *Proceedings of 38th Annual Conference of Nigerian Society for Animal Production. College of Animal Science, University of Makurdi, Nigeria. Pgs. 515-518.*

Anigbogu, N.M., Anosike, J.C. and Assam, E.M. (2011C). Effective Fiber (eNDF) Evaluation of

Life-Enzyme (*Zymomonas mobilis* Degraded Sawdust) Production and Fed to Goats as Feed. *Proceeding, 36th Conference, Nigerian Society for Animal Production, 13-16 March, University of Abuja, Nigeria, pgs. 762-763*.

Anigbogu, N.M., Ibe, S.N., Anosike, J.C. and Assam, E.M. (2009b). The Effect of Life-Enzyme (Sawdust Treated with *Zymomonas mobilis*) on the Performance Characteristics of Red Sokoto goats. *Journal of Sustainable Agriculture and Environment, 11(1): 12-18*.

Anigbogu, N.M., Madu-ijeoma, N.N., Ichita, N.A., and Ogbonna, U.A. (2010). Efficiency of Energy, Protein and Economic Values of Two Nitrogenous Sources on *Zymomonas mobilis* Treated Cassava Peel for Life-Enzyme Production as Feed for Sheep. *Tropical J. Agric. Res. and Biotech*. 2:1-8.

Anigbogu, N.M., Onyejekwe, I.E, Agbara, D.O., Nnochiri, I.U. and Chinedu-Ekeh, I. (2009a). Study on the Fibre Values (eNDF) of *Zymomonas mobilis* Degraded Rice Hull fed goats. *Tropical J. Agric. Res. and Biotech*. 1:30-39.

Anigbogu, N.M., Onyejekwe, I.E. and Odukwe, C.O. (2011b). Metabolism of Protein and Energy By Maradi Goats Fed *Zymomonas mobilis* Degraded Rice Hull Diets. *Proceedings of the 16th Annual Conference for the Animal Science Association of Nigeria, Kogi State University, Faculty of Agriculture Theatre, Anyigba, Kogi State, Nigeria. Pgs. 99-103*.

Arora, A., Nain, L., Gupta, J.K. (2005). Solid-state fermentation of wood residues by *Streptomyces griseus* BI, a solid isolate, and solubilization of lignins. *World J. Microbiol. Biotechnol*. 21(3):303-308. doi:10.1007/s11274-004-3827-3.

Baig, M.M.V., Baig, M.L.B., Baig, M.I.A., Yasmeen, M. (2004). Saccharification of banana Agro-waste by cellulolytic enzymes. *Afric. J. Biotehcnol*. 3(9):447-450.

Beauchemin, K.A, Rode, L.M., Sewalt, V.J.H. (1995). Fibrolytic enzyme increase fibre digestibility and growth rate of Steers fed dry forages. *Canadian Journal of Animal science*, 75: 41-64.

Belewu, M. A. (2001). Effect of fungus (*Volvariella volvaceae*) treated cotton waste as a replacement for cotton seed cake and meal by WAD goats. *Trop. J. Anim. Sci*. 4(1), 93-98.

Belewu, M. A. and Popoola, M. A. (2007). Performance characteristics of West African Dwarf goat fed *Rhizopus* treated sawdust. *Academic J. Short Communication*, 2(9), 496-498.

Belewu, M. A., Ademilola, A. A. (2002). Digestibility response of WAD goats to mushroom (*Volvariella volvaceae*) treated cotton waste. *Moore J. Agric. Res.*, 3(1), 83-86.

Belewu, M. A., and Belewu, K. Y. (2005). Evaluation of feeding graded levels of Aspergillus treated rice husk on milk yield and composition of goat. *Bull. Pure Appl. Sci.*, 24(1), 29-35.

Belewu, M. A., Muhammed, Y. O., and Ikwuomola, B. O. (2004). Comparative nutritional evolution of fungus treated and alkali treated rice husk by rats. *Moore J. Agric. Res.* 5(2), 129-134.

Benitez, E., Sainzh, H., Nogales, R. (2005). Hydrolytic enzyme activities of extracted humic Substances during the vermicomposting of a lignocellulosic olive waste. *Bioresour. Technol*. 96(7):785-90. doi:10.1016/j.biortech.2004.08.010.

Bhavsar, K., Shah, P., Soni, S.K., Khire, J.M. (2008). Influence of pretreatment of agriculturalResidues on phytase production by *Aspergillus niger* NCIM 563 under submerged Fermentation conditions. *Afr. J. Biotechnol*. 7(8):1101-1106.

Botella, C., Diaz, A., Ignacio de Ory, I., Webb, C., Blandino, A. (2007). Xylanase and pectinase Production by *Aspergillus awamori* on grape pomace in solid state fermentation. Process Biocem. 42(1):98-101. doi:10.1016/J.procbio. 2006.06.025.

Colombatto, D., Hervas, G., Yang, W.Z. and Beauchemin, K.A. (2002). Effect of enzymes supplementation of a total mixed ration on microbial fermentation in continuous culture, maintained at high and low pH. *Journal of Animal Science* 81:1040-1050.

Couto, R.R., Lopez, E., Sanroman, M.A. (2006). Utilization of grape seeds foe laccase Production in solid–state fermentors. *J. Food Eng*. 74(2):263-267. doi:10. 1016/j.jfoodeng .2005.03.004.

Couto, S.R., Dominguez, A., Sanroman, A. (2001). Utilization of Lignocellulosic wastes for Lignin peroxidase production by semi-solid state culture of *Phanerochaete chrysosporium* Biodegradation. 12(5):283-289. doi:10.1023/4:10 14392810649.

Couto, S.R., Rodriguez, R., Gallego, P.P., Sanroman, A. (2003). Bodegradation of grape cluster stems and lignolytic enzyme production by *Phanerochaete chrysosporium* during semi-solid-state cultivation. Acta Biotechnological. 23(1):65-74. doi:10.1002/abio.200390010.

Couto, S.R., Sanroman, (2005). Application of solid-state fermentation of lignolytic enzyme production. *Biochem. Eng. J.* 22(3):211-219. doi:10.1016/j.bej.2004. 09.013.

Dermibas, A., Ozturk, T. (2005). Anaerobic digestion of agricultural solid residues. *Int. J. Green Energy* 1(4):483-494. doi:1018/GL-200038719.

Elsashvili, V., Penninckx, M., Kachlishvili, E., Asatiani, M., Kvesitadze, G. (2006). Use of *Pleurotus dryinus* for lignocellulolytic enzymes production in submerged fermentation Of mandarin peels and tree leaves. *Enz. Microbiol. Technol*. 38(7):998-1004. doi.10.1016/J. enzmictec. 2005.08.033.

Emtiazi, G., Naghari, N., Bordbar, A. (2001). Biodegradation of Lignocellulosic waste by*Aspergillus terreus.* Biodegradation 12(4):257-261. doi:10.1023/A:10131-55621336.0961-9534(00)00015-5.

Gao, J., Weng, H., Zhu, D., Yuan, M., Guan, F., Xi, F. (2008). Production and characterization 6f cellulolytic enzymes from the thermoacidophilic fungal *Aspergillus terreus* M11 Under solid-state cultivation of corn stover. Bioresour. Technol. doi:10.1016/j.biortech. 2008.02.005.99(16):7623-7629.

Hao, J.J., Tian, X.J., Song, F.Q., He, X.B., Zhang, Z.J., Zhang, P. (2006). Involvement in Lingo-cellulolytic enzymes in the decomposition of leaf litter in a sub-tropical forest *J. Eukaryotic Microbial.* 53(3):193-198.

Haq, I.U., Javed, M., Khan, T.S. (2006). An innovative approach for hyperproduction of Cellulolytic and hemicellulolytic enzymes by consortium of *Aspergillus niger* MSK-7 and *Trichoderma viride* MSK-10. *Afr. J. Biotechnol.* 5(8):609-614.

Howard, R.L., Abotsi, E., Jansen Van Rensburg, E. L., Howard, S. (2003). Lignocellulose biotechnology: Issues of bioconversion and enzyme production. *Afr. J. Biotechnol.*2(12):602-619.

Hu, Z.H. and Yu, H.Q. (2005). Application of rumen microorganisms for enhanced anaerobic fermentation of corn stover. Process Biochem, 40(7):2371-2377.

Huang, D.L., Zeng, G.M., Feng, C.L., Hu, S., Jiang, X,Y., Tang, L., Su, F.F., Zhang, Y., Zeng, W., Liu, H.L. (2008). Degradation of lead-contaminated Lignocellulosic waste by *Phanerochaete chrysosporium* and the reduction of lead toxicity. Environ. Sci. Technol. 42(13):4946-4951.

Li, A., Antizar-Ladislao, B., Khraisheh, M. (2007). Bioconversion of municipal solid waste to glucose for bio-ethanol production. Bioprocess. Biosystems Eng. 30(3):189-196. doi:10. 1007/s00449-007-0114-3.

Martin, S.A. and Nisbet, D.J. (1992). Effect of direct-fed microbes on rumen microbial Fermentation. *Journal of Dairy Sci.* 75:1736-1744.

Mshandete, A., Bjournsson, L., Kivaisi, A.K., Rubin damayugi, S.T., Mattiasson, B. (2005). Enhancement of anaerobic batch digestion of sisal pulp waste by mesophilic aerobic Pre-treatment. Water Res. 39(8):1569-1575.

Mshandete, A.M., Bjournsson, L., Kivaisi, A.K..M.S.T., and Mattiasson, B. (2008). Effect of Aerobic pre-treatment on production of hydrolases and volatile fatty acids during Anaerobic digestion of solid sisal leaf decortications residues. *Afric. J. Biochem. Res.*2(5):111-119.

Mukherjee, R., and Nandi, B. (2004). Improvement of *in-vitro* digestibility through biological Treatment of water hyacinth biomass by two *Pleurotus spp. Int. Biodeterioration Biodegrade*. 53(1): 712.

Ojumu, T.V., Solomon, R.O., Betiku, E., Layokun, S.K., Amigun, B. (2003). Cellulase Production by *Aspergillus flavus* Linn Isolate NSPR 101 fermented in sawdust Bagasse and corncob. *Afr. J. Biotechnol.* 2(6):150-152.

Oliveira, L.A., Porto, A.L.F., Tambourgi, E.B. (2006). Production of xylanase and protease by *Penicillium janthinellum* CRC 87M-115 from different agricultural wastes. *Bioresour.Technol.* 97(6):862-867.

Philippoussis, A., Diamantopoulou, P., Israilides, C. (2007). Productivity of agricultural residues used for the cultivation of the medicinal fungus *Lentinula edodes.* Int. Biodeterioration biodegradation. 59(3):216-219.

Pothiraj, C., Balaji, P., Eyini, M. (2006). Enhanced production of cellulases by various fungal cultures in solid state fermentation of cassava waste. *Afr. J. Biotechnol*. 5(20):1882-1885.

Ragunathan, R. Swaminathan, K. (2004). Bioconversion of Lignocellulosic agro-waste by Fungus. *Pleurotus spp*. Biological memoirs. 30(1):1-6.

Rezende, M.I., Barbosa, A.M., Vasconcelos, A.F.D., Endo, A.S. (2002). Xylanase production by *Trichoderma harzianum* Rifai by solid state fermentation on sugarcane bagasse. *Braz. J. Microbiol.* 33(1): 67-72.

Roman, H.J., Burgess, J.E., Pletschke, B.I. (2006). Enzyme treatment to decrease solids and improve digestion of primary sewage sludge. *Afr. J. Biotechnol*. 5(10):963-967.

Roussous, S., Olmos, A., Raimbault, M., Saucedo-Castaneda, G. and Lonsane, B.K. (1991). Strategies for large scale inoculum development for solid state fermentation system. Conidiospores of *Trichoderma harzianum* Biotechnology Techniques 5:415-420.

Roussous, S., Raimbault, M., Viniegra-Gonzalez, G., Saucedo-Castaneda, G. and Lonsane, B.K. (1991). Scale-up of cellulases production by *Trichoderma harzianum* on a mixture of sugarcane bagasse and wheat bran in solid state fermentation system. *Micologia Neutropical Aplicada* 4: 83-98.

Saha, B.C. (2003). Hemicellulose bioconversion. *J. Ind. Microbiol. Biotechnol.* 30:279-29 doi:10.1007/s10295-003-0049-x.

Schilling, C.H., Tomasik, P., Karpovich, D.S., Hart, B., Garcha, J., Boettcher, P.T. (2004). Preliminary studies on converting agricultural waste into biodegradable plastics Part III: *Sawdust J. Poly. Environ.* 13:177-183.

Sepulveda-Huerta, E., Tellez-lius, S.J., Bocanegra-Garcia, V., Ramirez, J.A., Vazquez, M. (2006). Production of detoxified sorghum straw hydrolysates for fermentative purposes. *J. Sci. Food Agr.* 86(15):2579-2586.

Shi, J., Chinn, M.S., Sharma-Shivappa, R.R. (2008). Microbial pre-treatment of cotton stalks by Solid state cultivation of *Phanerochaete chrysosporium. Bioresour. Technol.* 99(14): 6556-6564.

Silva, E.M., Machuca, A., Milagres, A.M.F. (2005). Effect of cereal bran on *Lentinula edodes*Growth and enzyme activities during cultivation on forestry waste. Letters in Appl.Microbial. 40(4):283-288.

Sinegani, A.A.S., Emtiazi, G., Hajrasuliha, S., Shariatmadari, H. (2005). Biodegradation of some Agricultural residues by fungi in agitated submerged cultures. *Afr. J. Biotechnol*. 10: 1058-1061.

Singh, P., Suman, A., Tiwari, P., Arya, N., Guar, A., Shrivastava, A.K. (2008). Biological Pretreatment of sugarcane trash for its conversion to fermentable sugars. *World J. Microbiol. Biotechnol*. 24(5): 667-673.

Songulashvili, G., Elisashvili, V., Penninckx, M., Metreveli, E., Hadar, Y., Aladashvili, N., Asatiani, M. (2005). Bioconversion of plant raw materials in value-added products by *Lentinus edodes* and *Pleurotus spp. Int. J. of Med. Mushrooms* 7(3):467-468.

Tserki, V., Matzinos, P., Zafeiropoulos, N.E., Panayiotou, C. (2006). Development of Biodegradable composites with treated and compatibilized Lignocellulosic fibers. *J. Appl. Poly. Sci*. 100(6):4703-4710.

Ushida K., Jouany J. P. (1990). Effect of defaunation on fiber digestion in sheep given two isonitrogenous diets. *Anim. Feed Sci. Technol.* 29:153–159.

Table 1: Proximate composition of Undgraded sawdust (UDS), Sawdust degraded diastic microbes (SDDM), Diastic microbes, & Snail digestive system(%)

Composition	**UDS**	**SDDM**	**Diastic Microbes**	**Snail Gastro-interstinal Tract**
H_2O	8.50	9.20	9.30	10.00
Organic matter	99.40	96.90	92.50	89.90
Dry matter	91.50	90.80	90.70	90.00
Crude protein	1.00	7.60	48.90	76.70
Crude fibre	67.80	50.00	1.20	1.50
Ash	0.60	3.10	7.50	10.10
Ether extract	0.30	0.40	3.80	4.00
Nitrogen free extract	30.30	38.90	38.60	7.60
Calorific value (cal/100g)	400.10	398.70	437.90	756.70
ME/MJ/kg	13.20	13.16	14.45	24.97
Nitrogen	0.16	1.216	7.824	12.27

Table 2: Composition of experimental diets (kg) and the chemical compositions

Feedstuffs	**T1**	**T2**	**T3**
Maize offal	47.00	47.00	37.00
Untreated sawdust	15.00	-	-
SDDM	-	15.00	25.00
Palm kernel cake	32.50	32.50	32.50
Molasses	2.00	2.00	2.00
3.5% Ruminant Concentrated Mix (RCM)[1]	3.50	3.50	3.50
Total	100.00	100.00	100.00
Chemical Composition			
Crude protein	10.75	12.10	12.27
Ether extract	4.21	4.22	3.84
Crude fiber	18.35	15.68	19.91
Ash	4.59	5.01	5.46
Salt	0.72	1.32	1.91
Calcuim	0.81	0.89	0.92
Phosphorous	0.62	0.61	0.83
Lysine	0.64	0.85	0.90
Methionine	0.49	0.70	0.86
MER(MJ/kg)[2]	10.40	10.40	10.88

[1]Composition of 3.5% RCM: Protein - 0.5%, Oil - 0%, Fiber - 0%, Ash - 2.54%, Salt - 0.25%, Calcium - 0.64%, Phosphorus - 0.44%, Lysine - 0.20%, Methionine - 0.25%, MER - 0.08MJ/kg[2], Vitamin A - 10,000IU, Vitamin D - 1000IU, Vitamin E - 10mg, Vitamin B1 - 2mg, Vitamin B2 - 4mg, Vitamin B6 - 1.5mg, Vitamin C - 25mg, Vitamin K3 - 1.5mg, Vitamin B12 - 500mcg; [2]MER (MJ/kg): Metabokizable Energy for Ruminants (Mega joul/kg).

Table 3: Growth parameters of goats fed SDDM

Parameters	**T1**	**T2**	**T3**	**Sig[1]**
Initial weight (kg)	12.50^{a}	11.00^{b}	10.00^{c}	*
Final wt. at 63 days (kg)	11.00^{b}	16.00^{a}	11.00^{b}	**
Liveweight change at 63 days (kg)	-1.50^{c}	5.00^{a}	1.00^{b}	**
Daily wt. change (g)	-23.80^{c}	79.37^{a}	15.87^{b}	**
Daily feed intake (g)	258.25^{c}	435.87^{a}	308.25^{b}	**
Efficiency of feed utilization	-10.85^{c}	5.49^{b}	19.42^{a}	**

[a,b,c] means in the same row with different superscripts differ significantly at 1% and 5% respectively; [1]** = P<0.01, * = P<0.05.

Table 4: Data on Cost Benefits of Goats Fed SDDM

Parameters	**T1**	**T2**	**T3**	**Sig[1]**
Cost of feed/kg (₦)	40.27^{a}	40.43^{a}	36.43^{b}	*
Cost of feed consumed/goat (₦)	655.18^{b}	1,110.20^{a}	707.46^{b}	**
Cost of production/goat (₦)	6503.93^{a}	6257.10^{b}	5386.46^{c}	*
Gross profit/goat (₦)	5, 696.90^{b}	8,286.40^{a}	5,696.90^{b}	**
Profit/goat (₦)	-807.03^{c}	2,029.30^{a}	310.44^{b}	**
Return on investment (%)	-12.40^{c}	32.43^{a}	5.76^{b}	**
Economic Efficiency (EE)	-1.23^{c}	1.83^{a}	0.44^{b}	**

[a,b,c] means in the same row with different superscripts differ significantly 1 and 5% respectively; ** = P< 0.01, * = P< 0.05.

Table 5: Carcass characteristics of goats fed SDDM

PARAMETERS	**T1**	**T2**	**T3**	**Sig[1]**
Warm carcass wt. (kg)	3.2^{c}	6.05^{a}	3.43^{b}	**
Dressing out (%)	33.68^{b}	40.33^{a}	34.30^{b}	**
Wholesale cuts (g)				
Leg	896^{c}	1416^{a}	986^{b}	**
Loin	558^{c}	1242^{a}	651.6^{b}	**
Rib	326^{b}	735^{a}	312^{b}	**
Shoulder	786^{b}	1230^{a}	778^{b}	**
Breast and flank	998^{b}	1803^{a}	964.4^{b}	**
Lean meat/Bone values				
Lean meat	2570^{c}	5441^{a}	2915^{b}	**
Bone	993^{a}	984^{a}	776^{b}	**
Bone : lean ratio	1 : 2.59^{c}	1 : 5.52^{a}	1 : 3.75^{b}	**
Fat				
Abdominal fat	12^{b}	67^{a}	72^{a}	**
Pelvic fat	2^{c}	30^{b}	68^{a}	**
Pelt values				
Pelt weight (kg)	625^{c}	1,200^{a}	780^{b}	**
Pelt(cm)	1, 680^{b}	2,230^{a}	1,750^{b}	**
Offals (kg)[1]	3.69^{c}	5.06^{a}	4.17^{b}	**

[1]Head, Feet, Tail and Viscera; [a,b,c] means in the same row with different superscripts differ significantly at 1%; ** = P<0.01.