# Growth performance and cost benefit of West African Dwarf rams fed ammoniated and pelleted groundnut (*Arachis hypogaea* L.) haulm-based diets

* [1]Adewuyi, P.A., [1] Babayemi, O. J., [1] Adewumi, M. K. and [2]Sosina, O. A.
*[1] *School of Agriculture and Environmental Sciences, University of The Gambia*
[1] *Department of Animal Science, University of Ibadan, Nigeria*
[2] *Oyo State Agri-Business Development Agency (OYSADA), Ibadan, Nigeria*
***Corresponding author**: paademola@utg.edu.gm

**Abstract**

*Crop residue is bulky, often low in protein and digestibility and these characteristics can negatively affect rumen microbes resulting in poor performance and low economic return of the livestock. Elsewhere, pelleted feeds have been proved to be effective in livestock, poultry and rabbit feeding. However, information on results of feeding pelletized-ammoniated feed to small ruminant is scanty in Nigeria. Therefore, this study was conducted to investigate the effects of pelleting and urea treatment of groundnut haulm based diets on growth performance and cost benefits of West African Dwarf (WAD) rams. A total of sixteen WAD) rams weighing 9.75±1.22 kg on average were used for the study. The animals were randomly allotted to four different diets designated as D1-non pelleted-unammonited, D2-non pelleted-ammoniated, D3-pelleted-unammoniated and D4- pelleted-ammoniated consisting of 4 treatments and 4 replicates with one animal per replicate in a 2 x 2 factorial arrangement of a completely randomised design and were fed ad libitum for 105 days. Data were collected on average gain, feed conversion ratio, the cost (₦) per kg of the diet, the total feed cost (₦), the monetary value of weight gain (₦) and the net benefit (₦). Animals on pellet-ammoniated diet had the least (p<0.05) feed conversion ratio of 10.74. The results revealed that rams fed pelleted-ammoniated and pelleted-unammoniated diets had the highest (p<0.05) weight gain of 5.15 kg and 4.57 kg, respectively. From the cost benefit analysis, pelleted-ammoniated (D4) and pelleted-unammoniated (D3) fed rams recorded the highest (p<0.05) net benefit of ₦18,768.00 and ₦15,292.41, respectively. It was concluded that pelleted and ammoniated groundnut haulm-based diets supported growth performance of rams with optimal net benefit. It is therefore recommended that pelleted and ammoniated feeds should be incorporated into small ruminants' diet for improved performance and optimal net return.*

**Key words:** Groundnut haulm, urea treatment, growth performance, pelleted ammoniated feed, cost benefit analysis

Running title: **WAD rams on treated groundnut haulm-based diets**

## Performance de croissance et rapport coût-bénéfice des béliers nains d'Afrique de l'Ouest nourris avec des régimes à base de paille de cacahuète (*Arachis hypogaea L.*) ammoniée et granulaire

**Résumé**

*Les résidus de culture sont volumineux, souvent pauvres en protéines et en digestibilité, et ces caractéristiques peuvent avoir un impact négatif sur les microbes du rumen, entraînant une mauvaise performance et un faible retour économique pour le bétail. D'autre part, les aliments granulés se sont révélés efficaces dans l'alimentation du bétail, des volailles et des lapins. Cependant, les informations sur les résultats de l'alimentation avec des aliments granulés-ammoniés pour les petits ruminants sont rares au Nigéria. Par conséquent, cette étude a été réalisée pour examiner les effets du granulage et du traitement à l'urée des régimes à base de paille de cacahuète sur la performance de croissance et le rapport coût-bénéfice des béliers nains d'Afrique de l'Ouest (WAD). Un total de seize béliers WAD pesant en moyenne 9,75±1,22 kg ont été utilisés pour l'étude. Les animaux ont été répartis aléatoirement en quatre régimes* *différents désignés comme D1-non granulé-non ammonié, D2-non granulé-ammonié, D3-granulé-non ammonié et D4-granulé-ammonié, comprenant 4 traitements et 4 répétitions avec un animal par répétition dans un arrangement factoriel 2 x 2 d'un design complètement randomisé, et ont été nourris ad libitum pendant 105 jours. Les données ont été collectées sur la prise de poids moyenne, le rapport de conversion alimentaire, le coût (₦) par kg du régime, le coût total de l'alimentation (₦), la valeur monétaire de la prise de poids (₦) et le bénéfice net (₦). Les animaux nourris avec le régime granulaire-ammonié ont présenté le rapport de conversion alimentaire le plus bas ($p<0,05$) de 10,74. Les résultats ont révélé que les béliers nourris avec les régimes granulés-ammoniés et granulés-non ammoniés avaient la prise de poids la plus élevée ($p<0,05$) de 5,15 kg et 4,57 kg, respectivement. Selon l'analyse de coût-bénéfice, les béliers nourris avec les régimes granulés-ammoniés (D4) et granulés-non ammoniés (D3) ont enregistré les bénéfices nets les plus élevés ($p<0,05$) de ₦18 768,00 et ₦15 292,41, respectivement. Il a été conclu que les régimes à base de paille de cacahuète granulée et ammoniée favorisent la performance de croissance des béliers avec un bénéfice net optimal. Il est donc recommandé d'incorporer des aliments granulés et ammoniés dans le régime des petits ruminants pour améliorer la performance et le retour net optimal.*

**Mots-clés** : Paille de cacahuète, traitement à l'urée, performance de croissance, alimentation granulée ammoniée, analyse de coût-bénéfice

## Introduction

Production of small ruminant constitutes a major component of livestock industry in Nigeria and other parts of the world (FMA, 2008; GLSR, 2010; RIM, 2010). In Nigeria, populations of goats and sheep are about 34.5 million and 22.1 million respectively (RIM, 2010). The small ruminants are reared throughout the agro-ecological zones of the country but mostly domicile in the northern part of the country (Lawal-Adebowale, 2012). The importance of small ruminants in the livelihood of the poor farmers has been reported to be very high (GLSR, 2010). Small ruminants' meats are known to have a very wide acceptance among human populace because they transcend beyond cultural or religious barriers (Peacock, 1998). Nevertheless, they are mostly fed with roughage based diets like natural or established pastures, crop residues, forbs and fodder crops with little or no supplementation with agro-industrial by products as concentrates resulted in their low or poor performance. Groundnut haulms or hay is a leguminous crop residue often used in supplementing small ruminant diets for improved performance in different parts of the world (NDDB, 2012 ; Asaolu *et al*., 2010). In The Gambia, groundnut haulm is the most available feed resource for the small ruminant during the nine months period of dry season in the urban and peri-urban areas (Asaolu *et al*., 2010). Accordingly, Foster *et al*. (2009) also reported that when performance of lambs on different legume hays was assessed in USA, it was observed that groundnut hay had the best result. Feed processing like ammoniation and pelleting have been reported to improve livestock performance (Adewuyi, 2021). Ammoniation has been reported to increase dry matter intake, ease mechanical breakdown and a faster flow rate of materials in gastro intestinal tract (GIT), (Allen and Martens, 1988). According to Zorilla-Rios *et al*. (1985), 3.5% $NH_3$ treated wheat straw showed enhanced crude protein and *in vitro* dry matter digestibility. In poultry feeding, pellet feeds have been widely preferred to the mash because of diverse advantages ranging from ease of transportation, prevention of ingredient sorting, reduction of wastage by the animals, and better growth performance than non-pelleted (Van, 2005). Shreck (2011) also adduced that chopped corn stover improved average daily gain and efficiencies. Higher dry matter intake observed by Adewuyi (2021) in WAD rams fed pelleted diets was in consonant with report of Bonfante *et al*. (2016) who reported higher feed intake in heifers on pelleted diets in comparison with non-pelleted diets. According to Adewuyi (2021), higher net benefit was obtained from the combined effect of urea treatment and pelleting in sheep fed urea-pelleted groundnut haulm based diets. Therefore, this study was aimed at investigating growth performance and economic gain of WAD rams fed urea treated and pelleted ground haulm based diets.

## Materials and methods

### *Experimental site*

The study was conducted at the annex of the small ruminant pen of the Teaching and Research Farm of the University of Ibadan, Nigeria. The location falls within 7º 20′ N, 3º 50′ E at an altitude of 200 – 300 m above sea level. It falls within the sub-humid tropics. The annual rainfall ranged from 1150 – 1500 mm

### *Sourcing of experimental materials and diets preparation.*

The WAD rams were purchased from a popular small ruminant market in Iwo, Osun State, Nigeria. Groundnut haulm was sourced from Bode Saadu in Morro Local Government Area of Kwara State. The groundnut haulm was sun-dried and hammer milled. Four kilogramme (4 kg) of urea dissolved in 100 L water was carefully sprinkled on 100 kg dry matter of groundnut haulm (4% urea treatment) spread on large tarpaulin and thoroughly mixed together to form a total mixed ration (TMR). The treated groundnut haulm was filled into drums, compacted, sealed tightly with polyethylene sheets, and then covered with a heavy object placed on the cover to ensure air-tight condition for twenty one days for proper ensiling. Urea treatment and pelleting were done at reputable feed mills in Ibadan. The groundnut haulm (roughage): concentrate was 60:40, respectively. The ingredient composition is presented in table 1.

**Table 1: Ingredients composition (%) of experimental diets**

| | Diets | | | |
|---|---|---|---|---|
| Ingredient ( % ) | D1 | D2 | D3 | D4 |
| Urea Treated G/ H | - | 40.00 | - | 40.00 |
| Untreated G/H | 40.00 | - | 40.00 | - |
| Brewers Dried Grain | 10.50 | 10.50 | 10.50 | 10.50 |
| Dried Cassava Peel | 26.00 | 26.00 | 26.00 | 26.00 |
| Wheat bran | 9.20 | 9.20 | 9.20 | 9.20 |
| Palm Kernel Cake | 10.00 | 10.00 | 10.00 | 10.00 |
| Bone | 1.00 | 1.00 | 1.00 | 1.00 |
| Limestone | 2.50 | 2.50 | 2.50 | 2.50 |
| Premix | 0.55 | 0.55 | 0.55 | 0.55 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** |
| **Calculated nutrient composition** | | | | |
| CP ( % ) | 11.26 | 11.26 | 11.26 | 11.26 |
| ME (MJ/Kg DM) | 2.17 | 2.17 | 2.17 | 2.17 |

DI= Unammoniated-non-pelleted diet, D2= ammoniated-non pelleted diet, D3= Unammoniated pelleted diet, D4= ammoniated pelleted diet, G/H = Groundnut Haulm, CP = Crude protein, Metabolizable energy was determined using the equation according to Alderman (1985): ME = 11.78 + 0.00654 CP + (0.000665 EE) 2 - CF (0.00414 EE) - 0.0118 Ash.

### *Animals and their management*

A total of sixteen intact WAD rams weighing 9.75±1.22 kg on average were used for the study. Upon arrival at the experimental site, they were given Broad-spectrum antibiotic (Oxyteacycline LA) intramuscularly administered at 1 mL/10 kg body weight and Ivomec super (Ivermectin) at 1 mL/10 kg body weight through sub-cutaneous route to control both the endo and ectoparasites. They were labeled with red painter ink for easy identification. They were confined in groups for one month for adaptation. Thereafter, the animals were balanced for weight and moved to individual previously disinfected pens (1m x 1m) with concrete floor and covered with wood shavings. The pens were maintained in a cleaned manner and disinfected to remove faecal droppings, specks of dirt, and odours. Individual wooden feeders and plastic drinking bowls were used to serve the animal's feed and water respectively.

***Experimental design, diets and animal feeding***

The rams were randomly allotted to four dietary treatments with four replicates (four animals per treatment) in a 2 x 2 factorial arrangement in a completely randomised design. The diets were arranged as follows:

Diet 1 – Unammoniated groundnut haulm + concentrate (not pelleted, control)

Diet 2 – Ammoniated groundnut haulm + concentrate (not pelleted)

Diet 3 – Unammoniated groundnut haulm + concentrate (pelleted)

Diet 4 – Ammoniated groundnut haulm + concentrate (pelleted)

Animals were fed their assigned total mixed ration once a day at approximately 5% body weight with allowance for refusal and clean-fresh water given *ad libitum*. Rams were weighed before morning feeding to reduce possible gut fill error at the start of the experiment and subsequently once every week until termination of the experiment at 105 days. The difference between the total feed offered and refusals gave the total feed intake. Salt lick was constantly made available for the animals. The parameters considered were: initial body weight, final weight, weight gain, average gain, feed conversion ratio (feed consumed per weight gain), the cost (₦) per kg of the diet which was calculated by multiplying the percentage composition of the ingredient with the price per kg of each ingredient and adding it all together. The total feed cost (₦) was obtained from total feed intake multiply by the cost (₦) per kg feed. The monetary value of weight gain (₦) was calculated by multiplying weight gain by cost (₦) per kg mutton. The net benefit (₦), was obtained from the difference between the monetary value of weight gain (₦) and total feed cost (₦).

***Proximate analysis***

Proximate composition of urea treated and pelleted groundnut haulm based-diets was determined according to the methods of AOAC (2002).

***Data analysis***

Data were analysed using the General Linear Model of ANOVA (SAS, 2003). Means were separated using Duncan’s Multiple Range Test option of the same software. Significance was declared when $P < 0.05$

***Results and discussion***

***Proximate composition (%) of diets fed to WAD rams***

Table 2 showed the proximate composition of experimental diets fed to WAD rams. The diets consist of Unammoniated non-pelleted (D1), ammoniated non-pelleted (D2), Unammoniated pelleted (D3) and ammoniated pelleted (D4). Dry matter ranged from 93.08±0.66% (D3) to 93.64±0.53% (D4) and was similar (P>0.05) across treatment. Organic matter followed the same trend as dry matter and ranged from (79.59±0.53%) D4 to (81.63±0.66%) D3 and was not (P>0.05) different. Crude protein contents of D1 (11.85±0.74%), D2 (11.39±0.97%) and D4 (11.33±0.62%) was similar (P>0.05) but higher (P < 0.05) than D3 (9.54±0.68%). The ash content ranged from 11.45±0.51% (D3) to 12.75±0.43% (D4) and was similar (P>0.05) across the treatments. Ether extract value for D3 (3.03±0.10%) was highest and lowest in D1 (2.22±0.13%) but similar (P>0.05) for D2 (2.40±0.12%) and D4 (2.42±0.11%). Crude fibre values of 25.91±1.16% for D3 and 25.72±1.91% for D4 was similar (P>0.05) but higher (P<0.05) than 23.56±1.13% and 23.59±1.12% for D1 and D2 respectively. Nitrogen free extract of 49.87±0.41% for D4 was lower (P< 0.05) than 49.84±0.21%, 49.87±0.41% and 50.07±0.46% for D1, D2 and D3 respectively

***Fibre composition (%) of diets fed to WAD rams***

Presented in Table 3 are the fibre fractions of the feedstuff fed to WAD rams.

The NDF values for all the treatments were not different (P>0.05). The acid detergent fibre of 42.58±2.53%, 42.58±2.53%, 41.51±1.38% for D2, D3, and D4, respectively were similar (P>0.05) but higher (P<0.05) than 39.87±0.98% for D1. The acid detergent lignin of D1 (19.30±0.93%), D2 (21.10±1.93%), D3 (20.88±1.07%), and D4 (19.70±1.39%) was the same (P>0.05). Cellulose value of D1 (20.57±0.06%) was lower (P < 0.05) than the values of 21.48±0.64%, 21.40±0.15% and 21.82±0.06% for D2, D3 and D4 respectively. Hemicellulose values ranged from 13.16±2.00% (D4) to 14.60±2.06% (D1) and were similar (P>0.05) across the treatment diets.

**Table 2 : Proximate composition (%) of diets fed to WAD rams**

| | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| Diets | DM (%) | OM (%) | CP (%) | ASH (%) | EE (%) | CF (%) | NFE (%) |
| D1 | 93.43±0.61 | 80.90±0.61 | 11.85±0.74$^{a}$ | 12.53±0.50 | 2.22±0.13$^{c}$ | 23.56±1.13$^{b}$ | 49.84±0.21$^{b}$ |
| D2 | 93.59±0.56 | 80.84±0.56 | 11.39±0.97$^{a}$ | 12.75±0.43 | 2.40±0.12$^{b}$ | 23.59±1.12$^{b}$ | 49.87±0.41$^{b}$ |
| D3 | 93.08±0.66 | 81.63±0.66 | 9.54±0.68$^{b}$ | 11.45±0.51 | 3.03±0.10$^{a}$ | 25.91±1.16$^{a}$ | 50.07±0.46$^{a}$ |
| D4 | 93.64±0.53 | 79.59±0.53 | 11.33±0.62$^{a}$ | 14.05±1.81 | 2.42±0.11$^{b}$ | 25.72±1.91$^{a}$ | 46.48±0.32$^{c}$ |
| SEM | 0.84 | 0.82 | 2.42 | 2.80 | 0.60 | 2.01 | 0.20 |

$^{a,b,c}$ Means in the same column with different superscripts are significantly different (p<0.05). DM= Dry Matter, OM =Organic Matter, CP= Crude Protein, EE= Ether Extract, CF= Crude Fibre, D1= Unammoniated-non pelleted , D2= ammoniated-non pelleted, D3= Unammoniated-pelleted , D4= ammoniated-pelleted

**Table 3: Fibre composition of experimental diets**

| | Fibre fractions (%) | | | | |
|---|---|---|---|---|---|
| Treatment | NDF | ADF | ADL | Cellulose | Hemicellulose |
| D1 | 54.47±1.08 | 39.87±0.98$^{b}$ | 19.30±0.93 | 20.57±0.06$^{b}$ | 14.60±2.06 |
| D2 | 56.87±1.32 | 42.58±2.53$^{a}$ | 21.10±1.93 | 21.48±0.64$^{a}$ | 14.29±2.20 |
| D3 | 56.66±1.09 | 42.28±0.99$^{a}$ | 20.88±1.07 | 21.40±0.15$^{a}$ | 14.38±2.08 |
| D4 | 54.67±2.38 | 41.51±1.38$^{a}$ | 19.70±1.39 | 21.82±0.06$^{a}$ | 13.16±2.00 |
| SEM | 1.04 | 1.35 | 1.95 | 0.96 | 1.54 |

$^{a,b}$ Means in the same column with different superscripts are significantly different (p<0.05).
NDF= Neutral Detergent Fibre, ADF= Acid Detergent Fibre, ADL= Acid Detergent Lignin, D1= Unammoniated-non pelleted , D2= ammoniated-non pelleted, D3= Unammoniated-pelleted , D4= ammoniated-pelleted

***Main effects of urea treatment and feed forms on growth performance of WAD rams***

Table 4 shows the daily weight gain (DWG), daily dry matter intake (DMI), feed conversion ratio (FCR), and feed cost per kilogramme gain of WAD rams fed urea treated groundnut haulm based pelleted diets. Pelleting had significant (P < 0.05) effects on DWG and FCR. Pelleted feeds had a higher (P < 0.05) DWG value of 46.31 g/d compared to 21.59 g/d for rams fed non pelleted diets. Animals on pelleted diets had better efficiency of feed utilisation than those allotted to non-pelleted diets as indicated by the values of feed conversion ratio of 12.00 and 13.30 for animals on pelleted and non-pelleted diets respectively. The value of DMI for pelleted diets (547.09 g/d) was similar (P>0.05) to 462.00 g/d for rams on diets that were not pelleted.

Urea treatment elicited better feed utilisation by the animals as shown by lower (P<0.05) value of feed conversion ratio of 12.26 for the rams on urea treated diets compared to 13.30 for those fed untreated diets. DWG (g/d) ranged between (36.75 g/d and 31.15 g/d) and for rams on treated and untreated diets respectively. The DMI (g/d) ranged between 482.63 g/d and 526.46 g/d for animals allotted to untreated and untreated diets respectively and were similar (P>0.05)

***Effects of Interaction of urea treatment and feed forms on growth performance of WAD rams fed urea treated groundnut haulm based pelleted diets***

Table 5 reveals the effects of the interaction of urea treatment and pelleting on the performance of WAD rams fed urea treated groundnut haulm based pelleted diets. Urea treatment x pelleting had effects on weight

**Table 4: The main effects of urea treatment and feed forms on growth performance of WAD rams**

| | Parameters | | | | | |
|---|---|---|---|---|---|---|
| Treatment | IW/ Kg | FW/Kg | WG/Kg | DWG g/d | DMI g/d | FCR |
| **Feed form** | | | | | | |
| Pelleted | 9.25 | 14.11 | 4.86$^{a}$ | 46.31$^{a}$ | 547.09 | 12.00$^{b}$ |
| non pelleted | 12.50 | 15.06 | 2.267$^{b}$ | 21.59$^{b}$ | 462.00 | 13.30$^{a}$ |
| P-values | 0.2835 | 0.6330 | 0.0187 | 0.0187 | 0.0744 | 0.0001 |
| **Urea treatment** | | | | | | |
| Treated | 8.50 | 12.79 | 3.85 | 36.75 | 482.63 | 12.26$^{b}$ |
| Untreated | 13.70 | 16.41 | 3.27 | 31.15 | 526.46 | 13.03$^{a}$ |
| P-values | 0.774 | 0.1131 | 0.5402 | 0.5403 | 0.329 | 0.0011 |

$^{ab}$ Mean in the sams column with different superscripts are significantly different (P<0.05), IW= Initial weight, FW = Final weight, WG= Weight gain, DWG = Daily weight gain, FCR = Feed conversion ratio, DMI = Dry matter intake and W = Weight

gain, DWG, and FCR. Weight gain and daily weight gain followed the same trend. Weight gain was highest (5.15 kg) in animals on urea treated pelleted diet (D4) and lowest (1.97 kg) in rams allotted untreated non pelleted diet (D1). Daily weight gain values of 49.05g/d were highest for animals on urea treated pelleted diet (D4) and lowest values of 18.73 g/d for rams allotted untreated non pelleted diet (D1). FCR of 13.79 was highest in D2 and lowest (10.74) in D4. Dry matter intake increased from 450 g/d (D2), 474.00 g/d (D1), and 512.25 g/d (D4) to 578.93 g/d (D1) and was not affected by the synergy of urea treatment and pelleting.

**Table 5: Effects of Interaction of urea treatment and feed forms on growth performance of WAD rams fed urea treated groundnut haulm based pelleted diets**

| Parameters | Pelleted | | non pelleted | | SEM | P- Values |
|---|---|---|---|---|---|---|
| | Untreated[3] D3 | Treated[4] D4 | Untreated[1] D1 | Treated[2] D2 | | Interaction U X P |
| Initial weight (kg) | 9.25 | 9.25 | 10.75 | 9.75 | 1.22 | 0.7527 |
| Final weight (kg) | 13.82 | 14.40 | 12.72 | 12.32 | 1.792 | 0.5239 |
| Weight gain (kg) | 4.57 | 5.15 | 1.97 | 2.57 | 0.858 | 0.0395 |
| Daily Wt. gain (g/d) | 43.57 | 49.05 | 18.73 | 24.44 | 8.16 | 0.0048 |
| DM Feed Intake (g/d) | 578.93 | 515.25 | 474.00 | 450.00 | 39.55 | 0.6523 |
| FCR | 13.26 | 10.74 | 12.81 | 13.79 | 0.158 | 0.001 |

$^{a,b,c}$ Means in the same row with different superscripts are significantly different (p<0.05). FCR= Feed Conversion Ratio, DM = Dry Matter, 1= D1 (untreated non pelleted diet), 2= D2 (urea treated non pelleted diet), 3= D3 (untreated pelleted diet), 4 = D4 (urea treated pelleted diet), U x P - Interaction of ammoniated x pelleting

***Main effects of urea treatment and feed forms on the cost-benefit of feeding WAD rams urea treated groundnut haulm based pelleted diets***

Table 6 shows the cost per kg feed, total feed intake (kg), total weight gain (kg), total feed cost (₦), cost per kg weight gain (₦), the total cost of production /kg (₦), price per kg mutton (₦) and gross or profit margin (₦) of feeding urea treated based pelleted diets to WAD rams. Pelleting had a significant (P<0.05) effect on all the parameters considered. Cost/kg of pelleted diet (₦211.86) was higher (P<0.05) than the cost/kg feed of the non-pelleted diet (N122.73). Similarly, animals on pelleted diets consumed more feed (57.45kg), gain more weight (4.86kg), and incurred higher total feed cost (₦12171.36) compared to 48.51kg, 2.27kg, and ₦5953.63 respectively for rams fed non pelleted diets. The monetary value of weight gain (₦29160.00) for animals on pelleted diets was higher than (₦13, 620.00) for the animals fed non pelleted diets. The net benefit of ₦16, 988.64 for animals on pelleted diets was higher than ₦7,666.37 for those allotted non pelleted diets.

**Table 6: Main effects of urea treatment and pelleting on the cost-benefit of feeding WAD rams urea treated groundnut haulm based pelleted diets**

| Treatment | FC ₦/Kg | TFI Kg | WG Kg | TFC (₦) | Price/kg mutton (₦) | MVWG (₦) | NtB (₦) |
|---|---|---|---|---|---|---|---|
| **Feed form** | | | | | | | |
| Pelleted | 211.86[a] | 57.45[a] | 4.86[a] | 12171.36[a] | 6000.00 | 29160.00[a] | 16988.64[a] |
| non pelleted | 122.73[b] | 48.51[b] | 2.27[b] | 5953.63[b] | 6000.00 | 13620.00[b] | 7666.37[b] |
| P-values | 0.0001 | 0.0074 | 0.0187 | 0.0023 | 0.8600 | 0.0024 | 0.0031 |
| **Urea treatment** | | | | | | | |
| Treated | 179.37[a] | 50.67 | 3.85 | 9088.68 | 6000.00 | 23100.00 | 14011.32 |
| Unreated | 155.25[b] | 55.28 | 3.27 | 8582.22 | 6000.00 | 19620.00 | 11037.78 |
| P-values | 0.0001 | 0.329 | 0.5402 | 0.6541 | 0.8600 | 0.431 | 0.5211 |

[a,b,c] Means in the same row with different superscripts are significantly different (p<0.05). FC= Feed cost, DMI = Dry matter intake, WG= Weight gain, TFC = Total feed cost, MVWG = monetary value of weight gain, NtB= Net benefit, ₦ = Nigeria naira.

***Effects of the interaction of urea treatment and pelleting on cost-benefit of feeding WAD rams urea treated groundnut haulm based pelleted diets***

Table 7 reveals the cost-benefit of urea treated x pelleted groundnut haulm diets to WAD rams. Urea treatment x pelleting had effects (P<0.05) on weight gain (WG) (kg), total feed cost (TFC), the monetary value of weight gain (MVWG), and net benefit (NtB) amongst the parameters considered. Weight gain value of 5.15kg was highest in D4 (treated pelleted diet) and lowest (1.97 kg) in D1 (untreated non pelleted diet). The total feed cost value of ₦12131.94 was highest in animals fed (D4) and lowest value of ₦5823.09 in D1. MVWG ranged from ₦11820.00 (D1) to ₦30, 900.00 (D4). Net benefit of ₦18, 768.06 was highest in D4 and lowest ₦5996.91 in D1. However, a combination of urea treatment and pelleting had no effects (P>0.05) on feed cost (FC) and DMI of the rams fed the experimental diets. FC and DMI values ranged from ₦117.00/kg (D1) to ₦74.75/kg (D4) and 47. 22 kg (D2) to 224.25 kg (D3), respectively.

## DISCUSSION

### *Proximate composition of urea treated (ammoniated) and ensiled groundnut haulm*

The values dry matter of urea treated groundnut haulm (93.59% and 93.62%) compared to untreated (93.43 and 93.08) obtained in this study were similar and optimum for the animals. The dry matter contains the organic and mineral portion of feed after the moisture has been removed. Urea treatment did not affect the dry matter of the groundnut haulm from this study. Urea treatment and ensiling of crop residue or urea ammoniation have been established to enhance crude protein content and digestibility. Babayemi (2010) reported an increase in crude protein of urea-treated *Panicum maximum* and Adewumi *et al*. (2000) also reported an increase in digestibility of rice stover due to ammoniation. The increase in crude protein of urea-treated groundnut haulm observed in this study compared to untreated is consistent with the results of Olafadehan and Adebayo (2016) who reported an increase in crude protein content of urea-treated threshed sorghum top compared to untreated. The improvement in crude protein value observed in urea treated groundnut haulm may be due to the conversion of urea to ammonia by urease enzymes secreted by the microbes which are natural inhabitants of groundnut haulm and serve as a source of ammonia nitrogen which increases the protein content of the haulm.

**Table 7: Effects of interaction of urea treatment and pelleting on cost-benefit of feeding WAD rams urea treated groundnut haulm based pelleted diets**

| Parameters | Pelleted | | Non pelleted | | P-value |
|---|---|---|---|---|---|
| | Untreated[3] D3 | Treated[4] D4 | Untreated[1] D1 | treated[2] D2 | Interaction U X P |
| FC (₦)/Kg | 199.50 | 224.25 | 117.00 | 134.4 | 0.7311 |
| DMI (Kg) | 60.79 | 54.10 | 49.77 | 47.25 | 0.6523 |
| WG (kg) | 4.57 | 5.15 | 1.97 | 2.57 | 0.0395 |
| TFC (₦) | 12127.59 | 12131.94 | 5823.09 | 6350.40 | 0.0421 |
| Price/Kg mutton (₦) | 6000.00 | 6000.00 | 6000.00 | 6000.00 | 1.000 |
| MVWG (₦) | 27420.00 | 30,900.00 | 11820.00 | 15420.00 | 0.0022 |
| NtB (₦) | 15292.41 | 18768.06 | 5996.91 | 9069.60 | 0.0024 |

1= D1 (unammoniated non pelleted diet), 2= D2 (ammoniated diet), 3= D3 (unammoniated pelleted diet), 4 = D4 (ammoniated pelleted diet), U x P - Interaction of Urea treatment x pelleting 3- Urea treatment x pelleting interaction, ₦ = Nigeria Naira, FC= Feed cost, DMI = Dry matter intake, WG= Weight gain, TFC = Total feed cost, MVWG = monetary value of weight gain, NtB= Net benefit.

The lower value of crude fibre of urea treated groundnut haulm 21.20% compared to the untreated 25.04% may be as a result of removal of refractory phenol compounds (p-coumeric or ferrulic acid) of the cell wall by the ammonia. This result corroborates the report of findings of Olafadehan and Okoye (2017), who reported a reduction in crude fibre content of urea treated cowpea husk when compared to the untreated.

### *Chemical composition of experimental diets*

The dry matter content of the diets which is left over after the moisture or water has been removed contains all the nutrients in the feedstuff. The higher the dry matter, the more the nutrient in the feed and the better for the animal. The dry matter of the diets ranged between 93.08 to 93.64% and was similar. The organic matter of a feed is obtained when the ash portion is removed from the dry matter. It consists of protein, carbohydrates, lipids, vitamins, and nucleic acids.

The organic matter recorded for the diets in this study follows the same trend as the dry matter, they were high and similar among all the treatment groups. Urea treatment and pelleting at an individual level or when combined did not affect either dry or organic matter components of the diets under the present experimental condition.

The crude protein content of the diets ranged between 9.55 and 11.85% and was higher than the critical value of 7.0% for small ruminants according to NRC (1981) while it approximately falls within the minimum protein requirement of 10-12% recommended by ARC (1985) for ruminants.

The ash or content of the diets ranged between 11.45-12.75% and was not significantly different by urea treatment and pelleting. These values fall within 7.89-13.94% ash content in diets fed to WAD sheep by Amuda (2013) but higher than 4.6-6.56 of Olafadehan and Okoye (2017) who fed Red Sokoto goats with urea treated and ensiled cowpea husk based diets.

The ether extract content falls below 6-7% that may likely decrease microbial fibrolytic activity in the gastrointestinal tracts and resulted in reducing the digestibility of roughage-based feeds (Bauman *et al*., 2003).

The crude fibre ranged from 23.56-25.91% and was higher in pelleted diets than the non pelleted. This may be partially due to the higher amount of crude fibre from soluble proteins attached to the pelleted diets, which have more surface areas than the non pelleted. The crude fibre provides energy for the ruminants when the cellulose and hemicellulose are fermented by the rumen microorganisms.

The nitrogen-free extract for the urea treated and pelleted was the lowest probably because of the loss of sugars during urea ensiling and pelleting. The Nitrogen free extract of the diets ranged from 40.48-50.05% and was similar to 43.30-46.25% in diets fed to WAD sheep (Amuda, 2013).

The NDF is a measure of forage fibre or cell wall. The NDF of the diets was not affected by urea treatment and pelleting and ranged from 54.47 for D1 to 56.87 (D3). This value is below 55.0-60% that can limit forage intake and digestibility (Bamikole *et al*., 2004).

The acid detergent fibre (ADF) ranged from 39.87% for D1 to 42.58% in D2. This value was lower than 31.2-37.8% in diets fed to Red Sokoto goats (Olafadehan and Adebayo, 2016). The proportion of ADF in a diet determines intake and digestibility, the higher the value, the lesser the intake and digestibility due to the presence of lignin in ADF.

The acid detergent lignin (ADL) of the diets range from 19.30% for D1 to 21.10 in D2 but were all similar. Lignin is indigestible by the animals, the higher the value in a diet, the lower the digestibility. ADL was not affected by urea treatment and pelleting.

Cellulose and Hemicellulose are cell wall carbohydrates that are digestible by rumen microbes during fermentation that yielded volatile fatty acids used by the ruminants as sources of energy. The hemicellulose value observed in this study ranged from 13.16±2.00% in D4 to 14.60±2.06% for D1 but were all similar. The cellulose values were similar in D2, D3, and D4 but higher than D1. This may be partially due to reduction in lignin or separation of lignin and cellulose matrix through either pelleting or urea treatment thereby making more cellulose available in the processed diets.

***Growth performance of WAD rams fed urea treated (ammoniated) and pelleted groundnut haulm based diets***

Growth Performance of WAD rams fed urea treated and pelleted groundnut haulm based diets revealed that Dry matter intake (DMI), Daily weight Gain (DWG), and Feed Conversion Ratio (FCR) were affected by pelleting. The higher DMI of animals fed pelleted diets than animals on non-pelleted diets may be as a result of faster passage rate of pelleted diet in GIT as a result of reduced particle size. Higher DMI with pelleted diets has been reported by several authors, with increases ranging from 15 to 26% in comparison with non-pelleted diets (Bonfante *et al*., 2016). The improved DMI observed in pelleted diets was translated into increased weight gain (WG) as indicated by higher weight gain in pelleted feed than non pelleted. This result conflicts with Bonfante *et al*. (2016) who reported similar WG for heifers on pelleted and non pelleted diets. However, this result agrees with (Van, 2005) that reported increased daily gain with pelleted rations.

The FCR follows the same trend as the weight gain. The FCR is a measure of the ability of an animal to convert feed into bodyweight. The lower FCR of animals on pelleted rations is an indication of better feed utilisation efficiency. This may be due to the prevention of ingredient sorting by the animals and increased nutrient availability and efficiency of utilisation.

The higher microbial protein synthesis in pelleted diets than in the non pelleted can be attributed to higher feed intake of pelleted diets. This result corroborates the reports of Obasa *et al*. (2017) that increased feed intake enhanced microbial protein synthesis. Microbial protein synthesis for rams on urea treated diet was similar to those fed untreated diets. This may be due to the lack of adequate energy to translate the extra nitrogen into protein by the microbes. The result obtained in this study contradicts Olafadehan and Adebayo (2016) that reported higher microbial protein yield in Red Sokoto goats fed ammoniated sorghum top compared to unammoniated.

Urea ammoniation has both treatment and supplementary advantages by improving digestibility and also serving as a source of $NH_3$-N to rumen microbes. In this study, animals on urea-treated diets had higher DMI, DWG, and also better FCR. This may be adduced to a reduction in fibre content due to urea treatment and increased $NH_3$-N supply that possibly resulted in better feed utilisation. This result agrees with Olafadehan and Adebayo (2016) which reported increased performance of Red Sokoto goat fed urea treated threshed sorghum tops.

The combined effect of pelleting and urea treatment resulted in lower FCR or better efficiency of feed utilisation. The higher feed efficiency of utilisation observed may be due to the synergistic effect of the increased dry matter intake, due to pelleting and higher, digestion with additional NPN supply resulting from urea ammoniation.

***The cost-benefit of feeding urea treated (ammoniated) and pelleted groundnut haulm based diets to WAD rams***

The cost-benefit analysis in this study reveals that rams on pelleted diets incurred higher feed cost (FC) and total feed cost (TFC) than those fed non pelleted diets. This may be partially due to the high cost of pelleting production and also higher feed intake by animals on pelleted diets than those fed non pelleted. The greater weight gain by the animals on pelleted diets resulted in higher monetary benefits than those on non pelleted diets. This result was in consonant with the report of Obasa *et al*. (2017) that pelleted feed increased the profit margin in broiler chicken. On the contrary, urea treatment did not affect the monetary gain of the animals. This may be as a result of marginal higher weight gain by the animals on urea treated diets than those fed the untreated which could not translates to higher net benefit (NtB) in the animals fed treated diets than the untreated. This may be due to the higher total cost of production of urea-treated diets for animals fed the treated diets. Labour and water availability were among the factors identified to affect the economy of urea ammoniation, especially where family labour and water are not easily available (ESGIP, 2007). The combined effect of urea treatment and pelleting had a higher net benefit (NtB). This may be associated with higher feed intake and efficiency of utilisation of pelleted urea-treated feeds that translated into higher weight gain and eventually better monetary return.

**Conclusion**

The study showed that combined effect of pelleting and 4% urea treatment of groundnut-haulm based diets significantly enhanced growth performance of WAD rams and translated into the best economic gain.

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