Alkali Treated Groundnut Shells with Xylanase in Rations of *Yankasa* Rams on Growth Performance and Nutrient Digestibility

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Abstract
Scarcity of feedstuffs and its cost even when available are some of the factors militating against livestock production in Nigeria. It's therefore imperative to find alternatives and abundant feed resource that can curtail the glitch. The aim of the study was to determine the effect of alkali treated groundnut shells supplemented with xylanase in rations of Yankasa rams on performance and nutrient digestibility. Twenty rams with an average weight of 17 kg were randomly allotted to four treatment rations in a completely randomise design involving untreated groundnut shells (UTGNS), urea treated groundnut shells (UGNS), lime treated groundnut shells (LGNS) and urea-lime treated groundnut shells (ULGNS) all supplemented with xylanase at same rate for 90 days. The results showed that the rations had significant ($p<0.05$) influences in most of the parameters except few. Average daily gain was increased in the LGNS (78.37 g/d) group, average daily feed intake (695.78 g/d) in the UTGNS group and FCR was least (7.64) in ULGNS group. Nutrient digestibility was improved in ULGNS group for DM (67.77%), CP (61.71%) and CF (57.18%) while NFE digestibility was high in UGNS (53.14%). Based on the result obtained, urea and lime treatment of groundnut shells supplemented with xylanase in Yankasa rams ration is recommended.

***Keywords**: Digestibility; Exogenous enzyme; Feed conversion ratio; Urea; Lime.*

INTRODUCTION

Nigerian small ruminant livestock herd was estimated to be about 73.8 million goats and 42.1 million sheep – mainly indigenous breeds with its population concentrated in the Northern region (Herrero, 2020) while in 2012, some authors reported about 28 million goats and 23 million sheep in same country (Abdu et al., 2012). In spite of these impressive statistics on the increased population of sheep and goat over the years, their potentials are not fully realized due to low productivity, high mortality, low growth rate, low productive performance among others (Millam, 2016).

Feed scarcity is one of the most important factors militating against effective small ruminant production in the tropics especially during the dry season when roughages of poor nutritional status exist (Millam et al., 2020b). The cost of livestock feeds and feedstuffs in recent years has increased tremendously. Hence, the cost of feeding becomes a major problem to livestock producers in many developing countries such as Nigeria. It was reported that cost of feed account for about 70-80% of the total cost of animal production (Out et al., 2021). This therefore necessitates the need and interest in exploring abundant and neglected or underutilized feed resources (threshing by-products), such as groundnut shells which is usually found on groundnut threshing cites in groundnuts producing states in the northern part of the country (Millam et al., 2020a). These threshing cites are scattered all over those groundnut producing states. The groundnut shells produced after threshing (separating the pods from the seeds) usually constitute a nuisance of environmental pollution especially when they are left to rot in the field or when rain comes and wash them away to block drainages resulting into flooding; and air pollution – when they are incinerated (Millam, 2016).

Crop residue utilization as animal feed materials is attracting various animal nutritionist to focus their research interest on it in other to curb the menace of the problems caused by groundnut shells, vis-à-vis reducing its negative environmental impact; solving the problem of dry season feeding and reducing cost of production (Abid et al., 2020). This will enable low-income farmers to economically alternate conventional/commercial feeds without adverse effects on the performance of the animals. The groundnut shells are readily available and very cheap especially at the threshing cites and can the processed/treated using alkali chemicals to reduce its robust fibre structure and increase it protein value (Abdel Hameed et al., 2013). The use of alkali chemicals alone cannot totally improve the utilization of the groundnut shells; therefore, supplementation may be supportive (Millam & Abdu, 2017). Exogenous fibrolytic enzymes has been reported to have increased the performance, intake, and digestibility of fibrous crop residues in ruminant rations (Adesogan et al., 2019).

For a feedstuff to stand out as a better feed material and used as an alternative to commercial/conventional feedstuff, it should have a better nutritional quality (McDonald et al., 2010). The nutritive value of feeds can be appreciated from its performance in animals and through the use of digestibility studies (Nayawo et al., 2017b). Growth performance and nutrient digestibility are good indices for measuring the physiological status of animals (Millam et al., 2020b). Changes in these parameters can be used to access the response of animals to various physiological situations (Omotoso et al., 2019). The above parameters have been considered useful for evaluation of body condition and nutritional status in animals where other tissue related measurements are not available (Anya et al., 2018). Therefore, the present study was undertaken to investigate the effect of urea and lime treated groundnut shells supplemented with xylanase in rations of *Yankasa* rams on growth performance and nutrient digestibility.

MATERIALS AND METHODS

All research protocols and procedures involved in handling animals during the experimental period were conducted according to standard approved by Adamawa State University, Institutional Animal Care and Ethics Committee (ADSUIACEC/2020/002). It certifies that it adheres to the international standards on animal use and practice.

Study location

The study was conducted at the Small Ruminant Unit in Adamawa State University Teaching and Research farm, Sahuda road, Mubi North, Adamawa, Nigeria. It is a government-owned University located at the city of Mubi, Adamawa State. The University is located between latitude 10°16.6'6.9" north of the equator and longitude 13°16'1.2" east Greenwich Meridian with 560 meters above sea level (Weather Station, 2020).

Source, processing of groundnut shells, preparation and proximate composition

The groundnut shells used in this study were obtained from a local farmer in Dirbishi Ward, Mubi South Local Government Area (LGA) of Adamawa State. The groundnut shells were milled using a local grinding machine to a size of 0.5 cm, then stored in bags until required for further use. The processed groundnut shells were treated with urea, lime and urea-lime at 5% (i.e., 5 g urea dissolved in 1 litre of water to treat 1 kg of groundnut shells; 5 g of lime dissolved in 1 litre of water to treat 1 kg of groundnut shells; and 2.5 g of urea plus 2.5 g of lime mixed together dissolved in 1 litre of water to treat 1 kg of groundnut shells respectively). The solution (either that of urea, lime or urea-lime) was uniformly sprayed on the milled groundnut shells and mixed thoroughly using a shovel on a clean concrete floor (Can, Denek, Tufenk, & Bozkurt, 2004). The treated groundnut shells were ensiled in airtight Perdue Improved Cowpea Storage (PICS) bags for a period of 21 days as described by (Al-masri & Guenther, 1999). Thereafter, the treated groundnut shells were spread on a polythene sheet to air-dry, bagged and stored before the commencement of the experiment.

The other ingredients (maize offal, cotton seed meal, bone meal and salt) used for the experimental rations were obtained from *TIKE* livestock market, Mubi South LGA, Adamawa State. The enzyme (xylanase) was purchased from RONOZYME® Multi Grain (MG), DSM Nutritional Products Ltd, Switzerland: xylanase (Endo-1, 4-β-xylanase; EC 3.2.1.8).

Four rations were formulated using computer method (least-cost ration formulation) to include the treated groundnut shells, maize offal, cotton seed cake, bone meal and salt with the enzyme (Table 1). The formulation was made to meet the requirements of the rams. The enzyme was incorporated in the rations at same rate as recommended by the manufacturer (100 g per tonne).

Each ration was thoroughly mixed at a time on a clean concrete floor using shovel, then bagged and kept safe for the experiment.

A sample from each experimental ration was collected, and its proximate compositions was determined using the procedures described by (Zaklouta et al., 2011). The proximate analysis was carried out in the Nutrition and Biochemistry Laboratory of Animal Production Department, Adamawa State University, Mubi.

Management of experimental animals

Twenty yearlings (12-15 months) *Yankasa* rams used for the study were purchased from the *TIKE* livestock market in Uba Town, Askira/Uba LGA, Borno State. Prior to the commencement of the experiment, the animals were ear-tagged (for identification). The rams were given prophylactic treatments, consisting of intramuscular application of long-lasting antibiotics (Oxytetracycline LA®) and multivitamin at a dosage of 1 ml/10 kg body weight of the animals. They were drenched with 1 ml/10 kg body weight of albendazole and treated against ectoparasites with 0.5 ml/10 kg body weight of ivermectin (Ivomec®). The rams were quarantined for 4 weeks. Adequate feed and clean fresh water were provided daily to the rams' *ad libitum*.

Experimental housing, design and data collection

The experimental animals were housed in a well-ventilated, individual enclosure (2×2 m dimension) with corrugated iron roof, concrete floors and equipped with individual feeders and water troughs. These stalls were washed properly and disinfected a week before the commencement of the feeding trial. Each ration was assigned randomly to a group of five rams in a complete randomised design. The initial weights (mean 17.68 kg) of the rams were taken at the beginning of the trial using the WeiHeng (WH-A series) potable electronic hanging scale (WH-A08).

Table 1: Gross compositions of the experimental rations

Ingredients (kg)	UTGNS	UGNS	LGNS	ULGNS
Groundnut shells	40.00	40.00	40.00	40.00
Maize offal	32.50	48.00	46.10	55.00
Cotton seed cake	25.50	10.00	11.90	3.00
Bone meal	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50
Xylanase	0.10	0.10	0.10	0.10
Proximate compositions (%)				
Energy (kcal/kg)	1596.45	2177.10	2093.40	2446.65
Dry matter	93.0	93.5	93.0	91.5
Crude protein	9.1	11.3	11.3	13.5
Crude fibre	40.75	33.6	38.35	30.25
Ether extract	5.5	6.5	7.0	6.5
Ash	13.0	7.0	6.0	8.0
Nitrogen free extract	22.4	34.7	31.2	40.0
Feed cost/kg diet (₦/kg)	62.22	53.11	71.44	57.38

UGNS: untreated groundnut shell, UTGNS: urea treated groundnut shell, LTGNS: lime treated groundnut shell, ULGNS: urea-lime treated groundnut shell

The rams were fed at five percent (fresh weight basis) of their body weight individually throughout the feeding trial. The feed offered was adjusted at regular intervals of two weeks along with changes in weight. Clean fresh water was provided to the rams' *ad libitum* throughout the period of the feeding trial which lasted for 90 days. The total ration for a day was separated into two portions of equal weight and supplied to the animals at 8:00 hour and 14:00 hour. The subsequent weight of the rams was recorded fortnightly. Feed intakes were measured daily (Using kitchen electronic scale; WH-B05) while the feed/gain ratio were computed weekly until the end of the trial.
For the digestibility trial, three rams were selected from each treatment and used for the study. The rams were housed in individual metabolic cages according to the procedures of (Osuji et al., 1993). The metabolic cages were designed for separate collection of faeces and urine. Feed offered and left over was also measured daily using electronic kitchen scale (WH-B05). The leftover was deduced from the feed offered to compute the daily feed intake continuously till the end of the digestibility trial. Fourteen days was used as adjustment period on the crates, while seven days was for the collection of faeces and urine. Daily faeces voided out by each ram was collected and measured. At the end of the collection period, the total faeces voided out by each ram were then bulked, and representative aliquot (10%) sample was collected for proximate analysis. Apparent digestibility of the experimental rations was calculated using the methods described by (McDonald et al., 2010).

Statistical analysis
The experimental data were analysed using the Generalised Linear Model procedure (PROC GLM) of (SAS, 2002). The effects of dietary treatments were tested at probability level of 95% ($p<0.05$) and significant difference among the treatment means were determined by Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Growth performance

Present research on the effects of supplementing xylanase on the nutritive value of the experimental ration and the animal performance are not consistent. The performance of rams fed experimental rations are summarized in Table 2. Final body weight was significantly ($p<0.05$) different across all treatment groups; consequently, giving a significant difference in the total gain and average daily gain (ADG). Regarding the growth rates of the rams, the addition of xylanase along with lime treatment of GNS improved ADG (78.37 g/d) in the rams by 28.05 g/d compared to the untreated group (the lowest). This can be possible attributed to superior nutrient absorption and utilization which resulted in significantly higher live weight increase after the consumption of that particular ration (Millam et al., 2020a).

Table 2: Performance of *Yankasa* rams fed experimental rations

Parameters	UTGNS	UGNS	LGNS	ULGNS	SEM
Initial weight (kg)	18.08^{b}	17.04^{b}	20.44^{a}	15.17^{c}	0.55
Final weight (kg)	22.30^{b}	22.32^{b}	27.02^{a}	20.82^{c}	0.42
Total gain (kg)	4.23^{c}	5.28^{b}	6.58^{a}	5.65^{b}	0.34
Average daily gain (g/d)	50.32^{c}	62.87^{b}	78.37^{a}	67.24^{b}	4.05
Feed intake (kg)	58.45^{a}	44.26^{b}	55.55^{a}	42.99^{b}	1.86
Average daily intake (g/d)	695.78^{a}	526.90^{b}	661.33^{a}	511.81^{b}	22.15
Feed conversion ratio	13.89^{c}	8.96^{b}	8.84^{b}	7.64^{a}	0.48

Values within same row with different superscript are significantly ($p<0.05$) different, UTGNS: untreated groundnut shells, UGNS: urea treated groundnut shells, LGNS: lime treated groundnut shells, ULGNS: urea-lime groundnut shells, SEM: significant error of means

This show that in order to obtain better live weight increase in growing rams, the degree of supplementation provided to the LGNS ration is acceptable. Previous studies illustrate that supplementation of exogenous fibrolytic enzyme/lime-treated groundnut shell increased ADG (Arce-Cervantes et al., 2013); weight gain (Bueno et al., 2013); final body weight (Awawdeh & Obeidat, 2011); body weight (Titi & Lubbadeh, 2004) and live weight gain (McDonald et al., 2010; Millam et al., 2020a)

Regarding the rams feed intake; it was significantly ($p<0.05$) higher in both UTGNS (695.78 g/d) and LGNS (661.33 g/d) for average daily intake (ADI) compared to other treatments. It was numerically highest in the untreated group indicating that the addition of xylanase with alkali treatment of groundnut shells did not improved feed intake. Instead, ULGNS (lowest) reduced intake to about 183.97 g/d compared to the untreated group. The UTGNS group's rise could be attributable to the UTGNS group's considerably high fibre and NFE digestibility as observed in Table 3 (Adesogan et al., 2019). This suggests that xylanase was more effective in increasing the consumption of fibrous groundnut shells than alkali processed GNS. It's also possible that raw groundnut shells have a greater impact on ruminant consumption of groundnut shells. The findings back up previous reports that showed that rams fed untreated groundnut shells had higher consumption than those fed treated groundnut shells (Millam et al., 2020a). The increase could be due to the ration being more appealing and including more highly fermentable carbs and protein sources, thus, improving the ration's nutritional value (Abid et al., 2020; Melaku et al., 2004; Millam et al., 2020a). On the contrary, various studies have shown that exogenous enzymes/alkali treatment improved feed intake than the untreated groups in sheep (Adesogan et al., 2019; Bhasker et al., 2013; Bueno et al., 2013; López-Aguirre et al., 2016; Nayawo et al., 2017a; Sujani & Seresinhe, 2015; Vallejo et al., 2016; Wahyuni et al., 2012).

Feed conversion ratio/feed efficiency (FCR) was least in the group of rams receiving ULGNS (7.64) compared to the untreated group. This indicates that the addition of xylanase with urea and lime treatment was 6.25 more efficient than the untreated group. The observed result was similar to the reports made by various authors who used exogenous fibrolytic enzymes in the rations of ruminants (Arce-Cervantes et al., 2013; Mireles-Arriaga, Espinosa-Ayala et al., 2015; Thakur et al., 2010). In contrast, some authors reported unchanged FCR as the dosage of exogenous enzyme increases (Bueno et al., 2013; Torres et al., 2013) in lamb performance fed 0, 5 or 10 g of fibrolytic enzymes per 1 kg oat straw while some recorded no effect (Awawdeh & Obeidat, 2011; Lourenco et al., 2020). The improved FCR could be due to heat augmentation or energy loss as heat, both of which can alter the efficacy of feed used for growth. The greater the heat loss, the lower the feed consumption and, as a result, the slower the growth rate, and vice versa. This suggests that efficient feed utilization will boost growth when the poor quality status of ruminant feedstuff is addressed (either through chemical processing, use of additives, or any other means) to reduce fibre concentration (McDonald et al., 2010). This may have been the circumstance, based on the outcome.

Feed digestibility

Effects of supplementing xylanase with alkali treatments on the apparent digestibilities of the experimental diets are presented in Table 3. Addition of xylanase along with alkali treatment had significant ($p<0.05$) effect on DM, CP, CF and NFE digestibility's which resulted in the highest digestibility's for *Yankasa* rams. The DM, CP and CF digestibility's were increased to about 25.22%, 37.06% and 2.02% respectively in the group of rams receiving ULGNS compared to the untreated group. Additionally, NFE digestibility was increased to about 5.65% in the UGNS group compared to the untreated group.

These results agree with most of the published literature reporting increased total tract digestibility's of DM, CF or both resulting from the treatment of fibrous crop residues following alkali chemicals, fibrolytic enzyme supplementation or both (Beauchemin et al., 2019; Millam et al., 2021). Improved digestibility caused by xylanase supplementation in the ration could be linked to improved microbial colonization through modifying the fibre structure (López-Aguirre et al., 2016; Rode et al., 2001), increasing xylanase activity within the rumen (Salem et al., 2015; Valdes et al., 2015; Vallejo et al., 2016), or both (Beauchemin et al., 2000). Several reports on animal performance to feed enzymes mentioned that applying fibrolytic exogenous enzymes in rations of ruminants have a positive effect on digestibility of nutrients (Abid et al., 2020; Adesogan et al., 2019; Arce-Cervantes et al., 2013; Awawdeh & Obeidat, 2011; Bueno et al., 2013; López-Aguirre et al., 2016; Meale et al., 2014; Mireles-Arriaga et al., 2015; Salem et al., 2015; Sujani & Seresinhe, 2015; Valdes et al., 2015). Concerning alkali processing, especially in the group of rams receiving ULGNS (which improved DM, CP and CF digestibility), it was reported that treatment with both urea and lime can improved the digestibility of nutrients (Adesogan et al., 2019). It was proposed that better digestibility caused by alkali treatment was due to increased hydrolysis of structural carbohydrates generated by breaking fibrolytic linkages and causing cellulose component swelling. These methods increase cell wall degradability, allowing ruminal bacteria to attack structural carbohydrates and speed up hemicellulose and cellulose degradation (Adesogan et al., 2019; Millam et al., 2021).

Table 3: Nutrient digestibility of experimental ration fed to *Yankasa* rams

Parameters (%)	UTGNS	UGNS	LGNS	ULGNS	SEM
Dry matter	42.55[c]	55.97[b]	53.40[b]	67.77[a]	1.81
Crude protein	24.65[d]	59.29[b]	45.69[c]	61.71[a]	1.09
Crude fibre	55.89[a]	56.69[a]	49.77[b]	57.18[a]	2.62
Fats	56.16[a]	60.41[a]	39.28[b]	39.59[b]	3.14
Nitrogen free extract	47.49[b]	53.14[a]	45.03[b]	45.65[b]	2.24

Values within same row with different superscript are significantly (p<0.05) different, UTGNS: untreated groundnut shells, UGNS: urea treated groundnut shells, LGNS: lime treated groundnut shells, ULGNS: urea-lime groundnut shells, SEM: significant error of means

CONCLUSIONS

From the results obtained in the present study, it was observed that average daily weight gain was improved by LGNS; UTGNS relatively increased average daily feed intake while ULGNS showed better FCR. UGNS was cost effective. Apparent digestibility of DM, CP and CF was improved by ULGNS while UGNS increased digestibility of NFE. Therefore, it was thus concluded that the combination of urea and lime treatment on GNS with xylanase supplementation in rations of *Yankasa* rams improved weight gain, feed efficiency; digestibility of DM, CP and CF; and did not cause any major health disorders during the period (90 days) of the experiment.

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