VOL. 13 NO. 3,
AUGUST, 2026
E-ISSN 3026-8702
P-ISSN 3026-8745

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Clinical and Metabolism Studies (JCMS)

Nutrient Intake and Digestibility of Growing Yankasa Rams Fed Urea Treated and Untreated Sorghum Stover with Supplementation

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DOI: https://doi.org/10.70382/ajcms.v13i3.048

Abstract

An experiment was conducted to evaluate the nutrient intake and digestibility of Yankasa rams fed urea-treated and untreated sorghum stover with supplementation. Twenty rams were randomly allotted to four dietary treatments in a Completely Randomized Design. Rams on treatments 1 and 2 received untreated sorghum stover, while those on treatments 3 and 4 were fed urea-treated sorghum stover. Treatments 1 and 3 were supplemented with cottonseed cake alone (CSC), while treatments 2 and 4 were supplemented with a mixture of cottonseed cake and maize bran (CSC + MB, 50:50). The experiment lasted for 63 days. Urea treatment increased the crude protein (CP) content of sorghum stover by 219.55% and decreased acid detergent fibre (ADF) by 17.72%. Significant ($P < 0.05$) differences were observed in nutrient intake and digestibility. Dry matter intake (DMI) was highest in treatment 1 (576.10g/day) and lowest in treatment 4 (513.64g/day). Crude protein digestibility (CPD) and acid detergent fibre digestibility (ADFD) were highest in treatment 3 (83.65% and 79.36%, respectively) and lowest in treatment 1 (55.57% and 54.16\%, respectively). Based on improved nutrient intake and digestibility parameters, urea-treated sorghum stover supplemented with cottonseed cake alone or in combination with maize bran (50:50) is recommended for growing Yankasa rams.

Keywords: Yankasa rams, Urea treatment, Sorghum stover, Digestibility, Nutrient intake

Introduction

Sheep population in Nigeria which is estimated to be 33.9 million (FAO, 2008) which is primarily kept for meat production can bridge the supply-demand of animal protein gap in Nigeria. However, effective and efficient sheep production cannot be enhanced with the use of conventional feedstuffs such as maize, soybean cake and fish meal as supplements to low quality feeds due to their exorbitant cost, erratic supply (Akinmutimi, 2004) and the competition with humans and monogastric animals (Ajayi *et al.,* 2008). It is in this light that non-conventional energy and protein materials of farm and agro-industrial wastes were being exploited for livestock production in Nigeria (Ndubueze *et al.,* 2006; Okonkwo *et al.,* 2008). Such feed resources should be cheap, have high nutritive value, non-toxic, readily available, have low or no demand by both humans and other livestock species and without industrial usage (Egbo *et al.,* 2001; Amaefelu*,* 2002; Ndubueze *et al.,* 2006). The utilization of the cheapest and most available feedstuff is a major challenge facing livestock farmers in Nigeria amidst feed crisis (Bogoro, 1997).

These cheap feed resources include crop residues, agro-industrial by-products, animal processing wastes, brewery waste and by products, farm animal waste (poultry litters, animal feces) and other forms of fibre, protein and energy by products suitable for ruminant feeding. Farmers in the rural areas depend on crop residues to feed livestock during the period of feed scarcity (Fall *et al.,* 1987). Estimates revealed that over one billion metric tonnes of crop residues are produced worldwide, more than 340 million tons in Africa (Umunna and Iji, 1993) and over 111.5 million tonnes in Nigeria annually (Lufadeju, 1990). These provide much of the feed resources for ruminants in developing countries (Owen and Jayasuriya, 1989). Crop residues contribute substantially to the supply of nutrients for animals in the tropical and sub-tropical developing countries. According to Fall *et al.* (1987) about 25% of cereal crops are retained in crop residues, making them valuable nutrient sources. The feeding value of crop residues especially cereals such as sorghum and millet were largely ignored and this has resulted in development of crop varieties and hybrids that produce fewer residues than unimproved varieties (Williams *et al.,* 1997), yet it is the most important feeds for ruminants in small-holder crop-livestock production system of Asia and Africa. Thus, its importance in ruminant nutrition in the long dry season of Semi-arid areas needs not to be over emphasized despite its limitations.

This research was therefore designed to study the effect of feeding untreated and urea treated sorghum stover with supplements on the nutrient intake and apparent nutrient digestibility of growing Yankasa rams.

Materials and Methods Description of the study area

The experiment was carried out at the Small Ruminant Farm of the Department of Animal Health and Production, Bauchi State College of Agriculture, Bauchi, Bauchi State. The college is located along coordinates 10°16'57.3"N 9°47'56.0"E (VYMaps.com**)**. The state has a prominent climate marked by dry and wet seasons. The rains commence in April and ends in October. The average rainfall is 700mm in the northern parts and 1, 300mm in the southern parts. The wettest months are July, August and September. The dry season starts in November and ends in April (BASGD 2006).

Experimental animals and their management

Twenty (20) growing Yankasa rams weighing 14 to 16 kg (averagely 15 kg) of about 8 to 10 months were used for the experiment. The rams were sourced from Durum and Mararaban Liman Katagum Markets in Bauchi Local Government Area of Bauchi state. The animals were housed in

individual pens and allocated to four (4) treatments of five (5) animals each in a Completely Randomized Design. The house was constructed with corrugated iron roof and a concrete floor with large windows to enhance ventilation. Saw dusts /wood shavings were used as bedding materials to protect the animals from dampness and cold. Before the beginning of the experiment, the animals were treated against ecto and endo parasites using Ivormectin injection and Albendazole bolus and also injected intra-muscularly with O*xytetracycline* long-acting broad-spectrum antibiotic as a precautionary measure against bacterial infections. The animals were kept for a period of two weeks to enable them adapt to confinement before the commencement of the feeding trial. During the adaptation period, the experimental diets were offered to the animals *ad libitum*.

Processing of sorghum stover

Sorghum stover was sourced from Firo area of Yali District, Ganjuwa Local Government Area of Bauchi state, after grain harvest. It was allowed to dry for 3 weeks and thereafter milled mechanically to about 3cm using special residues milling machine. The drying and milling process was done in different batches. This was termed as untreated sorghum stover (USS). Another batch of the milled sorghum stover was treated with urea as described below.

Urea treatment of sorghum stover

One hundred kilogram of milled sorghum stover was treated with 5% urea solution (Five (5) kilograms of urea dissolved in 100 litres of water) in batches. The urea solution was sprinkled over 100 kg of milled sorghum stover and mixed thoroughly and compressed into an airtight polythene bag of dimension 112 cm by 76 cm in a plastic container and ensiled for three weeks. At the end of the three weeks period, the ensiled material was opened and air dried under shade for 3 days. Continuous raking of the material was carried out for uniform drying and to minimize the risk of mould. This was termed as urea treated sorghum stover (UTSS).

Experimental diets and animals feeding

There were four (4) treatments as follows: Treatment 1 (untreated milled sorghum Stover (USS) supplemented with 300g cottonseedcake alone), Treatment 2 (untreated milled sorghum stover (USS) with 300 g cottonseed cake and maize bran (50:50), Treatment 3 (urea treated milled sorghum stover (UTSS) supplemented with 300g cottonseed cake alone), and treatment 4 (urea treated milled sorghum stover supplemented with 300g cotton seed cake and maize bran (50:50). All supplements were fed at 300 g per head per day, while the basal untreated and urea treated milled sorghum stover were fed *ad libitum*. The supplements were fed twice a day, half at each time; in the morning (09:00 hrs.) and evening (16:00 hrs.).

Clean drinking water was offered to all animals on a daily basis. During the 9 week experiment, feed offered and feed refusals were recorded for each animal in each treatment in order to determine daily feed intake.

Digestibility study

A digestibility trial was conducted using three (3) Rams from each treatment making a total of twelve (12) in the trial. The rams were kept in individual cages which were equipped with feeding and watering troughs. The digestibility trial lasted for 10 days with 3 days adaptation period to accustom with fecal collection bag and seven days collection period.

Chemical analysis

All the diets were analyzed for chemical composition. Each sample was milled to pass through a 1.0mm screen using a telator cyclotee 1093. The milled samples were used for proximate analysis to determine Nitrogen (N) for use in crude protein determination (N x 6.25), Crude fibre (CF), Ether Extract (EE) and Ash according to AOAC (1999). Neutral Detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to procedures outlined by Van Soest *et al.* (1991).

Data analysis

Data were analyzed using one way Analysis of Variance (ANOVA) with Statistical Package for Social Sciences (SPSS) version 21 (2006). Significant difference means were separated using least significant difference (LSD).

Chemical composition of experimental diets

Chemical composition of untreated and urea treated sorghum stover and supplements are presented in Table 1. Urea treatment increased crude protein content of sorghum stover by 219% over the untreated sorghum stover and decreased the content of NDF and ADF by 12.45 and 17.72%, respectively. The increase in crude protein (CP) contents of sorghum stover with urea treatment is higher than the values (12.35% and 12.38%) reported by Ngele (2007) and Sahoo *et al,* (2002). This finding is also in agreement with findings of Yulistiani *et al.* (2003) which found an increase in CP content of urea treated rice straw to be 2.7 times CP and also slightly higher compared to previous experiment reported by Prasad *et al.* (1998) which were 2.34 times was recorded for urea treated straw kept in bale and 2.433 kept in stack. However, the increase in nitrogen content in the experiment currently reported was higher compared to the result reported by Ahmed *et al.* (2002). This difference could be due to method of ensiling, the variety of the straws, urea treatment level as well as the nitrogen content of the straw. Yulistiani *et al.* (2000) reported that rice straw with low nitrogen content could benefit more from urea treatment to improve nutritive value especially nitrogen content.

Similar results of increased in CP and reduced neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of urea treated wheat straw (Abebe *et al.,* 2004; Kjos *et al.,* 1987) and maize straw, husks and Cobs (Oji *et al.,* 2007) have been reported. However, Sahoo *et al.* (2002) reported increased NDF and ADF contents of urea treated wheat straw, while Habib *et al.* (1998) reported increase NDF, but decreased ADF contents of wheat straw varieties in response to urea treatment. However, there was a slight increment in ash content of urea treated sorghum stover due to urea ammoniation of the stover.

Table 1: Chemical composition of untreated, urea treated sorghum stover and supplements

Parameters (%)	USS	UTSS	CSC	MB + CSC
Dry matter	90.20	88.23	93.60	91.27
Organic matter	83.53	79.60	87.80	84.22
Crude protein	5.83	18.63	30.39	25.59
Ash	6.67	8.63	5.80	7.05
Neutral detergent fibre	49.39	43.24	48.59	48.76
Acid detergent fibre	42.21	34.73	39.17	37.53
Hemicelluloses	7.18	8.51	9.42	11.23

TSS = Treated Sorghum Stover, USS = Untreated Sorghum Stover, CSC = Cottonseed Cake, MB + CSC Maize Brand and Cottonseed Cake

Nutrient intake of rams fed the experimental basal diets with supplements

Table 2 showed the nutrient intake of Yankasa rams fed untreated and urea treated sorghum stover with supplements. The average daily feed intake and dry matter intake (DMI) were significant (P<0.05) across the dietary treatments. The daily feed intake of the urea treated sorghum stover was higher than those of the other treatments which is in agreement with some findings (Ngele *et al.,* 2009; Getahun, 2014). This may be attributed to treatment rendered to the basal diet which reduced the particle size of the straw thereby given a better chance for the animals to consume higher amount. The result is also in agreement with that of Yulistiani *et al.* (2000) who found 28% value higher than the untreated maize stover with *Centrosema pubescens.* FAO (1986) stated that urea treatment may increase voluntary feed intake of the treated straw by as much as 25 to 30% over that of the untreated straw. Smith *et al.* (1989) also reported a significant increase in DMI of the urea treated maize stover compared to that of the dry fresh maize stover while Tesfaye *et al.* (2005) reported that dry matter intake of treated maize stover was 22% higher than that of untreated stover. On the other hand, Saadullah *et al.* (1982) observed no trend of intake increment for urea treated rice straw fed to calves. Also, according to Munthali *et al.* (1992), urea treatment of maize stover did not increase dry matter intake compared with the water treatment of maize stover. Significant (P<0.05) difference was observed in crude protein intake (CPI). Rams fed UTSS recorded higher intake of (149.78 and 127.41 g/day) in treatment 3 and 4 while those fed USS record the least (95.12 and 110.26 g/day) in treatment 2 and 1. The organic matter intake (OMI) was also significant (P<0.05) across the dietary treatments with rams on sole supplement (CSC alone) irrespective of the basal diets recorded high value. Acid detergent fibre intake showed no significant (P>0.05) effect across the dietary treatment while the neutral detergent fibre intake showed significant (P<0.05) difference with T1 having the highest value of 326.93 g/day in contrast to T4 having the lowest value 263.81 g/day.

Table 2: Nutrient intake of Yankasa rams fed untreated and urea treated sorghum stover with supplements

Parameters	Treatments				
	T1	T2	T3	T4	SEM
Average basal feed intake (g/day)	314.58^{c}	310.83^{c}	327.38^{b}	371.82^{a}	12.05*
Average supplement intake (g/day)	300	300	300	300	0.00^{NS}
Total Average feed intake (g/day)	614.58^{c}	610.83^{c}	627.38^{b}	671.82^{a}	12.05*
Dry matter intake (g/day)	576.10^{a}	557.79^{b}	558.35^{b}	513.64^{c}	5.28*
Organic Matter Intake (g/day).	566.86^{a}	515.63^{b}	543.81^{c}	469.03^{d}	8.36*
Crude Protein Intake (g/day)	110.26^{c}	95.12^{d}	149.78^{a}	127.41^{b}	4.66*
NDFI (g/day)	307.46^{a}	301.77^{b}	281.79^{c}	263.81^{d}	3.96*
ADFI (g/day)	255.70^{a}	245.48^{b}	226.76^{c}	206.99^{d}	4.27*

^{a,b,c}means with different superscript along the same row are significantly different, T1= untreated sorghum stover + cotton seed cake alone, T2= untreated sorghum stover + cottonseed cake and maize bran (50:50), T3=urea treated sorghum stover + cottonseed cake alone, T4=urea treated sorghum stover + cottonseed cake and maize bran (50:50), NDFI= Neutral Detergent Fibre Intake, ADFI= Acid Detergent Fibre Intake, * = Significant difference (P<0.05), NS = No Significant difference, SEM = Standard Error Mean, LS = Level of Significance,

Nutrient digestibility of rams fed fed untreated and urea treated sorghum stover with supplements

Table 3 showed nutrient digestibility of Yankasa rams fed untreated and urea treated sorghum stovers with supplements. Significant differences (P< 0.05) were recorded in all the treatments. Dry matter digestibility (DMD) values obtained in this study (79.99 and 78.82%) for treated basal diets were higher than 51.33% reported by Jokthan *et al*. (2013). Xu *et al*. (2019) reported DMD of 72.55% which was lower than the values recorded in this study. Adeola *et al*. (2021) and El-Nommeary *et al*. (2021) reported DMD of 75.64 and 70.58%, respectively which were within the range recorded in this study. Organic matter digestibility (OMD) was significantly (P<0.05) higher in animal fed treated basal diet as compared to untreated. The OMD values recorded in this study were higher than 64% reported by Hirut *et al*. (2011). Xu *et al*. (2019) reported OMD of 77.75% which fell within the range in this study. Crude protein digestibility (OMD), neutral detergent fibre digestibility (NDFD) and acid detergent fibre digestibility (ADFD) were significantly (P<0.05) higher in rams fed treated basal diet. According to Bonsi *et al.* (1996) lower CP content of feeds affect microbial growth and fermentation in the rumen and consequently digestibility of DM and other nutrients which was in accordance with this study. Banamana *et al.* (1990) reported that increasing CP in the diet increased the digestibility of OM, ADF and CP. Mulligan *et al*. (2001) also reported that increasing dietary CP content increased the digestibility of low-quality hay which is consistent with the result in the present study.

Table 3: Nutrient digestibility of Yankasa rams fed untreated and urea- treated sorghum stover with supplements

Parameters (%)	Treatments				SEM
	T1	T2	T3	T4	
Dry matter digestibility	68.84^{b}	73.53^{b}	79.99^{a}	78.82^{a}	1.70*
Organic Matter Digestibility	71.61^{b}	75.33^{b}	81.59^{a}	80.00^{a}	1.06*
Crude protein digestibility	55.57^{c}	61.21^{b}	83.65^{a}	78.91^{a}	1.24*
Neutral detergent fibre digestibility	64.16^{b}	70.92^{b}	80.56^{a}	79.97^{a}	1.55*
Acid detergent fibre digestibility	54.16^{b}	69.92^{b}	79.36^{a}	77.97^{a}	2.43*

^{a,b,c}means with different superscript along the same row are significantly different, T1= untreated sorghum stover + cotton seed cake alone, T2= untreated
sorghum stover + cottonseed cake and maize bran (50:50), T3=urea treated sorghum stover + cottonseed cake alone, T4=urea treated sorghum stover + cottonseed cake and maize bran (50:50), * = Significant difference (P<0.05), NS = Not Significant, SEM = Standard Error Mean, LS = Level of Significance

Conclusion

Based on the results obtained in this current study, urea treatment increased the crude protein content of sorghum stover by 219% and decreased acid detergent fibre by 21.57%. It can be concluded that both untreated and urea - treated sorghum stover supplemented with cotton seed cake alone or in mixture with maize bran (50:50) fed to Yankasa rams gave high feed intake and better feed conversion ratio.

Recommendations

It can be recommended that growing Yankasa rams should be fed urea treated sorghum stover supplemented with cotton maize bran and cotton seed cake and maize bran (50:50) for better nutrient intake and digestibility.

Acknowledgement

This research was funded by Federal Polytechnic Bauchi; Tedfund Center of Excellence for Integrated Farming System. We are thankful for this support.

References

Abebe, G., Merkel, R. C., Animut, G., Sahlu, T. and Goetsch, A. L. (2004). Effect of ammoniation of wheat straw and supplementation with soybean meal or broiler litter on feed intake and digestion in yearling Spanish goat wethers. *Small Ruminant Research*, 51(1): 37–46.

Adeola, E. A., Garba, Y. and Baba, M. (2021). Growth performance and in vivo nutrients digestibility of growing Yankasa ram lambs fed diets containing graded levels of sesame residue. *Journal of Animal Health and Production*, 9(2): 107–111.

Ahmed, A., Khan, M. J., Shahjalal, M. and Islam, K. M. S. (2002). Effects of feeding urea and soybean meal-treated rice straw on digestibility of feed nutrients and growth performance of bull calves. *Asian-Australasian Journal of Animal Sciences*, 15(4): 522–527.

Ajayi, H. I., Olomu, J. M. and Oyedeji, J. O. (2008). Potentials of African pear (*Dacryodes edulis*) as a feedstuff for animals. *Proceedings of the 13th Annual Conference of the Animal Science Association of Nigeria (ASAN)*, September 15–19, 2008, Zaria, Nigeria, pp. 142–145.

Akinmutimi, A. H. (2004). *Evaluation of sword bean (Canavalia gladiata) as an alternative feed resource for broiler chickens*. Ph.D. Thesis, Department of Non-Ruminant Animal Production, Michael Okpara University of Agriculture, Umudike, Nigeria.

AOAC (1999). *Official Methods of Analysis*. 16th Edition. Association of Official Analytical Chemists, Washington, D.C., USA.

Banamana, M. S., Oldham, J. D. and Mowlem, A. (1990). The effect of amount of protein in the concentrate on hay intake and rate of passage, diet digestibility and milk production in British Saanen goats. *British Journal of Nutrition*, 64(2): 333–342.

BASGD (2006). *Bauchi State Government Diary*. Published by Brepols Publishers, Belgium.

Bogoro, S. E. S. (1997). *Effect of protein-energy supplementation on rumen kinetics, metabolite profiles and growth performance of rams fed fibre diets*. Ph.D. Thesis, Abubakar Tafawa Balewa University, Bauchi, Nigeria.

Bonsi, M. L. K., Tuah, A. K., Osuji, P. O., Nsahlai, I. V. and Umunna, N. N. (1996). The effect of protein supplement source or supply pattern on the intake, digestibility, rumen kinetics, nitrogen utilization and growth of Ethiopian Menz sheep fed tef straw. *Animal Feed Science and Technology*, 64(1): 11–25.

Egbo, M. L., Doma, U. D. and Lacdaks, A. B. (2001). Rabbit management in Bauchi metropolis. *Proceedings of the 26th Annual Conference of the Nigerian Society for Animal Production (NSAP)*, March 18–21, 2001, ABU Zaria, Nigeria, pp. 160–162.

El-Nomeary, Y. A. A., Abd El-Rahman, H. H. H., Shoukry, M. M., Abedo, A. A., Salman, F. M. and Mohamed, M. I. (2021). Effect of different dietary protein sources on digestibility and growth performance parameters in lambs. *Bulletin of the National Research Centre*, 45(40): 1–11.

Fall, S., Guerin, H., Sall, C. and Mbaye, N. D. (1987). Cereal straws in the feeding system of ruminants in Senegal. In: Said, A. N. and Dzowela, B. H. (Eds.), *Overcoming Constraints to Efficient Utilization of Agricultural By-Products as Animal Feed*. Proceedings of the Fourth Animal Workshop, October 20–27, 1987, Mankon Station, Bamenda, Cameroon, pp. 173–188.

FAO (1986). Better utilization of crop residues and by-products in animal feeding: research guidelines. *FAO Animal Production and Health Paper No. 50/2*, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (2008). *Livestock Statistics for Nigeria (1998–2008)*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Getahun, K. (2014). Effects of wheat straw urea treatment and *Leucaena leucocephala* foliage hay supplementation on intake, digestibility, nitrogen balance and growth of lambs. *International Journal of Livestock Production*, 6(4): 88–96.

Habib, G., Hassan, M. F. and Siddiqui, M. M. (1998). Degradation characteristics of straw from different wheat genotypes and their response to urea-ammoniation treatment. *Animal Feed Science and Technology*, 72(3–4): 373–386.

Hirut, Y., Solomon, M. and Mengistu, U. (2011). Effect of concentrate supplementation on live weight change and carcass characteristics of Hararghe Highland sheep fed a basal diet of urea-treated maize stover. *Livestock Research for Rural Development*, 23(12): Article #245.

Jokthan, G. E., Muhammad, S. A. and Osuhor, C. U. (2013). Effect of cottonseed cake replacement with broiler litter on performance of Yankasa rams fed maize husk basal diet. *FUTY Journal of Environment*, 8(1): 147–155.

Kjos, N. P., Sundstøl, F. and Birkelo, C. P. (1987). The nutritive value, weather damage and good quality straw of barley, wheat and oat, untreated and treated with ammonia or sodium hydroxide. *Journal of Animal Physiology and Animal Nutrition*, 58(1–5): 106–120.

Lufadeju, E. A., Blackett, G. A. and Ørskov, E. R. (1990). The effect of variety of spring barley straw and ammonia treatment on nutritive value. *Proceedings of the Nutrition Society*, 49(1): 97A.

Mulligan, F. J., Caffrey, P. J., Rath, M., Kenny, M. J. and O'Mara, F. P. (2001). The effect of dietary protein content and hay intake level on the true and apparent digestibility of hay. *Livestock Production Science*, 68(1): 41–52.

Munthali, J. T. K., Musa, F. A. and Jayasuriya, M. C. N. (1992). The effect of urea treatment on intake and digestibility of maize stover by cattle. In: Stares, J. E. S., Said, A. N. and Kategile, J. A. (Eds.), *The Complementarity of Feed Resources for Animal Production in Africa*. Proceedings of the Joint Feed Resources Network Workshop, March 4–8, 1991, Gaborone, Botswana, pp. 249–256.

Ndubueze, A. I., Ukachukwu, S. N., Ahamefule, F. O. and Ibeawuchi, J. A. (2006). Milk yield and composition of grazing White Fulani cows fed poultry waste-cassava peel-based diets. *Pakistan Journal of Nutrition*, 5(5): 436–440.

Ngele, M. B., Adegbola, T. A., Bogoro, S. E. S., Kalla, D. J. U., Abubakar, M. and Chiroma, A. (2007). Nutritive value and pathogenic microbial flora of rice straw treated with poultry litter. *Journal of League of Researchers in Nigeria*, 8(2): 6–11.

Ngele, M. B., Kalla, D. J. U., Abubakar, M., Dass, U. D. and Amba, A. A. (2009). Enhancing crop residues for livestock feeding in the tropics. *Journal of League of Researchers in Nigeria*, 10(2): 1–20.

Oji, U. I., Etim, H. E. and Okoye, F. C. (2007). Effect of urea and aqueous ammonia treatment on the composition and nutritive value of maize residues. *Small Ruminant Research*, 69(1–3): 232–236.

Okonkwo, A. C., Isaac, L. J., Solomon, L. P. and Uyoh, G. D. (2008). Effects of dietary cassava leaf meal on growth performance of weaner rabbits. *Proceedings of the 33rd Annual Conference of the Nigerian Society for Animal Production (NSAP)*, March 17–20, 2008, Ayetoro, Nigeria, pp. 142–144.

Owen, E. and Jayasuriya, M. C. N. (1989). Use of crop residues as animal feeds in developing countries. *Research and Development in Agriculture*, 6(3): 129–138.

Prasad, R. D. D., Reddy, M. R. and Reddy, G. V. N. (1998). Effect of feeding baled and stacked urea treated rice straw on the performance of crossbred cows. *Animal Feed Science and Technology*, 73(3–4): 347–352.

Saadullah, M., Haque, M. and Dolberg, F. (1982). Effectiveness of ammoniation through urea in improving the feeding value of rice straw in ruminants. *Tropical Animal Production*, 7(1): 20–25.

Sahoo, B., Saraswat, M. L., Haque, N. and Khan, M. Y. (2002). Influence of chemical treatment of wheat straw on carbon-nitrogen and energy balance in sheep. *Small Ruminant Research*, 44(3): 201–206.

Smith, T., Chakanyuka, C., Sibanda, S. and Manyuchi, B. (1989). Maize stover as feed for ruminants. In: Said, A. N. and Dzowela, B. H. (Eds.), *Overcoming Constraints to Efficient Utilization of Agricultural By-Products as Animal Feed*. Proceedings of the Fourth Animal Workshop, October 20–27, 1987, Mankon Station, Bamenda, Cameroon, pp. 218–231.

Tesfaye, A., Chairatanayuth, P., Vijchulata, P. and Tudsri, S. (2006). Production and utilization of crop residues in three agro-ecological zones of Eastern Shoa Zone, Ethiopia. *Kasetsart Journal of Natural Science*, 40(3): 643–651.

Umunna, N. N. and Iji, P. A. (1993). The natural feed resources for ruminant animals in Nigeria. In: Adamu, A. M., Mani, R. I., Osinowo, O. A., Adeoye, K. B. and Ajileye, E. O. (Eds.), *Forage Production and Utilization in Nigeria*. Proceedings of the Second NLPD Workshop, February 11–14, 1991, Zaria, Nigeria, pp. 16–31.

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74(10): 3583–3597.

Williams, T. O., Fernández-Rivera, S. and Kelley, T. G. (1997). The influence of socio-economic factors on the availability and utilization of crop residues as animal feeds. In: Renard, C. (Ed.), *Crop Residues in Sustainable Mixed Crop-Livestock Farming Systems*. CAB International, Wallingford, UK, pp. 25–39.

Xu, Y., Li, Z., Moraes, L. E., Shen, J., Yu, Z. and Zhu, W. (2019). Effects of incremental urea supplementation on rumen fermentation, nutrient digestion, plasma metabolites, and growth performance in fattening lambs. *Animals*, 9(9): Article 652.

Yulistiani, D., Gallagher, J. R. and Van Barneveld, R. (2003). Intake and digestibility of untreated and urea treated rice straw base diet fed to sheep. *Indonesian Journal of Animal and Veterinary Science*, 8(1): 8–16.