NUTRIENT DIGESTIBILITY AND NITROGEN METABOLISM IN WEST AFRICAN DWARF SHEEP FED DIFFERENTLY PROCESSED BREADFRUIT (*Artocarpus altilis*) MEAL

Okoruwa, M.I

Department of Animal Science, Ambrose Alli University, P.M.B. 14, Ekpoma, Edo State, Nigeria
Corresponding author's email: odionokos@yahoo.com; okosmich@gmail.com

Abstract
An experiment was conducted to determine nutrient digestibility and nitrogen metabolism in sheep fed differently processed breadfruit meal. Twenty West African dwarf sheep with mean weight body of 6.00 ± 0.55kg were randomly allotted to four dietary treatments with five sheep per treatment in a completely randomised design. Ficus foliage with breadfruit meals and concentrate diet were used as experimental diets: Diet A (50% unpeeled raw breadfruit meal + 20% ficus foliage + 30% concentrate), diet B (50% peeled raw breadfruit meal + 20% ficus foliage + 30% concentrate), diet C (50% unpeeled soaked breadfruit meal + 20% ficus foliage + 30% concentrate) and diet D (50% unpeeled boiled breadfruit meal + 20% ficus foliage + 30% concentrate). Metabolism trial was conducted at the end of 12 weeks feeding trial using sixteen sheep to assess the effect of diets on nutrient digestibility and nitrogen metabolism. Results obtained showed that ash digestibility (56.72%), faecal nitrogen (7.63g/day) and urinary nitrogen (4.20g/day) were significantly ($P < 0.05$) higher in sheep on diet A than other treatment diets. Sheep on diet B were significantly ($P < 0.05$) better in terms of digestibility of crude protein (71.53%), crude fibre (75.46%) with ether extract (51.68%), nitrogen intake (20.01g/day), nitrogen balance (12.26g/day) and nitrogen absorbed (14.90g/day) than sheep on diets A, C and D. Nitrogen free extract digestibility (67.89%) and nitrogen retention (61.61%) were significantly ($P < 0.05$) higher in sheep fed on diet C . No significant ($P > 0.05$) difference exists in sheep with regards to dry matter digestibility. It was concluded that the sheep fed 50% peeled raw breadfruit meal + 20% ficus foliage + 30% concentrate diet improved nitrogen digestibility and nitrogen metabolism.

Keywords: Breadfruit, digestibility, nitrogen metabolism and sheep

Introduction
One of the major factors limiting the productivity of ruminant animals in Nigeria is the over – dependence of low digestibility feeds which at certain periods of the year cannot meet even the maintenance requirements of their body. Ramena and Reddy (2011) categorised these feed resources as high fibre and low protein with organic matter digestibility of between 30 and 45%. These feeds are mainly native grasses, crop residues and fibrous agro-industrial waste products, which form the bulk of feeds consumed by ruminants in the tropical countries. They are produced in large quantities and are relatively cheap, since they are not competed for by man or monogastric animals. The poor condition of sheep production in the tropics is more likely to be as a result of inefficient digestion in the rumen and utilization of the nutrients absorbed from these low quality feeds. Though several attempts have been made by livestock farmers to improve the nutritive value of these low quality feeds (Alhassan *et al.*, 2012) returns to the economy from sheep industrial sector have been very much below the potential requirement of livestock. Thus, there has been a growing interest in many developing tropical countries like Nigeria to identify potentially less-known tropical energy-rich feeds to supplement the available low energy feed sources in ruminant diets in other to reduce scarcity and high cost of feeds.

Breadfruit (*Artocarpus altilis*) is one of such less-known tropical energy-rich feed sources that have been successfully introduced to the forest zone of the South-western Nigeria (Oladunjoye *et al.*, 2010). Breadfruit has a great productive ability and its production usually exceeds demand in the major producing areas in Southern Nigeria. The fruit is highly perishable in fresh form and long term storage for shipment under commercial condition is not feasible (Amusa *et al.*, 2002)· Moreover, breadfruit is not known to be processed into any acceptable storable food form for man in Nigeria (Oladunjoye *et al.*, 2010). Breadfruit is rich in energy and low in protein, hence it could be a potential energy feed source for sheep when properly processed. However, ficus (*ficus thionning*) foliage can be used as supplement fodder to alleviate feed crisis. The high crude protein content and presence of green foliage during the critical period of the year make it a good feed source for ruminants (*Yashim et al.,2014).* There is a paucity of information on nutrient utilization of differently processed breadfruit meals for sheep. Hence, the study herein reported was to determine the nutrient digestibility and nitrogen metabolism in West African dwarf sheep fed differently processed breadfruit (*Artocarpus altilis*) meal.

Materials and Methods

Location of study

The experiment was carried out at sheep and goat unit of the Teaching and Research Farm, Ambrose Alli University, Ekpoma. The Farm location is between latitude 6.42^{0}N and Longitude 6.09^{0}E with a unimodal rainfall pattern which starts from April and ends in October. The area has an average annual rainfall of 1556mm with temperature that range between 26^{0}C and 34^{0}C.

Experimental diets

Ficus foliage was obtained from a mature tree around the Teaching and Research Farm at the Ambrose Alli University, Ekpoma. The foliage was chopped into small sizes of about 5cm before used. Breadfruits were harvested from the same tree in a Farm Plantation around Ekpoma in Edo State, Nigeria. The breadfruits were prepared into meals thus;

URBM = Unpeeled Raw Breadfruit Meal
PRBM = Peeled Raw Breadfruit Meal
USBM = Unpeeled Soaked Breadfruit Meal
UBBM = Unpeeled Boiled Breadfruit Meal

Concentrate composition ingredients that comprised the following: 50% brewer's dry grain, 35% wheat offal, 10% rice bran, 1.50% vitamin, 2.00% bone meal, 1.00% limestone and 0.50% salt was formulated. The differently prepared breadfruit meals were used in combination with ficus foliage and formulated concentrate as the experimental diets in a ratio of 50:20:30 respectively. However, the four experimental diets prepared were; diet A (50% URBM + 20% ficus foliage + 30% concentrate), diet B (50% PRBM + 20% ficus foliage + 30% concentrate), diet C (50% USBM + 20% ficus foliage + 30% concentrate) and diet D (50% UBBM + 20% ficus foliage + 30% concentrate). The experimental diets were offered at the rate of 5% (dry matter basis) of their body weight.

Experimental animals and their management

Twenty West African Dwarf (WAD) male sheep aged approximately about 7 months with a mean body weight of 6.00 ± 0.55kg were sourced from villages within Ekpoma. The sheep were randomly allotted to the four dietary treatments (A, B, C and D) with five sheep per treatment in a completely randomized design. The experimental pens were cleaned and disinfected before the arrival of the sheep. On arrival, the sheep were given prophylactic treatments against ecto and endo parasites. The sheep were housed individually in an open – sided, well-ventilated pens. The experimental diets were offered once daily in the morning at about 8:00am. The animals also had free access to fresh water and salt lick daily. Their feeding that lasted for 12 weeks was preceded by 14 day of adaptation period.

Nutrient digestibility and nitrogen metabolism studies
Four (4) West African dwarf sheep that were randomly selected from each treatment (totalling 16) were used for the nutrient digestibility and nitrogen metabolism studies. The sheep were housed in individual metabolic cages with slated floors adapted for faecal and urine collection. Sheep were fed with their weighed treatment diets for the last 7 days after a 7-day adjustment period of metabolic cages. The quantity of feeds offered which represented the fraction of the quantity of the feed offered to each sheep per day and the leftover which represented the one that was not consumed were weighed daily. The weight difference between them was recorded and taken as the feed intake. Daily faecal and urine samples were also weighed. Sub-samples of the faecal were bulked together and stored, while the sub – sample of the urine were stored in sample bottles and frozen, until they were required for nutrient determination in the laboratory. Thus, apparent nutrient digestibility was calculated using this formula:

$$\text{Nutrient Digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrient intake}} \times \frac{100}{1}$$

Nitrogen balance by the sheep were calculated as the difference between nitrogen intake and nitrogen excreted from faeces and urine, while nitrogen retention percentage was computed from nitrogen balance expressed as a percentage of nitrogen intake.

Chemical and statistical analyses
Samples of the differently processed breadfruit meal, ficus foliage, concentrate diet and faecal output were analysed for proximate composition using the procedures of AOAC (1990). Urine samples were also analysed for nitrogen content, using the same method of AOAC (1990). Data obtained from nutrient digestibility and nitrogen metabolism were subjected to analysis of variance (ANOVA) to determine the significance of treatment effects following the method described by SAS (1990). Significance differences between means were separated using Duncan multiple range test.

Results and Discussion
The proximate composition of differently processed breadfruit meal, ficus foliage and concentrate diet (% DM basis) are presented in Table 1.

Table 1: Proximate composition (% DM basis) of differently processed breadfruit meal, ficus foliage and concentrate diet

Component	URBM	PRBM	USBM	UBBM	Ficus *Foliage*	Concentrate
Dry Matter	86.02	86.00	85.98	85.99	62.78	89.06
Crude Protein	4.60	4.87	4.85	4.53	16.88	20.01
Crude Fibre	5.01	5.33	5.29	5.20	25.74	13.00
Ash	3.82	3.95	2.72	3.09	11.31	7.98
Ether Extract	2.41	2.91	2.11	2.56	3.30	1.09
Nitrogen Extract	84.16	82.94	85.03	83.92	36.77	57.92

Dry matter content as reflected in their values ranged from 62.78% in ficus foliage to 89.06% in concentrate diet. The crude protein and fibre values of differently processed breadfruit that ranged from 4.53% to 4.87% and 5.01% to 5.33% respectively were generally low in their contents. Hence, the need to add ficus foliage and concentrate diet that had 16.88% & 20.01% in crude protein and 25.4% & 13.00% in crude fibre were necessary to augment the fibre content of the diet and supply fermentable protein to balance the supplied nutrient from the processed breadfruit meals that encouraged rumen degradation as well as promote productivity. Ash content that ranged between 2.72% and 11.31% was lowest in USBM and highest in ficus foliage. Difference observed in ash content of breadfruit meals could be due to leaching in water during soaking and boiling of the breadfruit (Elseed 2005). Ether extract values (1.09% to 3.30%) were lowest in concentrate diet compared with differently processed breadfruit and ficus foliage. This implies that the total ether extract content present in breadfruit and ficus foliage were higher than the one in concentrate diet used. Nitrogen free extract values of differently processed breadfruit (82.94% to 85.03%) were considerably high indicating high carbohydrate content in the study diets. However, the proximate composition of differently processed breadfruit meal used in this study were similar to values reported by (Oladunjoye *et al*., 2010), while values of ficus foliage were slight different from those reported by *Ajayi et al*. (2005).

Table 2: Nutrient digestibility (% DM) of West African Dwarf (WAD) sheep fed experimental diets

	Diets				
Parameters	A	B	C	D	SEM±
Dry Matter	66.82	68.52	64.39	63.99	0.96
Crude Protein	55.49^{c}	71.53^{a}	68.99^{a}	60.34^{b}	1.20
Crude Fibre	57.63^{c}	75.46^{a}	66.82^{b}	64.37^{b}	0.86
Ether Extract	45.28^{b}	51.68^{a}	48.79^{b}	38.98^{c}	0.54
Ash	56.72^{a}	50.04^{b}	49.93^{b}	42.03^{c}	0.78
Nitrogen Free Extract	42.88^{c}	63.95^{a}	67.89^{a}	53.29^{b}	0.62

^{a,b,c} Means within the same row with different superscripts differ significantly (P < 0.05),
SEM = Standard Error of Means

Apparent nutrient digestibility of WAD sheep fed experimental diets is indicated in Table 2. Dry matter digestibility values that ranged from 64.39% for diet C to 68.52% for diet B were not significantly difference (P > 0.05) among treatment diets. This non-significant difference could probably explain the similarity in nutrient accumulation in the diets. Crude protein digestibility was differed significantly (P < 0.05) with diets B (71.53%) and C (68.99%) recorded the highest followed by diet D (60.34%) and diet A (54.49%). This observation could be as a result of complete elimination of residual anti-nutritional factors through drying, soaking and boiling of the breadfruit meal in diets B, C and D. Subsequently, allowed the fermentable products of rumen micro-organisms that resulted in synthesis of microbial protein and the amount of protein digestibility available to the sheep. This is in line with the report of Oladunjoye *et al.* (2004) who observed complete elimination of trypsin inhibitors, tannin and haemagglutinin in breadfruit that have been subjected to drying, soaking and boiling as means of processing into meals. Crude fibre digestibility that ranged from diet A (57.63%) to diet B (75.46%) was significantly (P < 0.05) lower in sheep on diet A. This low value recorded in diet A could be attributed to its processing effects on the unpeeled breadfruit which could not reduced the level of residual anti – nutritional factors, hence affected the fibre combination of the diet and its utilization in sheep. Yashim *et al.* (2014) reported that the extent at which protein and fibre degraded in the rumen of ruminants depend on the processing effect, lignin and anti-nutritional factors of the diet. Ether extract digestibility values of 45.28, 51.68, 48.79 and 38.98% were obtained for sheep on diets A, B, C and D respectively. However, ether extract digestibility values did not follow any specific trend in the dietary treatments, suggesting the level of fats and oil in the diets which could probably interfered with the digestibility, absorption and utilization in sheep (Aregheor *et al.,* 2003). Significant (P < 0.05) difference was observed in ash digestibility values that ranged between 42.03 and 56.72%. Ash digestibility was not optimally digested in dietary treatment D compared with diets A, B and C. This observation could probably be traced to leaching of breadfruit in water during boiling. However, boiling as a means of processing have been reported by FAO (1990) to reduce the nutritional value with losses and changes in major nutrients that includes; protein, carbohydrate, minerals and vitamins which explained the decrease that was observed in the ash content of boiled breadfruit meal in diet D. Digestibility of nitrogen free extract that was higher in diets B (63.95%) and C (67.89%), explaining the proportion of the soluble carbohydrate content of the breadfruit meal and ficus foliage that could probably used by the rumen microbes for their multiplication and activity (Ibrahim and Yashim 2014). Moreover, nutrient digestibility in ruminants have been reported by Okoruwa *et al.* (2014) as the direct method for estimating feed digestion by ruminants, hence studies on nutrient digestibility of ruminant feeds are very important as they allow for the estimation of nutrient actually available for ruminant animals.

Table 3: Nitrogen metabolism in West African dwarf sheep fed differently processed breadfruit meal

	Diets				
Parameters	A	B	C	D	SEM±
Nitrogen intake (g/day)	19.98^{a}	20.01^{a}	17.92^{a}	14.89^{b}	0.82
Faecal nitrogen (g/day)	7.63^{a}	5.11^{a}	4.85^{b}	4.08b	0.21
Urinary nitrogen (g/day)	4.20^{a}	2.64^{b}	2.03^{b}	2.62^{b}	0.02
Nitrogen balance (g/day)	8.15^{b}	12.26^{a}	11.04^{a}	8.19^{b}	0.30
Nitrogen absorbed (g/day)	12.35^{a}	14.90^{a}	13.07^{a}	10.81^{b}	0.17
Nitrogen retention (%)	40.79^{c}	61.27^{a}	61.61^{a}	55.00^{b}	0.64

^{A,B,C} Means Within The Same Row With Different Superscripts Differ Significantly (P < 0.05),
SEM = Standard Error Of Means

Presented in Table 3, is the nitrogen metabolism in West African dwarf sheep fed differently processed breadfruit meal. Nitrogen intake (g/day) values of 19.98, 20.01, 17.92 and 14.89 were obtained for diets A, B, C and D respectively. The significant (P < 0.05) difference that was observed in the nitrogen intake was lower in diet D than other treatment diets. This could be due to the effect of heat during the processing that denatured the protein content retained in the breadfruit. This fact supported the result obtained by Lyimo *et al*. (2006) who noted that protein content of bean varieties were significantly affected negatively by boiling as means of processing. Faecal nitrogen was significantly (P < 0.05) higher in diet A (7.63g/day) compared with diets B (5.11g/day), C (4.85g/day) and D (4.08g/day), explaining the higher amount of residual anti – nutritional factors in diet A that could probably interfered with the fermented nitrogen ingested from ficus foliage in the rumen and reduced the digestibility of the diet influencing higher faecal nitrogen output. This is in agreement with the findings of *Ajayi et al.* (2005) who reported that nitrogen concentration in faeces is strongly depends on the residual content of anti – nutritional factors of the diet. Urinary nitrogen values that ranged between 2.03 and 4.20g/day was also significantly (P < 0.05) higher in sheep on diet A. This could probably trace to the higher concentration of ammonia content in the rumen which was later converted to urea and excreted as urine. This is in line with the report of Ososanya *et al.* (2013) who reported that nitrogen excreted in urine depends on urea recycling and the efficiency in utilization of ammonia produced in the rumen by microbes for microbial protein synthesis.

Nitrogen balance and retention were reported by Tripathi and Karim (2010) to be proportion of nitrogen utilized by ruminants from the total nitrogen intake for body process. Thus, the more the nitrogen consumed and digested the more the nitrogen retained and vice versa. However, nitrogen balance was significantly (P < 0.05) affected by the dietary treatments with sheep in diets B(12.26g/day) and C (11.04g/day) higher than those fed on diets A (8.15g/day) and D (8.19g/day). Nitrogen absorbed almost followed the same trend as observed in nitrogen balance. The lower significant ($P < 0.05$) values of nitrogen absorbed in diet D (10.81g/day) might be attributed to diet constituents as a result of the boiling effect that reduce the nutritional protein content of the breadfruit. The significant ($P < 0.05$) lower value of nitrogen retention percentage obtained in sheep on diet A (40.79%) could be due to low availability of protein for proper digestion due to the formation of tannin protein complex that reduced the protein digestion (Abdu *et al.*, 2012). However, the combination of ficus foliage with differently processed breadfruit meals posted positive nutrient digestibility for experimental sheep, which reflected in nitrogen balance and retention of the sheep, suggesting that nutrient requirement for sheep to improve rumen microbial activity were adequately met and utilized efficiently which promoted higher positive nitrogen balance and retention in sheep.

Conclusion

Based on the results obtained from this study, it can be concluded that, feeding differently processed breadfruit meal could be used as good source of diets for better performance of sheep by small ruminant farmers. However, significant improvement was pronounced in nutrient digestibility and nitrogen metabolism in sheep fed 50% peeled raw breadfruit meal with 20% ficus foliage and 30% concentrate diet.

References

Abdu, S. B., Ahmed, H., Joktham, G. E., Adamu, H. Y. and Yashim S. M. (2012). Effects of levels of ficus (*Ficus sycomorus)* supplementation on voluntary feed intake, nutrient digestibility and nitrogen balance in Yankasa bucks fed urea treated maize stover basal diet. *Iranian Journal of Applied Animal Science*, 2(2): 151 – 155.

Ajayi, D. A., Adeneye, J. A. And Ajayi, F. T. (2005). Intake and nutrient utilization of West African Dwarf goats fed mango (*Mangifera indica*), ficus (*Ficus thionning*) gliricidia (*Gliricidia sepium*) foliages and concentrates as supplements to based diets of guinea grass (*Panicum maximum*). *World Journal of Agricultural Science.* 1(2): 184 – 189.

Alhassan, A. J., Sule, M. S., Atiku, M. K., Wudil, A. M., Abubakar, H. and Mohammed S. A. (2012). Effects of aqueous avocado pear (*Persea americana*) seed extract on alloxan induced diabetes rats. *Greener Journal of Medical Sciences*, 2(1): 5 – 11.

Amusa, N. A., Kehinde, L. A. and Ashaye, A. O. (2002). Bio- deterioration of breadfruit (*Artocarpus commuis*) in storage and its effect on the nutrient composition. *African Journal Biotechnology*, 1(2): 57 – 60.

AOAC (1990). *Association of Official Analytical Chemists*. Official methods of analysis. Washington DC: AOAC.

Aregheor, E. M. Abdulrazak, S. A. and Fiegihaara, T. (2003). Evaluation of some agro-industrial by – products available in Samoa for sheep and Goat. *Asian – Austerlasian Journal of Animal Science.* 16(11): 1593 – 1598.

Elseed, F. A. (2005). Effect of supplemental protein feeding frequency on ruminal characteristics and microbial N production in sheep fed treated rice straw. *Small Ruminant Research.* 57: 11 – 17

FAO (Food and Agricultural Organisation, 1990). Root tubers, plantain and bananas in human nutrition. F.A.O. Rome. Italy

Ibrahim, T. A. and Yashim, S. M. (2014). Growth response, nutrient digestibility and haematology parameters of red Sokoto bucks fed lime treated maize cob supplement with concentrate diet. *Nigerian Journal of Animal Science,* 16(2): 264 – 271.

Lyimo, M., Mugula, J. and Elias, T. (2006). Nutritive composition of broth from selected bean varieties cooked for various periods. *Journal of Science, Food and Agriculture,* 58(4): 535 – 539.

Okoruwa, M. I., Adewumi, M. K., Bamigboye, F. O. and Ikhimioya, I. (2014). Effects of feeding Guinea grass and varying levels of Avocado seeds with orange peels on nitrogen metabolism and rumen micro – organisms in rams. *Nigerian Journal of Animal Science*, 16(1): 124 – 132.

Oladunjoye, I. O. Ologhobo, A. D. and Olaniyi, C. O. (2010). Nutrient composition, energy value and residual anti-nutritional factors in differently processed breadfruit (*Artocarpus altilis*) meal. *African Journal of Biotechnology*, 9(27): 4259 – 4263.

Oladunjoye, I. O., Ologbobo, A. D., Farinu, G. O., Eniola, I. A., Amao, O. A., Adedeji, T. A. and Salako, R. A. (2004). Chemical composition and energy value of processed breadfruit (*Artocarpus altilis*). *Proceedings* of the Nigerian Society of Animal Production. Usman Dan Fodio University. Sokoto, Nigeria. Pp 144 – 145.

Ososanya, T. O. Odubola, O. T. and Shuaib-Rahim, A. (2013). Intake, Nutrient digestibility and Rumen ecology of West African Dwarf Sheep fed palm kernel oil and wheat offal supplemented diets. *International Journal of Agricultural Science*, 3(5): 380 – 386.

Ramena, R. and Reddy, G. (2011). Processed crop residues to improve ruminant performance. *Journal of Veterinary Science*, 5(3 & 4): 33 – 36.

SAS (1990). *Statistical Analysis System*. SAS user's guide. Cary, NY: SAS Institute.

Tripathi, M. K. and Karim, S. A. (2010). Effect of individual and mixed yeast culture feeding on growth performance, nutrient utilisation and microbial protein synthesis in lambs. *Animal Feed Science and Technology*, 155: 163 – 178.

Yashim, S. M., Jokthan, G. E., Lamidi, O. S., Yakubu, R. L., Hassan, M. R., Ibrahim, T. A. and Abdu, S. B. (2014). Performance, Nutrient Digestibility and Nitrogen balance of growing Yankasa Rams fed *Digitaria smutsii* Hay Supplemented with *Ficus Sycomorus* leaf meal. *Nigerian Journal of Animal Science.* 16(1): 85 – 93.