

Nutrient Digestibility, Nitrogen Metabolism and Rumen Fermentation Patterns of West African dwarf Rams fed diets containing graded levels of *Garcinia kola* (Bitter kola) Seed Meal

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Target Audience: Livestock farmers, Ruminant Nutritionists

Abstract

Garcinia kola contains secondary metabolites which can be used to modulate rumen ecology to improve its feed degradability and microbial efficiency. Therefore, this study was conducted for 84 days to assess the nutrient digestibility, nitrogen metabolism and rumen fermentation patterns of West African dwarf (WAD) sheep fed diets containing graded levels of *Garcinia kola* seed meal (GKSM). Sixteen WAD rams weighing 12.00 ± 0.05 kg were randomly allotted to four dietary treatments containing 0%, 2.5%, 5% and 7.5% of GKSM in a completely randomized design. Data obtained on digestibility, nitrogen metabolism and Rumen fluid were analyzed using one way analysis of variance. Results obtained showed that crude protein digestibility (91.63%), Nitrogen Free Extract (17.85%) and Ash digestibility (91.08%) were significantly ($p < 0.05$) highest in Ram fed diet 3. Rams on diet 2 and 3 were similar ($p > 0.05$) but significantly ($p < 0.05$) higher in crude fibre digestibility than those on diets 1 and 4. Nitrogen intake values decreased across the dietary treatments as the GKSM inclusion levels increased. Total volatile acids values obtained were significantly highest in Ram fed diet 3 when compared with other dietary treatments. It was concluded that rams fed diets containing 5% GKSM had better Nitrogen metabolism and nutrient digestibility.

Keywords: *Garcinia kola*, nutrient digestibility, nitrogen metabolism, fermentation

Description of Problem

The ability of the average Nigerian family to sustain animal protein intake is a sensitive barometer for assessing the physical and economic well-being of the nation. However, in spite of the enormous natural and human resources, Nigeria remain among the least consumers of animal protein in Africa (1). One of the evergreen plants found in the equatorial forest of the sub-saharan African is the *Garcinia kola*. It belongs to family of tropical plants known as Guttiferae. *Garcinia kola* is a non-timber forest that is mostly utilized in

African for its medicinal benefits (2). *Garcinia kola* seeds have anti-microbial, antiviral, anti-oxidant, anti-inflammatory and other biological properties, they act as digestibility enhancers, stimulating the secretion of endogenous digestive enzyme (3). The phytochemical analysis of the extract of *Garcinia kola* revealed the presence of flavonoids, tannins, cardiac glycosidase and reducing sugar (4). Previous studies have shown that some plants or their extracts with high concentrations of bioactive plant secondary metabolites such as saponins, tanins,

essential oils, organosulphur compounds, flavonoids and other other metabolites appear to have potential to inhibit methane production in rumen (5).

Plant extracts in the rumen form complexes with dietary proteins and thus protect them from microbial fermentation. Plant extracts also have appetizing properties which promote increased feed intakes, better performance and secretion of endogenous enzymes and digestive juices, leading to improved nutrient digestibility. Plant extracts have also the potential to provide ammonia control and nitrogen binding activity. The objectives of this study were to determine the nutrient digestibility, nitrogen metabolism of West African dwarf sheep fed diets containing *Garcinia kola* and its efficacy in modulating rumen ecology.

Materials and Method

The experiment was carried out at southern farm of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. It lasted for sixteen (16) weeks.

Source and Processing of the test ingredient

The fresh bitter kola seeds were purchased from a local market, at Bodija market in Ibadan, Oyo state, Nigeria. Weighed fresh, sliced into smaller pieces so as to increase the surface area for air drying for four (4) consecutive days. Milling of the dried pieces of *Garcinia kola* into fine powder followed which was incorporated into the diet at varying levels of 0, 2.5, 5, 7.5% respectively to formulate four experimental diets as indicated in Table 1.

Table 1: Gross composition of experimental diets (g/100g)

Parameters	T ₁ (0% GKM)	T ₂ (2.5%GKM)	T ₃ (5%GKM)	T ₄ (7.5%GKM)
Dried cassava peel	40.00	37.50	35.00	32.50
Palm kernel cake	10.00	10.00	10.00	10.00
Brewer dried grains	10.00	10.00	10.00	10.00
Groundnut haulms	20.00	20.00	20.00	20.00
Cowpea husk	15.00	15.00	15.00	15.00
<i>Garcinia kola</i> seed meal	0.00	2.50	5.00	7.50
Dicalcium phosphate	2.00	2.00	2.00	2.00
Urea	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00

GKM: *Garcinia kola* seed meal

Experimental animals and their management

Sixteen West African dwarf rams weighing between 12.00 ± 0.05kg were used. Animals on arrival at the farm were given necessary prophylactic treatment. The animals treated against endo and ectoparasites using Ivomectin at the rate of 1ml/50kg body weight. After the acclimatization period, the rams were allotted into four treatments of three replicates each balanced for body weight. Animals were

housed individually in a well-ventilated pen. The experimental design used was completely Randomized Design (CRD). At the onset of the experiment, initial body weight of the animals were measured and recorded weekly. The animals were fed 5% based on their body weight.

Data Collection

Digestibility and Nitrogen Metabolism Trial.

At the end of the feeding trials, the

animals were allotted to individual metabolic cages designed for separate collection of faeces and urine. Digestibility and nitrogen metabolism trials were carried out in the last 7-days feeding trial after 14 days adjustment period. The quantity of feed offered and left over for each ram was weighed daily. The weight difference between them was the feed intake. Daily faecal sub-samples were weighed, oven dried, bulked together. Representative sample (10%) aliquot was obtained from the orts and stored in air-tight container until needed for chemical analysis. Daily urine samples (20ml) for each sheep were collected in sample bottles containing sulphuric acid and frozen until needed for chemical analysis. Nitrogen metabolism by the rams was calculated as the difference between Nitrogen intake and nitrogen excreted from faeces and urine while percentage nitrogen retention was computed from nitrogen balance expressed as a percentage of nitrogen intakes.

Collection of Rumen Fluid

Rumen fluid was collected at the end of the experiment from sheep in each treatment for determination of rumen pH, ammonia nitrogen, volatile fatty acids with the suction tube inserted directly to the rumen through the oesophagus according to the procedure

described by (6). After collection, the rumen fluids were stored in ice-packed container pending laboratory analysis.

Chemical Analysis

All samples of feeds and faeces were analyzed for proximate compositions using the procedures described by (7). The fibre fractions were determined according to (8).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA). Separation of mean was done using Duncan multiple range test (9).

Results and Discussion

The proximate composition of experimental diets is shown on the Table 2. The result revealed that the diets had relatively high dry matter (DM) contents as reflected in their values that ranged from 80.34% to 85.09%. This indicated that the diets can be stored for longer period of time without spoilage. The crude protein ranges from 12.68 – 13.80 %. These values are higher than the 7% critical crude protein required for ruminal function (10) (Ahamefule, and Udo, 2010) and within 10 - 13 % recommended for growth and maintenance for ruminants (11).

Table 2: Chemical Composition (%) of experimental diet

Parameters	T ₁ (0% GKM)	T ₂ (2.5%GKM)	T ₃ (5%GKM)	T ₄ (7.5%GKM)
Dry matter	85.09	84.74	82.09	80.34
Crude protein	13.84	13.45	12.72	12.68
Crude fibre	16.07	15.64	15.32	14.71
Ether extract	9.07	9.24	9.35	9.74
Ash	7.36	7.03	6.42	5.10
Nitrogen free extract	53.66	54.64	56.19	57.77
Acid detergent fibre	31.47	36.23	38.14	38.04
Neutral detergent fibre	43.44	47.74	53.46	52.98
Acid detergent lignin	8.53	7.68	7.12	6.38
Hemicellulose	11.97	11.51	15.32	14.94
Cellulose	22.94	28.35	31.02	31.66

The Dry matter digestibility obtained as shown in the Table 3 in this study followed a particular pattern. It increased progressively from treatment 1 – 3. The high fibre digestibility recorded in T₂ and T₃ might be due to modulation effects of the GKSM on the rumen ecology which favour fibre digestion. This was better explained by (12) that rumen

microbes break fibrous feed constituents like soluble and structural carbohydrates such as hemicellulose and cellulose to provide energy for their own utilization and host animals. The values obtained in the fibre fractions were in line with (13) who reported the range of ADF between 65 to 85% for WAD sheep fed pineapple waste.

Table 3: Nutrient Digestibility of West African Dwarf Sheep Fed with Diet containing *Garcinia kola* (Bitter kola) seed meal.

Parameters	T ₁ (0% GKM)	T ₂ (2.5%GKM)	T ₃ (5%GKM)	T ₄ (7.5%GKM)	SEM(±)
Crude protein	85.41 ^b	91.63 ^a	92.92 ^a	87.05 ^b	1.07
Crude fibre	83.24 ^b	90.54 ^a	89.82 ^a	85.39 ^b	0.97
Ether extract	67.18 ^c	81.42 ^{ab}	84.49 ^a	79.05 ^b	2.02
Ash	84.57 ^b	89.67 ^a	91.08 ^a	83.18 ^b	1.05
Nitrogen free extract	54.52 ^c	74.71 ^{ab}	78.52 ^a	69.67 ^b	2.85
Acid detergent fibre	69.05 ^c	88.43 ^a	86.64 ^a	81.34 ^b	2.33
Neutral detergent fibre	76.62 ^b	85.55 ^a	83.68 ^a	77.48 ^b	1.26
Acid detergent lignin	74.45 ^b	89.35 ^a	88.41 ^a	85.22	1.94
Hemicellulose	88.66	92.25	91.12	88.53	0.79
Cellulose	66.25 ^c	89.20 ^a	89.20 ^a	82.13 ^b	2.77

^{abc} means in the same row with different superscripts are significantly different (P< 0.05) SEM: Standard Error of Mean.

Nitrogen metabolism of rams fed diets containing GKSM is presented in Table 4. Nitrogen intake for sheep on diet 1 (8.93g/day) was higher and differed significantly from other treatments. This could be probably due to the higher crude protein in the diet 1. This is in line with (3) who reported that crude protein combination in a diet has a significant effect on the nitrogen intake of sheep. Faecal Nitrogen-output was also higher in diet 1 (1.29g/day) which differ significantly among the treatments. The difference observed might be connected with the degree of crude protein utilization in the diet. (3) found that the addition of high protein feed in a diet changes the pattern of nitrogen excretions towards increasing nitrogen excretion. The Urinary N-output values ranged from 1.56g/day to 3.7g/day with T1 having the highest value and

differed significantly from other treatments. This observation having the highest value and differed significantly from other treatments. This observation could be a reflective of ammonia-Nitrogen (NH₃-N) concentration in the rumen that depend in the quantity and solubility of the diets fed to the sheep. This can be attributed to rapid breakdown of dietary protein to ammonia which increases nitrogenous excretion rather than contributing directly to the animal nutrient requirements (14). (10) also reported that nitrogen excreted in urine would depend on urea recycling and the efficiency of utilization of ammonia produced in the rumen by microbes for microbial protein synthesis. Nitrogen balance and retention which were functions of nitrogen ingested and digested showed no significant difference among the treatments. The

Nitrogen-retention highest value obtained on T₃ (52.86%) might be influenced by the presence of optimum antimicrobial effects of GKSM which delay ruminal protein degradation and dietary protein were denatured due to suppression of bacterial population responsible for the rapid protein degradation (14). The low Nitrogen-balance observed in diet 2 and 4 might be influenced by the

residual anti-nutritional factors found in test ingredients (*Garcinia kola* seed meal) which probably contributed negatively to their diets utilization by the rams. However, the study diets posted positive Nitrogen-balance for all the experimental sheep, suggesting that the protein requirements for the rams to improve rumen microbial activity were adequately met by the diets.

Table 4: Nitrogen Metabolism (g/day) of West Africa Dwarf Sheep Fed diets containing *Garcinia kola* seed meal

Parameter (g/day)	T ₁ (0% GKM)	T ₂ (2.5%GKM)	T ₃ (5%GKM)	T ₄ (7.5%GKM)	SEM (±)
Nitrogen Intake	8.93 ^a	3.79 ^b	3.93 ^b	3.82 ^b	0.89
Faecal Nitrogen output	1.29 ^a	0.32 ^b	0.28 ^b	0.50 ^b	0.13
Urinary Nitrogen output	3.71 ^a	1.59 ^b	1.56 ^b	1.58 ^b	0.35
Nitrogen Balance	3.93	1.89	2.09	1.73	0.43
Nitrogen Retention (%)	40.89	49.19	52.86	43.33	2.17

^{ab} means in the same row with different superscripts are significantly different (P< 0.05) SEM: Standard Error of Mean

Indicated in Table 5 are the Rumen fermentation parameters of West African dwarf sheep fed diets containing *Garcinia kola* seed meal. Based on this study, it was found that the rumen pH was similar among treatments. The rumen pH ranged from 5.25 to 5.38 which is similar to the findings of (15). (16) reported that pH was not significantly different when ruminants were supplemented with different hays. Optimum pH for maximum microbial growth is between 6.5 and 7.0. The mean values for ammonia nitrogen concentration in the fluid of WAD sheep was

significantly affected by supplementation of urea of 1% for all treatments and were 6.16mg/dl-9.13mg/dl. This was in contrary to the findings of (17) who found that the ammonia nitrogen concentration in the rumen fluid was not significantly different but tended to increase with the high level of 4% urea. The highest value of 1370.83mmol/ml total volatile fatty acids was obtained in treatment 3 with 5% inclusion level of *Garcinia kola* seed meal compared with treatment 2 with lowest value of 491.83mmol/ml.

Table 5: Rumen fermentation parameters of West African dwarf sheep fed diets containing *Garcinia kola* seed meal

Parameters	T ₁ (0% GKM)	T ₂ (2.5%GKM)	T ₃ (5%GKM)	T ₄ (7.5%GKM)	SEM (±)
pH	5.32	5.34	5.38	5.25	0.07
NH ₃ -N (mg/ml)	7.00 ^b	6.16 ^c	7.36 ^b	9.13 ^a	0.24
Lactic acid (mmol/ml)	764.17 ^a	225.33 ^c	354.50 ^{bc}	521.50 ^b	50.64
Butyric acid (mmol/ml)	325.00 ^b	179.83 ^b	518.33 ^a	239.67 ^b	34.92
Acetic acid (mmol/ml)	320.83 ^b	183.33 ^b	511.83 ^a	237.00 ^b	34.39
Propionic acid (mmol/ml)	223.17 ^a	128.67 ^b	340.67 ^a	158.33 ^b	22.33
Total Volatile acid (mmol/ml)	869.00 ^b	491.83 ^b	1370.83 ^a	635.00 ^b	91.64

^{ab} means in the same row with different superscripts are significantly different (P< 0.05) SEM: Standard Error of Mean

Conclusion and Application

This study showed that inclusion of *Garcinia kola* up to 5%:

1. It can be used to promote effective improved digestibility and nitrogen metabolism of West African dwarf sheep
2. It can also be used for rumen ecology manipulation to improve livestock production.

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