

Storage characteristics, digestibility and nitrogen balance in west african dwarf sheep fed preserved elephant grass, caged layer waste and cassava peel diets during dry season

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Abstract

The storage characteristics, digestibility and nitrogen balance of three experimental diets consisting of elephant grass at 15, 36 and 33 %, and caged layer waste at 23, 36 and 35 %, respectively with fixed quantity of cassava peels and sawdust ash at 38 % and 2 %, respectively were assessed using West African Dwarf sheep. Results showed that there was a significant ($P < 0.05$) reduction in the nutrient composition of the feed fractions of DM, CP, ash, NFE, P and K while the contents of EE, NDF, ADF, ADL, Ca, Mg, Na, Zn, Fe, Cu and Mn were not influenced ($P > 0.05$) by the length of storage. Apparent digestibility of DM, CP, ash and NDF was high but not significantly affected by the composition of the experimental diets. However, digestibilities of CP, ADF and ADL were significantly higher ($P < 0.05$) in rams offered diets 1 and 2 than the rams fed diet 3. Nitrogen balance in the rams fed the experimental diets was high (6.04 to 74.96 %) of intake but similar ($P > 0.05$) among the treatments. It was concluded that the experimental diets have good potentials for dry season feeding of small ruminants.

Keywords: Storage characteristics, digestibility, N-balance, WAD sheep

Introduction

One of the most important factors determining the profitability of any livestock enterprise is optimal level of feeding. This aim is most problematic to achieved during the dry season when available feed is scarce and of low nutritive quality (Adejumo and Ademosun, 1985; Davies and Onwuka, 1993; Pamo and Pieper, 2000). It is therefore a common feature to find well-fed and robust small ruminants in the rainy season to have appreciably lost weight in the following dry season (McDonald, 1972; Pagot, 1992; Adegbola, 1998). The challenge to Animal Scientists and researchers is feed production and utilization in the dry season to stem the cyclic pattern of weight gain and loss between seasons. Elephant grass (*Pennisetum purpurascens*) is a perennial grass, which when harvested young could be preserved

as a major source of fodder for small ruminants in the dry season. Most studies on the utilization of this grass have focused on its use as hay and silage (Davies and Onwuka, 1993; Manyuchi *et al.*, 1996; Mpairwe *et al.*, 1998; Sarwar and Nisa, 1999). Large quantities of caged layer wastes are produced annually in all commercial farms (Fontenot, 1999) and they constitute a nuisance to the environment by presenting disposal problem where they are not used as manure (Muller, 1980). Caged layer waste is a rich source of protein ranging between 25 – 30 % crude protein of which 40 – 50 % is true protein (Kayongo *et al.*, 1993) that can be utilized by ruminants to produce high quality meat and milk (Adegbola, 1998). The utilization of cassava peels has not attracted competition by man, livestock and feed processing industry in Nigeria. Dried cassava peels as an

adequate energy source in sheep feeding has been recognized (Adchowale, 1981; Adegbola and Asadio, 1986; Nemunyan and Maffaja, 1987; Okendo and Adegbola, 1995). In the present study the storage characteristics, nutrient digestibility and nitrogen balance in West African Dwarf sheep fed diets consisting of different combinations of dried elephant grass, caged layer waste, cassava peels and sawdust ash were assessed.

Materials and Methods

Experimental site

The experiment was conducted at the Small Ruminant Experimental Unit of the Teaching and Research Farms, University of Agriculture, Abeokuta. The location, which is 76 m above sea level, falls within latitudes 7° 5.5' - 7° 8.0' N and longitudes 3° 11.2' - 3° 12.5' E. The climate is humid and is located in the derived savanna zone of South Western Nigeria. It receives a mean annual precipitation of 1,037 mm, mean annual temperature of 34.7° C and mean relative humidity of 82 %.

Ingredient collection and processing

Elephant grass (after 6 to 8 weeks regrowth) was harvested along the Teaching and Research Farm of the University of Agriculture, Abeokuta. The succulent and less hardened parts of the grass were cut, chopped with a sharp cutlass to about 2 cm length and thereafter sun-dried for 4 days to about 10–15% moisture content. The dried grass was then packed into sacks until needed.

Fresh caged layer waste was collected from the Poultry Unit of the Teaching and Research Farm of the University of Agriculture, Abeokuta. The droppings were sun-dried on black polythene nylon for 8 days. As the drying progresses, the lumps were manually crushed to reduce the particle size. The dried droppings were thereafter packed into sacks until needed.

Fresh cassava peels were collected from different gari-processing locations around the Abeokuta Township. The peels were spread on concrete floor and sun drying was done for 3 days after which the peels were packed into sacks. Fresh wood ash from burnt sawdust was collected from a sawmill. The ash was sieved to pass through a 1 mm screen to remove extraneous materials.

Ingredient mixing and storage

Three experimental diets consisting of elephant grass at 45, 40 and 35 %, and caged layer waste at 25, 30 and 35 %, respectively with fixed quantity of cassava peels and sawdust ash at 28 % and 2 %, respectively were formulated to contain about 17.00 % crude protein (Table 1). Sawdust ash was used as a mineral source (Sowande *et al.*, 2002). The grass was poured first followed by poultry droppings, cassava peels and wood ash, respectively. The ingredients were manually mixed together on a concrete slab. Three batches of each diet weighing 25 kg were produced and stored at room temperature for three months (September to December) in a well-ventilated room.

Digestibility and nitrogen balance trial

Nine rams, weighing 14.5 ± 0.7 kg and 18 months of age, were used for the digestibility and nitrogen (N) balance trials. Three rams were allotted to each of the preserved diet at 30 days of storage. These were randomly selected and transferred to individual metabolism cage allowing for separate collection of faeces and urine to determine nutrient digestibility and N balance in the rams. The rams were maintained at 4 % of their body weight on the experimental diets for 21 days with free access to water.

Data collection

Sampling from each batch of feed was done immediately after feed mixing. Subsequently sam-

pling was done on monthly basis. During each sampling, collection was made from the top, middle and bottom of the bags after manual stirring.

The rams were allowed 14 days adjustment period before 7-day total collection of faeces and urine. Faecal collection from each ram was oven dried at 65°C for 24 hr., weighed, hulked and aliquots (25%) was taken from individual animal for chemical analysis. Urine samples were collected in urine sample bottles previously rinsed with dilute sulphuric acid (10% H₂SO₄) to preserve nitrogen. Total volume was determined and 25% stored in the deep freezer at -20°C until required for chemical analysis.

Chemical analysis

The gross energy of the feeds was determined using Gullenkamp adiabatic bomb calorimeter (CBA-305). The proximate composition of feed and faecal samples as well as nitrogen in urine was determined (A. O. A. C., 1990). The same method was used in determining the mineral concentration in feed and faeces samples. Determination of neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) was by the method of Goering and Van Soest (1970).

Statistical analysis

All the data generated were subjected to one-way analysis of variance in a completely randomized design using the statistical package (SPSS, 1999) while significantly different means were separated using Duncan (1955) Multiple Range Test within the same package. Predictive equation relating the chemical composition of the feed to length of storage was derived by fitting the monthly values of the various chemical components of the feed to linear, quadratic, cubic, exponential and power functions. Test of goodness of fit was based on coefficient of determination

(R²) values. The cubic function was selected as having the best fit.

Results

The chemical composition of the experimental diets fed to West African Dwarf sheep is presented in Table 1. Dry matter contents of the diets varied between 90.27 (%) and 90.62%. Crude protein content increased as the percentage of poultry (layer) droppings increased from 17.44% in diet 1 to 18.73% in diet 3. The CF in the diet decreased in line with the reduction in the amount of elephant grass in the diets from 50.00% in diet 1 to 34.67% in diet 3. The EE and ash contents of the diets decreased respectively from 1.41% and 9.69% in diet 1 to 1.31% and 8.93% in diets. Nitrogen free extract increased from 21.46% in diet 1 to 36.36% in diet 3. The NDF, ADF and ADL contents of the diets followed similar trend as in CF. Calcium content of the diets ranged between 1.53% and 1.70% while the concentrations of P and Mg reduced respectively from 0.38% and 1.23% in diet 1 to 0.28% and 0.66% in diet 3. Potassium content of the diets ranged from 2.75% to 3.60% while the Na content ranged between 0.85% and 1.30%.

Table 1: Chemical composition of *Exoco* experimental diets (3% DM)

| Variables | Diets | | |
|-------------------------|-------|-------|-------|
| | 1 | 2 | 3 |
| Dry matter | 90.62 | 90.53 | 90.27 |
| Crude protein | 17.44 | 17.92 | 18.73 |
| Crude fibre | 50.00 | 47.33 | 34.67 |
| Diet extract | 1.41 | 1.34 | 1.31 |
| Ash | 9.69 | 9.36 | 8.93 |
| Nitrogen free extract | 21.46 | 34.15 | 36.36 |
| Neutral detergent fibre | 38.13 | 37.27 | 30.13 |
| Acid detergent fibre | 33.24 | 32.16 | 25.09 |
| Acid detergent lignin | 26.18 | 34.09 | 18.26 |
| Calcium | 1.70 | 1.53 | 1.60 |
| Phosphorus | 0.38 | 0.36 | 0.28 |
| Magnesium | 1.23 | 0.79 | 0.66 |
| Potassium | 3.60 | 2.75 | 3.15 |
| Sodium | 1.30 | 0.83 | 0.95 |
| Gross energy (100kg DM) | 18.54 | 18.50 | 18.33 |

Effect of length of storage on the chemical composition of the experimental diets is presented in Table 2. Storage length significantly influenced ($P < 0.05$) the chemical composition of the feed in terms of DM, CP, ash and NFE. The DM in diets 1 and 3 was lower ($P < 0.05$) at 90 days than at 0 day while the reverse was the trend in diet 2 at 0 and 90 days of storage. The CP contents of each of the diet reduced ($P < 0.05$) with increasing length of storage. Diet 3 had significantly higher ($P < 0.05$) CP contents at 0, 30, 60 and 90 days of storage than both diets 1 and 2. There was a general reduction ($P < 0.05$) in the ash contents of the three diets from 10.33%, 10.00% and 11.33% at 0 day to 6.95%, 5.94% and 5.94% respectively for diets 1, 2 and 3. The NFE contents of diets 1, 2 and 3 increased ($P < 0.05$) from 20.56%, 33.24% and 33.80% to 47.76%, 49.57% and 50.95% respectively. The content of EE, NDF, ADF and ADL of the diets were not significantly influenced ($P > 0.05$) by the length of storage. The concentrations of Ca, Mg, Na, Zn, Fe, Cu and Mn were not significantly influenced ($P > 0.05$) by the length of storage although there was a general decline in the amount of these minerals as storage advanced. Potassium concentration in diet 3 at 60 days of storage was significantly higher ($P < 0.05$) compared to the K content of other diets. There was a decline ($P < 0.05$) in the concentration of K in diets 1 and 2 respectively from 0.25% and 0.40% at 0 day to 0.18% and 0.26% at 90 days of storage. Potassium contents in diet 3 did not follow a consistent pattern. Diet 1 had the lowest concentration of K at 0, 30, 60 and 90 days of storage compared to other diets.

Parameter estimates for predicting the chemical composition of the feed during prolonged length of storage are presented in Table 3. Coefficient of determination (R^2) values for DM, CP, EE, ash, NFE, NDF, ADF, ADL, Ca, P, Mg, K, Na, Zn, Fe, Cu and Mn are shown.

Apparent nutrient digestibilities of the experimental diets in West African Dwarf sheep are presented in Table 4. The dry matter digestibility in the rams was not significantly affected ($P > 0.05$) by dietary treatments. The highest DM digestibility of 71.36% was found in rams offered diet 2 while the lowest (66.63%) was found in rams fed diet 3. Crude protein digestibility in the rams was not significantly affected ($P > 0.05$) by dietary treatments. However, the highest CP digestibility was observed in diet 2 and the least in diet 3. There was significant treatment effect ($P < 0.05$) on the apparent digestibility of crude fibre. The rams fed diet 3 had the lowest ($P < 0.05$) CF digestibility. The rams offered diets 1 and 2, as well as those fed diets 2 and 3 had similar ($P > 0.05$) CF digestibility while the rams fed diet 1 had a significantly higher ($P < 0.05$) CF digestibility than those offered diet 2. Ash and NDF digestibilities were not significantly affected ($P > 0.05$) by dietary treatments. However, there was a decrease in ash digestibility from 68.68% in diet 1 to 60.56% in diet 3. Neutral detergent fibre digestibility also decreased from 60.39% in diet 1 to 50.01% in diet 3. There was a significant dietary treatment effect ($P < 0.05$) on the ADF digestibility in West African dwarf rams fed the experimental diets. Acid detergent fibre digestibility of rams fed diet 3 was significantly lower ($P < 0.05$) compared to the rams fed other diet. The rams fed diets 1 and 2 had comparable ($P > 0.05$) ADF digestibility. Diets offered significantly affected the ADL digestibility in West African dwarf rams. Digestibility of ADL was similar ($P > 0.05$) in rams fed diets 1 and 2 while the digestibility of ADL in rams offered diet 3 was significantly lower ($P < 0.05$) compared in those fed diets 1 and 2.

Nitrogen balance in West African Dwarf sheep fed the experimental diets is presented in Table 5. Nitrogen (N) intake was not different ($P > 0.05$) in the rams fed the experimental diets. The highest

Table 2: Effect of level of stocking on the chemical composition of the experimental diets

| Diet | DM (%) | CP (%) | HF (%) | ASH (%) | NFE (%) | NDF (%) | ADF (%) | Starch (%) | Ca (%) | P (%) | Mg (%) | K (%) | Na (%) | Zn (ppm) | Fe (ppm) | Cl (ppm) | S (ppm) |
|--------|--------|--------------------|--------------------|---------|--------------------|--------------------|---------|------------|--------|-------|-------------------|-------|-------------------|----------|--------------------|----------|---------|
| Diet 1 | 0 | 90.67 ^a | 17.42 ^a | 1.57 | 10.33 ^a | 20.94 ^a | 56.65 | 41.00 | 21.57 | 0.65 | 0.38 ^a | 0.30 | 0.25 | 216.00 | 182.5 ^a | 15.00 | 223.33 |
| | 30 | 91.65 ^a | 17.25 ^a | 1.58 | 9.31 ^b | 33.10 ^b | 60.13 | 35.67 | 18.53 | 0.59 | 0.36 ^a | 0.44 | 0.22 ^b | 214.33 | 148.82 | 11.67 | 218.15 |
| | 60 | 90.11 ^a | 16.30 ^a | 1.37 | 9.47 ^b | 36.15 ^b | 59.41 | 34.14 | 16.54 | 0.56 | 0.32 ^a | 0.41 | 0.21 ^b | 204.67 | 146.67 | 8.82 | 214.67 |
| | 90 | 89.57 ^a | 16.22 ^a | 1.00 | 6.69 ^c | 47.78 ^c | 58.74 | 33.18 | 15.01 | 0.54 | 0.29 ^a | 0.35 | 0.18 ^c | 322.33 | 172.67 | 6.50 | 211.33 |
| | SE | | | | | | | | | | | | | | | | |
| Diet 2 | 0 | 81.33 ^a | 17.02 ^a | 1.90 | 10.00 ^a | 30.24 ^a | 59.53 | 39.13 | 23.00 | 0.75 | 0.34 ^a | 0.66 | 0.42 ^a | 215.00 | 145.00 | 26.67 | 247.67 |
| | 30 | 91.74 ^a | 17.65 ^a | 1.40 | 9.35 ^b | 36.62 ^b | 54.67 | 39.15 | 20.67 | 0.88 | 0.31 ^b | 0.65 | 0.34 ^b | 211.00 | 138.67 | 18.67 | 238.67 |
| | 60 | 90.33 ^a | 17.54 ^a | 1.10 | 9.22 ^b | 38.37 ^b | 63.99 | 17.89 | 17.65 | 0.84 | 0.33 ^b | 0.59 | 0.31 ^b | 306.67 | 136.67 | 13.33 | 236.00 |
| | 90 | 89.93 ^a | 16.07 ^a | 1.03 | 5.34 ^c | 49.57 ^c | 51.38 | 22.00 | 16.02 | 0.46 | 0.29 ^b | 0.53 | 0.28 ^b | 202.67 | 173.67 | 12.83 | 227.67 |
| | SE | | | | | | | | | | | | | | | | |
| Diet 3 | 0 | 91.13 ^a | 18.74 ^a | 1.47 | 11.33 ^a | 15.87 ^a | 71.67 | 40.67 | 26.00 | 1.02 | 0.39 ^a | 0.42 | 0.32 | 221.90 | 133.00 | 23.33 | 226.67 |
| | 30 | 91.98 ^a | 18.58 ^a | 1.33 | 8.03 ^b | 38.42 ^b | 78.33 | 41.67 | 20.33 | 0.99 | 0.28 ^b | 0.39 | 0.32 ^a | 227.00 | 122.40 | 20.33 | 216.65 |
| | 60 | 90.64 ^a | 18.46 ^a | 1.17 | 7.79 ^b | 42.64 ^b | 68.85 | 44.00 | 19.00 | 0.96 | 0.25 ^b | 0.38 | 0.36 ^a | 225.00 | 83.30 | 18.67 | 165.00 |
| | 90 | 89.13 ^a | 17.12 ^a | 1.05 | 5.94 ^c | 49.94 ^c | 57.80 | 34.91 | 16.01 | 0.94 | 0.34 ^b | 0.31 | 0.28 ^b | 220.00 | 109.67 | 14.33 | 191.33 |
| | SE | | | | | | | | | | | | | | | | |

Storage characteristics digestibility and N-balance in WAD sheep

Table 3: Cubic regression equation ($a + bx + cx^2 + dx^3$) relating chemical composition of the diets to length of storage

| Variables | Diets | | | R ² | |
|-------------------------|---------|--------|---------|----------------|------|
| | | b | c | d | |
| Dry matter | 87.778 | 8.596 | -5.556 | 0.965 | 0.24 |
| Crude protein | 18.029 | -0.488 | 0.416 | -0.135 | 0.49 |
| Ether extract | 1.547 | 0.144 | -0.328 | 0.074 | 0.75 |
| Ash | 10.556 | -3.830 | 2.844 | -0.681 | 0.81 |
| Nitrogen free extract | 79.202 | 13.563 | -8.398 | 2.041 | 0.78 |
| Neutral detergent fibre | 63.222 | 7.379 | -1.139 | 0.716 | 0.21 |
| Acid detergent fibre | 40.131 | -2.533 | 2.660 | -0.900 | 0.38 |
| Acid detergent lignin | 22.889 | -3.909 | 0.929 | -0.131 | 0.82 |
| Calcium | -0.806 | 0.144 | 0.071 | -0.014 | 0.07 |
| Phosphorus | 0.334 | -0.063 | 0.043 | -0.011 | 0.52 |
| Magnesium | 0.537 | -0.074 | 0.029 | -0.006 | 0.19 |
| Potassium | 0.347 | -0.422 | 0.487 | -0.119 | 0.22 |
| Sodium | 0.258 | -0.077 | 0.042 | -0.009 | 0.52 |
| Zinc | 219.167 | 1.306 | -4.222 | 0.861 | 0.21 |
| Iron | 153.500 | -7.610 | -14.278 | 5.056 | 0.11 |
| Copper | 21.667 | -6.731 | 2.389 | -0.435 | 0.39 |
| Manganese | 232.556 | 10.685 | -24.417 | 6.120 | 0.18 |

Table 4: Apparent nutrient digestibility of the experimental diets fed to West African Dwarf sheep (%)

| Nutrients | Diets | | | +SEM |
|-------------------------|--------------------|---------------------|--------------------|-------|
| | 1 | 2 | 3 | |
| Dry matter | 67.97 | 71.63 | 66.63 | 0.235 |
| Crude protein | 73.23 | 76.72 | 73.45 | 0.899 |
| Crude fibre | 69.22 ^a | 61.94 ^{ab} | 51.48 ^b | 0.809 |
| Ash | 68.68 | 67.07 | 60.56 | 0.390 |
| Neutral detergent fibre | 60.39 | 59.72 | 50.01 | 0.527 |
| Acid detergent fibre | 64.01 ^a | 66.38 ^a | 57.08 ^b | 0.438 |
| Acid detergent lignin | 81.42 ^a | 74.67 ^a | 69.64 ^b | 0.536 |

^{a, b} means along the same row with similar superscripts are not significant ($P > 0.05$)

SEM = Standard error of means

N intake was from diet 1 while the least was from diet 3. There was no significant effect ($P > 0.05$) attributable to dietary treatment on faecal and urinary excretion of N. Faecal and urinary excretion of N followed similar trend as observed in intake. Nitrogen absorption and retention were

not significantly affected ($P > 0.05$) by dietary treatment. Nitrogen absorption was highest in rams offered diet 2 and lowest in those fed diet 3. However, when expressed as percentage of intake the rams fed diet 2 still had the highest N absorption and the least was in diet 1. The highest N reten-

Table 5: Nitrogen balance of West African Dwarf sheep fed the experimental diets

| Items | Diets | | | +SEM |
|--------------------|-------|-------|-------|-------|
| | 1 | 2 | 3 | |
| Intake (g/day) | 76.39 | 72.38 | 67.62 | 0.399 |
| Excretion (g/day) | | | | |
| Faecal | 22.19 | 16.86 | 16.08 | 0.392 |
| Urinary | 1.46 | 1.36 | 1.17 | 0.013 |
| Absorption (g/day) | 54.20 | 55.72 | 51.54 | 0.192 |
| % of intake | 70.95 | 76.67 | 76.22 | 0.292 |
| Retention (g/day) | 52.74 | 54.36 | 50.37 | 0.182 |
| % of intake | 69.04 | 74.90 | 74.49 | 0.297 |

SEM = Standard error of means

tion of 54.36 g/d was recorded in rams fed diet 2 and the lowest retention of 50.37 g/d in those fed diet 3. When expressed as percentage of intake the rams fed diet 2 still had the highest N retention of 74.90% and the least retention of 69.04% was in diet 1.

Discussion

The CP and CF contents of the experimental diets are reflections of the relative proportions of layers' droppings and elephant grass. The CP increased as the proportion of layers' droppings increased in the diets while the crude fibre reduced as the quantity of elephant grass decreased in the diets. The CP and CF in the present study are higher than those reported by Oladotun et al. (2003). These arise from the differences in the proportion of layers' droppings used as well as different type and quantity of grasses used in the two studies. The fibre fractions of the diets were very high and decreased as the proportion of elephant grass in the diet decreased. Mpairwe et al. (1998) reported high NDF and ADF contents for elephant grass suggesting that the grass contributed the bulk of the fibre fractions. This implies that diet 3 might contain more digestible components than the other two diets. The contents of Ca, P, Mg, K and Na in the experimental diets are higher than the critical values recom-

mended for sheep (McDowell, 1985) and the desirable concentrations of mineral in feed dry matter for maintenance recommended for sheep (SCA, 1990). This implies that the mineral contents would be adequate to promote growth in the animals. The gross energy in the experimental diets agrees with Chesworth (1992) who reported that the gross energy of most animal diets is usually about 18.5 MJ/kg DM.

For all the parameters examined except NFE, which increased, there was a general decline in nutrients as the length of storage increased from 0 to 90 days. The changes observed might be due to fluctuation in humidity and temperature of the storage environment because storage of the feeds was done at room temperature. Also, the residual moisture (about 12%) in the feed might have presented convenient medium for microbial degradation of nutrients in the stored feed. Increase in DM up to 30 days of storage indicated loss of moisture. However, the decrease in DM content of the feed after 30 days of storage indicates a decline in nutrient contents of the feed during storage (Johnson et al., 1984). Laflamme (1989) reported a decrease in dry matter content of stored grasses with subsequent increase in non-digestible fractions. In the present study, the loss of DM might be due to loss of some of the

digestible fractions of the feed. This assertion is supported by the significant decline in CP, CF, EE and ash contents of the stored feed. Oladotun *et al.* (2003) reported a similar reduction in CP, CF and EE during storage of feed consisting of *Panicum maximum*, poultry droppings, cassava peels and woodlark while the contents of DM, ash, Ca and P appreciated with increase in length of storage. The decline in CP, NDF, ADF and ADL as the length of storage increased might be because the consistency of the structural components of the feed is being lost over time (Oladotun *et al.*, 2003). This loss in consistency could have been facilitated by conversion of uric acid in the layers' droppings to ammonia by aerobic bacteria (Nahm, 2003) taking advantage of the fluctuations in humidity and temperature of the storage environment. At the end of storage, the DM content of about 90 % is close to the value reported by Owen (1991). The CP obtained in this study, is higher than the level (11–12 %) required for moderate level of production by sheep (ARC, 1980; Gatenby, 2002). The level of fibre fraction in the test diets suggests that it would be sufficient to meet the fibre requirements of the ruminants. Also, the mineral concentration indicates that the feeds would be adequate to meet the mineral requirements of sheep (McDowell, 1985). The length of storage used in this study agrees with the recommendation of Oyediji (1996) that feed stored for more than 90 days is old and should be released for feeding to ruminant animals.

Parabolic or cubic regression equation gave the best coefficient of determination (R^2) when the data on storage were fitted to predict the chemical composition of the feeds beyond 90 days of storage. Olori *et al.* (1998) classified the goodness of fit of a model as 'good' if $R^2 > 70$ %, 'fair' if $R^2 < 70$ % but > 40 % and 'poor' if $R^2 < 40$ %. The level of R^2 observed for CP, ash, NFE and ADL suggests that the parameters could be used to

predict the future contents of these components of the feed. The parameters could also be used to fairly predict the yield of CP and P of the feed when the feed is intended to be stored for more than 90 days.

Productivity of ruminants is influenced primarily by feed intake, which, in turn, is determined by feed digestibility and the capacity of the diet to supply the correct balance of nutrients required by the animals. Feed intake in this study is within the intake level recommended for sheep (Gatenby, 2002). Food and Agricultural Organization (1995) classified digestibility of feed as high (>60 %), median (40–60 %) and low (<40 %). In this study, the apparent digestibility of DM, CP, CF, ash, NDF, ADF and ADL were high except the medium value obtained for CF in rams fed diet 3 and NDF in rams fed diets 2 and 3. Dry matter digestibility is within the 49–70 % reported for sheep and goats fed combinations of elephant grass, poultry droppings, crop residues and agro-industrial by-products (Taiwo *et al.*, 1995; Adesuwale and Taiwo, 1996). Digestibilities of CP and ADF are higher than 47.2 % and 57.0 %, respectively reported by Taiwo *et al.* (1995) however; digestibility of NDF is lower than the 61.1 % reported by the same authors. The significantly different CP digestibility in the rams fed the experimental diets could be attributed to the CP contents of the diets. The CP increased from 17.44 % in diet 1 to 18.73 % in diet 3. It has been reported that maximum dietary crude fibre digestion in the rumen occurs when dietary CP is between 12 and 16 % diet (Pritchard and Males, 1985; Stritzler, 1988; McAllan, 1991) increasing the level of CP in the diet beyond 16 % had no further effect on fibre digestion (McAllan *et al.*, 1982). The proportion of elephant grass and layers' dropping significantly affected the digestibility of ADF. Overall, the grass: concentrate ratio decreased from diet 1 to diets 3. Joanning *et al.* (1981) and Bourquin *et al.* (1990)

reported that both NDF and ADF digestibilities decrease as the dietary concentrate level increases and this has been reported to be due to depression of ruminal pH in the wether sheep (Merchen *et al.*, 1986). Similarly, Kraem *et al.* (1997) reported that digestibility of fibre fractions decreased with high level (40–60%) of concentrate supplementations.

GIE (2003) reported that nitrogen (N) excreted in faeces largely originates from endogenous sources and undigested microbial CP intake, faecal and urinary excretions of N were not significantly affected by the quantity of poultry droppings in the diets. This agrees with Kadehatsion and Pfeiffer (1996) but is contrary to Bran-Bellus *et al.* (1999) who reported proportional increase in urinary N excretion with increase dietary crude protein. The high N balance in the three diets could be attributed to the high digestibility of CP in the diets and low N loss via the urine. The N balance of 5.5–9.2 g/d reported by Rude *et al.* (1994) is lower than the values obtained in this study.

Conclusion

The chemical composition of the experimental diets was affected by storage under ambient condition with a reduction in the nutrient contents up to 90 days of storage. However, the diets were still adequate to meet the nutrient requirements of sheep. Apparent nutrient digestibility and nitrogen balance of the feed were high when offered to sheep and is indicative of the nutritive potential of the diets for dry season feeding.

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