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Research Article
Nitrogen Utilization and Blood Analysis of West African Dwarf Rams Fed Yam Peel Based Diets

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Abstract

Background and Objectives: The need for utilization of alternative feed sources that are far removed from human and industrial interests are now being stressed as a panacea to improve productivity in livestock. The replacement value of yam peel for maize in terms of nitrogen utilization, haematology and serum chemistry in sheep was evaluated in this study. **Materials and Method:** Yam peel meal (YPM) was incorporated to replace maize at 0% (T_1), 33.3% (T_2), 66.6% (T_3) and 100% (T_4) in a supplemental diet fed to West African Dwarf (WAD) Rams. The treatment groups were designated as T_1, T_2, T_3 and T_4, respectively. A total of 32 yearling WAD rams were weighed and randomly assigned to four dietary treatments with four replicates of two animals per replicate in a Completely Randomised Design (CRD). The basal diet of *Panicum maximum* was fed at 2.5% while the supplemental diets were offered at 1% of the bodyweight of the animals. **Results:** Results revealed higher crude protein, crude fiber and nitrogen-free extract for YPM compared with maize. Significant differences ($p>0.05$) exist in the mean values obtained from digested nitrogen (DN), urinary nitrogen (UN), nitrogen balance (NB) and nitrogen retention (NR). T_3 had consistently highest values in DN, NB and NR. Significant differences exist ($p>0.05$) only among the White blood cell with values which ranged from 11.60 ± 0.3 g dL^{-1} in T_2 to 13.60 ± 0.8 g dL^{-1} in T_4. **Conclusion:** Yam peel replacement for maize up to 100% did not pose any health hazard to WAD rams. Combination of maize and YPM at 33.3 and 66.6%, respectively improved nitrogen utilization better than all other treatment groups.

Key words: Blood profile, maize, nutrient utilization, replacement, yam peel meal, crude protein, crude fiber

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

It is estimated that the world population could reach 9.1 billion humans in 2050, thereby increasing the demand for food by 60%[1]. Sheep meat is an excellent food source which provides protein and important minerals such as iron and zinc. These nutrients are very valuable due to their high bioavailability in meat compared to plant sources[2]. Sheep production is important for the economic and social livelihood of the large human population in the tropics, contributing meat, milk, and clothing in domestic markets[3].

Despite its importance and production potential, sheep-like other ruminants in Nigeria usually reach market size late. This is because they are usually fed with tropical grasses of low nutritional value especially during the dry season. They are raised on the extensive system and are rarely given supplements but scavenge on kitchen wastes and other by-products when available[4]. A major approach to improving productivity has been to develop feeding system as part of production systems and use the diet offered to sheep, specifically lambs, as a means to improve nutrient retention while ensuring improved health status of the animals[5].

The need for utilization of alternative feed ingredients that are far removed from human and industrial interests in order to reduce the cost of feed are now being stressed as a panacea to improve productivity[6]. However, some of the alternative feed ingredients and agro-industrial by-products are known to have some anti-nutritional factors that limit their usage and could be detrimental to the health of the animals[7]. There is a need for further research on this claim.

Maize (*Zea mays*) is an important food and feed utilised as silage, crop residue and grain used as a source of carbohydrate, protein, iron, vitamin and minerals for man and animals[8]. Maize has now risen to a relatively expensive commercial crop on which many agro-based industries depend on as raw material[9]. Yam peels, on the other hand, are basic wastes or by-products when yam is peeled during processing for cooking and other purposes. It is one of the various household wastes that have potentials as an alternative feed source and is cheaply available in Nigeria[10]. Yam peels are fed directly to sheep and goats soon after peeling, or sun-dried 4-7 days, depending on ambient temperature, to dehydrate it thereby preventing microbial fermentation of the product or fungal infestation.

The peels constitute about 10% of the yam and they are known to have some anti-nutritional factors that limit their usage[7]. The crude fiber ranges between 9 to 15% with an appreciable quantity of fermentable carbohydrate[11]. However, a proximate analysis conducted by other authors revealed varied nutritional composition in terms of crude protein from[10,12-13] 3.4-12.86%. Even though in most households, yam peels are served to sheep and goat fresh, it can be sundried and mixed with other ingredients to enhance its utilization.

Nutrient utilization is affected by the age of the animal, level of feedstuff consumed, nature and quality of nutrients in the feed among other factors[14]. Blood is an important index of physiological and pathological changes in an organism that is used in assessing the body ability to respond to haematological and serum bio-chemical upset. Ogunbosoye *et al.*[15] observed that nutritional studies should not be limited to performance alone but the effect on the blood constituents is also a vital tool that helps to detect any deviation from normal in the animals' body. Despite the usefulness of yam peels as non-conventional feeding stuff, there is a paucity of information on the replacement value of maize for yam peels in growing rams especially in South Western Nigeria where it is in abundance. This study was conducted to evaluate the response of West African Dwarf rams in terms of nitrogen utilization and haemato-biochemistry to supplemental diets in which graded levels of yam peels replace maize.

MATERIAL AND METHODS

Experimental location: The experiment was conducted at the small ruminant unit of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria from 20th April 2019 to 13th July 2019. Ado-Ekiti experiences a sub-humid tropical climate and lies between Latitude 07°37°15° and Longitude 05°15°7°. It has an average humidity of 72%, a temperature range of 20-28°C and a bimodal rainfall distribution between April and October with peak in June and September and a break in August. The dry season is between November and March. The average precipitation in the area is 1367mm

Experimental design and animals management: A total of 32 growing WAD rams were purchased from the ruminant market in Otun-Ekiti, Moba Local Government Area, Ekiti State. The pen house was cleaned, disinfected and partitioned into pens with the floor covered with wood shavings for easy faeces and urine absorption. The animals were quarantined for acclimatization to the new environment for 28 days during which mandatory and prophylactic treatments were administered on them.

The animals were weighed and randomly assigned to four dietary treatments with four replicates of two animals per replicate in a Completely Randomised Design (CRD). Experimental Diets- Basal diet of *Panicum maximum* grass was

obtained daily from established paddock within the Teaching and Research Farm and were allowed to wilt overnight before feeding to the animals.

Yam peels were obtained from kitchens, restaurants and farmsteads. The peels were dried for 4-7 days, milled using a hammer mill and taken for proximate analysis. Locally available feed ingredients: maize, palm kernel cake, groundnut cake, bone meal, vitamin-mineral premix and salt were purchased from agro-allied shop in Ado Ekiti and were milled together incorporating the yam peels in graded levels as shown in Table 1. The animals were offered the basal diet and the concentrate feed at 2.5 and 1% of their body weight respectively.

Digestibility trial: A digestion trial of 12 animals was done. The trial lasted for 21 days; 14 days for adaptation and 7 days for faeces and urine collections. Feed and freshwater were offered twice daily at 8:00 am and 4:00 pm in two equal portions. Feed, faecal samples and urine voided were weighed daily and stored in the refrigerator. At the end of the collection period, the seven daily faecal samples of each ram were ground, mixed and kept in nylon bags for analysis. Also, 5% of the individual acidified daily urine samples were pooled and sub-samples subjected to N- determination for apparent nutrient digestibility.

Blood samples collection: At the end of the digestibility trial, an average of 8 mL blood samples was collected from the right jugular vein of the individual experimental West African Dwarf (WAD) sheep punctured using sterilized needle and syringe and emptied into collecting tube. Five millimeters of blood collected from each of these animals were stored in plastic sample bottles containing Ethylene-diamine-tetra acetic acid (EDTA anticoagulant) bottles for haematological studies. These blood samples were taken to the laboratory where the following haematological parameters were determined: Red Blood Cell Count (RBC), White Blood Cell count (WBC), Packed Cell Volume (PCV), Haemoglobin Concentration (Hbc), Monocytes (M), Eosinophils (E), Neutrophil (N) and Lymphocytes (L). The remaining 3mls were deposited into the anticoagulant free plastic tube and allowed to clot at room temperature within 3 h of collection. The serum samples were later stored at a temperature of -20°C for biochemical studies. The haematological studies were carried out using the colorimetric method while biochemical analyses were done using the method described by Ogunsanmi *et al.*[16].

Table 1: Ingredients composition of the concentrate (g 100 g^{-1})

	Treatment (% yam peel meal)			
Ingredient	T_1	T_2	T_3	T_4
Yam peel	0	20	40	60
Maize	60	40	20	0
PKC	22	22	22	22
GNC	8	8	8	8
Bone meal	1	1	1	1
Wheat offal	7.5	7.5	7.5	7.5
Vitamin/min premix	1	1	1	1
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

PKC: Palm kernel cake, GNC: Groundnut cake

Statistical analysis: The data collected were subjected to analysis of variance (ANOVA) using SAS (2002)[17] and the means were separated using Duncan Multiple Range Test of the same package.

RESULTS

Proximate composition of the test ingredients: Result of proximate analysis of maize and yam peels meal (YPM) used in this study is shown in Table 2. The dry matter of YPM was analyzed to be 82.30 g 100 g^{-1} while that of maize was 78.51 g 100 g^{-1}. Higher crude protein, crude fiber and nitrogen-free extract were recorded for YPM (10.20, 15.50 and 68.20 g 100 g^{-1}) compared with maize (8.92, 13.30 and 61.56 g 100 g^{-1}), while the values for ash, ether extract, and energy were increased in maize (9.92 g 100 g^{-1}, 4.10 g 100 g^{-1} and 3251 kcal kg^{-1}, respectively) than those of yam peels (7.20 g 100 g^{-1}, 3.20 g 100 g^{-1}, 3020 kcal kg^{-1} ME, respectively).

Proximate composition of graded levels of yam peel meal fed as supplements to WAD rams: Table 3 shows the results of the proximate composition of graded levels of YPM concentrates fed as supplements to rams in this study. The dry matter (DM) of the concentrate ranged from 78.2 g 100 g^{-1} DM in 0% of YPM (T_1) to 82.6 g 100 g^{-1} DM in 100% of YPM (T_4). The crude protein (CP) values varied from 13.3 g 100 g^{-1} in (T_1) and 14.4 g 100 g^{-1} in (T_4). The ether extract ranged from 4.0 g 100 g^{-1} in T_3 to 4.6 g 100 g^{-1} in T_1. The values of the nitrogen-free extract (NFE) ranged from 52.1-58.1 g 100 g^{-1} from T_1 to T_4. The Ash varied from 8.6 g 100 g^{-1} in T_1 to 10.8.1 g 100 g^{-1} in T_3. The crude fiber was highest in T_4 (25.9 g, 100 g^{-1}) and lowest in T_1 (15.3 g, 100 g^{-1}). The Gross energy content ranged from 2996.2 kcal ME^{-1} in T_2 to 3035.7 kcal ME^{-1} in T_4.

Mean nitrogen utilization of WAD rams fed graded levels of yam peels meal supplements: Table 4 depicts the mean nitrogen utilization of West African Dwarf rams fed graded

levels of YPM supplements. There were no significant differences ($p<0.05$) in nitrogen intake and faecal nitrogen among all the treatment groups. The nitrogen intake were 2.13±0.2, 2.26±0.3, 2.24±0.2 and 2.23±0.3 g 100 g^{-1} in T_1 to T_4, while the faecal nitrogen ranged from 0.72±0.2, 0.82±0.1, 0.86±0.1 and 0.88±0.1 g 100 g^{-1} in T_3, T_1,T_2 and T_4 respectively. Significant differences ($p>0.05$) exist in the mean values obtained from Digested Nitrogen (DN), Urinary Nitrogen (UN), Nitrogen Balance (NB) and Nitrogen Retention (NR). T_3 had consistently highest values in DN (1.52±0.2 g 100 g^{-1}), NB (1.39±0.1 g 100 g^{-1}) and NR (62.05±1.3%). There were no significant differences ($p<0.05$) in the mean values of UN of T_1 (0.16±0.2 g 100 g^{-1}) and T_3 (0.13±0.2 g 100 g^{-1}) but these values were significantly lower ($P>0.05$) than those of T_2 (0.22±0.1 g 100 g^{-1}) and T_4 (0.20±0. g 100 g^{-1}). Nitrogen balance and NR was lowest in T_4 (1.15±0.3 g 100 g^{-1} and 51.56±1.3%, respectively).

Haematology indices of West African dwarf rams fed diets containing graded levels of yam peel meal: The haematological variables of West African Dwarf rams fed diets containing graded levels YPM supplements are presented in Table 5. There were no significant differences ($p<0.05$) among the means of most of the haematological parameters analysed. Packed cell volume ranged from 28.00±1.2 % in (T_4) to 30.20±1.2% in (T_2). Haemoglobin value was lowest at 8.06±1.8 gL^{-1} in T_4 and highest at 9.25±1.9 g L^{-1} in T_1.

Table 2: Proximate composition of test ingredients (g 100 g^{-1})

Nutrient	Yam peel	Maize
DM	82.3	78.51
Crude protein	10.2	8.92
Ash	7.2	9.92
Ether extract	1.2	4.10
Crude fiber	15.5	13.30
NFE	68.1	61.56
Energy Kcal/kg ME	3020.0	3251.00

DM: Dry matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, NFE: Nitrogen free extract, GE: Gross energy

Table 3: Proximate Composition of the experimental diets (g 100 g^{-1})

	Treatment (% in peel meal)				
Nutrient	T_1	T_2	T_3	T_4	PM
DM	78.2	79.6	80.5	82.6	86.5
Crude protein	13.3	14.1	14.0	14.4	6.5
Ether extract	4.6	4.4	4.0	4.1	4.0
NFE	58.1	54.4	54.0	52.1	55.7
Ash	8.6	9.6	10.8	19.0	7.9
Crude fiber	15.3	17.5	17.19	20.4	25.9
Energy Kcal kg^{-1} ME	3003.2	2996.2	3100.2	3035.7	2670.3

Table 4: Mean nitrogen utilization of WAD Rams fed diets containing graded levels of yam peel meal

	Treatment			
Parameter	T_1	T_2	T_3	T_4
Nitrogen intake (g day^{-1})	2.13±0.2	2.26±0.3	2.24±0.2	2.23±0.3
Faecal nitrogen (g day^{-1})	0.82±0.1	0.86±0.1	0.72±0.2	0.88±0.1
Digested nitrogen (g day^{-1})	1.33±0.2	1.40±0.2	1.52±0.3	1.35±0.2
Urinary nitrogen (g day^{-1})	0.16±0.2^b	0.22±0.1^a	0.13±0.2^b	0.20±0.09^a
Nitrogen balance (g day^{-1})	1.17±0.2^b	1.18±0.2^b	1.39±0.1^a	1.15±0.3^b
Nitrogen retention (%)	54.92±1.4^b	52.21±1.3^c	62.05±1.5^a	51.56±1.3^c

Means with different superscripts a, b, c along the same row are significantly different

Table 5: Haematology Parameters of West African Dwarf Rams fed diets containing increasing levels of yam peel meal

	Treatment			
Parameter	T_1	T_2	T_3	T_4
PCV (%)	29.60±1.3	30.20±1.2	32.00±1.5	28.00±1.2
HB (g L^{-1})	9.25±1.9	8.64±1.6	8.25±1.8	8.06±1.8
RBC ×106 (µL)	10.00±0.6	10.00±0.2	10.20±0.4	10.60±0.5
WBC ×103 (mn)	12.50±0.7^b	11.60±0.3^b	12.00±0.5^b	13.60±0.8^a
MCV (μm^3)	28.30±1.6	26.80±1.2	28.00±1.5	26.00±1.5
MCHC (%)	30.60±1.6	30.80±1.3	32.60±1.6	32.80±1.6
MCH (pg)	8.20±0.4	8.60±0.2	9.00±0.3	9.00±0.2
Differential leucocyte counts (%)				
Lymphocyte	58.60±1.4	56.80±1.7	60.00±1.6	62.00±1.8
Monocyte	3.60±0.4	3.40±0.1	3.20±0.1	3.20±0.1
Neutrophil	4.12±.15	4.06±.14	4.08±.18	4.20±.15
Basophil	0.10±0.05	0.10±0.5	0.10±0.05	0.20±0.03
Eosinophil	3.96±0.1	4.00±0.1	4.10±0.2	4.10±0.3

Means with different superscripts a, b, c along the same row are significantly different, PCV: Packed cell volume, RBC: Red blood cells, Hb: Haemogloblin, WBC: White blood cell, MCHC: Mean corpuscular haemoglobin concentration, MCV: Mean corpuscular volume, MCH: Mean corpuscular haemoglobin

Table 6: Serum biochemistry of west African dwarf rams fed diets containing increasing levels of yam peel meal

	Treatment			
Parameter	T_1	T_2	T_3	T_4
Al (g dL^{-1})	3.60±0.3	3.40±0.2	3.30±0.2	3.50±0.2
Gl (g dL^{-1})	2.90±0.2	2.80±0.1	2.80±0.2	3.00±0.2
TP (g dL^{-1})	6.50±0.2	6.20±0.3	6.60±0.3	6.50±0.4
TC (mg dL^{-1})	77.20±1.6	75.60±1.7	77.00±1.8	76.50±0.4
Tg (mg g^{-1})	15.60±0.6	16.20±0.4	17.00±0.5	16.40±0.9
HDL (mg dL^{-1})	37.80±1.0	39.20±1.4	40.60±1.4	42.00±1.4
LDL (mg dL^{-1})	13.07±0.8	14.20±0.8	14.60±0.4	15.00±0.8

Means with different superscripts a, b, c along the same row are significantly different, TP: Total protein, Gl: globulin, Al: Albumin, TC: Total cholesterol, TG: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein

Significant differences exist ($p>0.05$) only among the White Blood Cell (WBC) with values which ranged from 11.60±0.3 g dL^{-1} in T_2 to 13.60±0.8 g dL^{-1} in T_4.

The Basophil had values of 0.1±0.05×10^3 µL in T_1 to 0.2±0.03×10^3 µL in T_4. The mean corpuscular haemoglobin concentration was 30.60±1.6 g dL^{-1}, 30.80±1.3 g dL^{-1}, 32.60±1.6 g dL^{-1} and 32.80±1.6 g dL^{-1} in T_1, T_2, T_3 and T_4, respectively, while Mean corpuscular haemoglobin (MCH) varied from 8.20±0.4 to 9.00±0.3 g dL^{-1} in T_1-T_4. Monocytes ranged from 3.20 to 3.60×10^3 µL from T_1-T_4.

Serum biochemistry of West African dwarf rams fed diets containing graded levels of yam peel meal: Table6shows the serum biochemical response of West African Dwarf rams to graded levels of YPM supplement. There were no significant differences ($p<0.05$) among the values of all the serum biochemistry variables analysed. Globulin (Gl) ranged from 2.80±0.1 g dL^{-1} in T_1 to 3.00±0.2 g dL^{-1} in T_4. The values of Total Protein (TP) were 6.20±0.30 g 100 mL^{-1}, 6.50±0.4 g 100 mL^{-1}, 6.50±0.20 g 100 mL^{-1} and 6.60±0.40 g 100 mL^{-1} in T_2, T_1, T_4 and T_3, respectively. Total Cholesterol (TC) varied from 75.60±1.7 g dL^{-1} to 77.20±1.6 g dL^{-1} from T_1 to T_4. Triglyceride (TG) had the values of 15.60±0.6, 16.20±0.4, 16.40±0.9 and 17.00±0.5 g dL^{-1} TI, T_2 T_4 and T_3, respectively. Low-density lipoprotein (LDL) and high-density lipoprotein (HDL) increased progressively from T_1 to T_4.

DISCUSSION

The Crude Protein (CP) content of yam peels meal (YPM) used in the experimental study (10.20 g 100 g^{-1}) was higher than 6.6 and 9.87 g 100 g^{-1} as discovered by Aruna *et al.*[18] and Essien and Sam[19] but less than 12.69 g 100 g^{-1} obtained by Uchewa *et al.*[13]. This value was also higher than the crude protein value of maize (8.92 g 100 g^{-1}) used in this study. However, the CP obtained from the two sample ingredients fell below the expected value of crude protein (12-14%) for growing sheep[20]. The Nitrogen free extract (NFE) of YPM (68.10 g 100 g^{-1}) is comparable with the NFE value of 61.87 g 100 g^{-1} for YPM obtained by Akinmutimi and Anakebe[21]. It is also comparable to the NFE of maize (61.56 g 100 g^{-1}) obtained in this study. This suggests that both YPM and maize contain high NFE and moderate CP which indicates a high level of soluble carbohydrate that could enhance palatability and increase feed intake and digestibility. The CP of the concentrate diets (13.3-14.4 g 100 g^{-1}) is however within the range of CP for growing sheep[20].

The haematological parameters measured were within the ranges reported in literatures. The packed cell volume (PCV) range of 28.00-30.20%obtained in this study fell within the values 22.00-37.00% for normal healthy sheep as reported by Sowande *et al.*[22].

A deviation from the normal range may indicate a departure from the normal physiological process[23]. However, in this study, the tendency for normal compensatory accelerated production of PCV as observed with increasing values of yam peel inclusion with reduction at 100% replacement of yam peel for maize. This could be as a result of infection or stress due to the presence of antinutritional factors in yam peel as in another root tuber by-products that may be beyond the tolerable level for the health of the animals. Mahgoub *et al.*[24] observed low PCV for sheep fed non-conventional feed source rich in tannin. The value of Haemoglobin (Hb) has the physiological function of transporting oxygen to tissues of the animal to aid the oxidation of ingested food to release energy for the body. The values of haemoglobin obtained from the present study (8.0-9.2 g dL^{-1}) were higher than 7.38 g dL^{-1} obtained for intensively managed WAD sheep[25]. This implies that all the animals in the treatment groups have haemoglobin values capable of supporting high oxygen-carrying capacities.

The RBC values in all the treatment groups were within the expected values for red blood cell (RBC) for normal healthy sheep (8.0-18.0×10^6 µL). The RBC obtained in this study fell

below the value of 16.79×10^6 µL obtained when WAD was fed yam peel-based diet at 3% of their body weight[26]. However, ruminants[27] are not exposed to diseases when the values of RBC obtained fall within $9\text{-}15 \times 10^6$ µL.

More importantly, White blood cell functions include fighting, defending the body phagocytes against the invasion of foreign organisms and distributing antibodies in the immune response. White blood cells values obtained from this study was within the normal expected value of $4.0\text{-}13.0 \times 10^3$ µL for healthy sheep. The slight but not significant increase in animals fed T_4 diet may be as a result of antinutritional factors present in 100% replacement of maize for yam peel in the diet which may constitute a stressor. Increase in WBC counts, however, is an indication of the animal fighting against the presence of an infection with blood cells that are capable of generating antibodies[28].

The neutrophil is the main defender of the body against antigens and foreign organisms. The values of neutrophil obtained from the experimental study contained 4.06- 4.20 % which is within the range for healthy sheep[27]. High levels of neutrophils may indicate an active infection while low neutrophils indicate a depressed bone marrow. Lymphocytes help to protect the body from viral infections. The normal value for lymphocytes is 50-70%, the value of lymphocytes obtained from the study ranged from 56.80-62.00%, which is within the expected value for normal lymphocytes. Monocyte which helps in fighting severe infections are the largest cells in the bloodstream. The normal expected monocyte value is 0-4.0%, the value of monocyte from this study is 3.20-3.60% which was also within the expected monocyte value for any healthy sheep[27].

June 22, 2020 the body uses eosinophil to protect itself against parasitic organisms and allergic reactions, for the eosinophil value in this study ranges from 3.93×10^6 µL in T_1 and 4.10×10^6 µL in T_4, it is within the eosinophil value for sheep whose value ranges from $1.0\text{-}8.0 \times 10^6$ µL. The Basophil value ranges from $0.10\text{-}0.20 \times 10^6$ µL in the study while T_4 had the higher value and exceeded the value of expected basophil in sheep which was $0\text{- }1.0 \times 10^6$ µL by Radiostitis[27]. High levels of basophils are found in allergic reactions, low levels are usually normal. The Mean corpuscular haemoglobin concentration (MCHC), for normal sheep, ranges from 30.60- 36.80 g dL^{-1}. MCHC in this study was within the normal sheep value of 30-36 g dL^{-1}. Mean corpuscular volume (MCV) in the study was slightly higher than the maximum value of 25 μm^3 for healthy sheep. This could be as a result of processes involved in the yam peel meal preparation. The mean corpuscular haemoglobin was higher in T_3 and T_4 (8.20-9.00 pg) because the normal values of mean corpuscular haemoglobin are usually 5.2-8.0 pg, as reported by Radostitis[27]. This means that higher inclusion of YPM had little effect on mean corpuscular haemoglobin (MCH) of the rams. However, the lower value of MCH (6.39pg) was obtained when WAD does were fed YPM at 3% of their body weight[26].

The mean value of albumin (2.80-3.00 g dL^{-1}) obtained from the study is in line with normal value (2.70-4.55 g dL^{-1}) reported by Onasanya *et al.*[29] for healthy sheep. The albumin levels are similar to the levels of 2.98 to 3.43g dl obtained when YPM was combined with cowpea husk for WAD goats[30]. The Triglyceride which showed a range of 15.60-17.00 mg dL^{-1}, was within the range for healthy sheep. The Total Protein (TP) in this experiment had similar values in all the treatments whereas it decreased as the level of YPM increased in broiler diets fed YPM in replacement for maize[31]. This could be as a result of differences in the species of the animals under study. Increasing trend in TP values was also observed when cowpea husk was combined with YPM for WAD goats[30]. This may be due to higher protein values of the test ingredient due to protein enrichment of the YPM diet by cowpea. The total protein represents the sum total of different proteins. However, the TP falls within the total protein expected for normal adult sheep (6.6–8.6 g dL^{-1}). The total cholesterol levels of 75.60- 77.00 mg dL^{-1} obtained in this study were within the normal range of 43.0-103.00 mg dL^{-1} reported for adult male sheep by Radostits *et al.*[27]. The HDL values recorded in this study was lower than the range of 46.1 to 71 mg dL^{-1} obtained by Sitmo[32] but increased steadily from 37.80 to 42.00 mg dL^{-1} as the level of YPM increased in the diet. This may be an indication of improved production of good cholesterol as the proportion of yam peels increased in the diet[33]. The low LDL in all the treatment groups could be a positive effect of the diet on the maintenance of cholesterol levels within adequate range in the experimental animals[34]

The non-significant differences in the nitrogen intake in all the treatment groups could be due to the similarity in the protein content of the concentrate diet. Nitrogen intake as a proportion of intake is a major indicator for protein nutrition[35]. Faecal nitrogen output was not increased significantly in other diets compared with the control probably because the inclusion of YPM did not add any residual toxic or astringent factors associated with some tuber crop by-products [36,37]. The better protein retention in T_3 could be as a result of a better amino acid profile of the treatment leading to a complementary effect of both yam peel meal and maize (66.6 and 33.3% inclusion in the diet, respectively) which favoured improved digestibility. Positive nitrogen balance obtained in all the treatments was an indication that substantial quantities of the protein nutrients were absorbed in the gastrointestinal

tract[38]. In this study, only T_3 had nitrogen retention (NR) of 62.05% which was within the limit of the estimated range of 57.26-65.23% for WAD goats[38]. This is a reflection of lesser nitrogen excretion and better performance. However, NR in all the treatments was higher than the highest value of 50.48% obtained when WAD goats were fed milled bio-fiber waste rations[39].This could be as a result of better nitrogen utilization. The poorest digestibility observed in T_4 (100%) YPM may be attributable to higher fiber content. These tallies with the work of Zhang *et al.*[40] that high fiber feed reduces digestibility and inclusion in diets even though an energy source must be to the extent where they contribute positively to nutrient digestibility.

CONCLUSION

Partial or total replacement of maize for yam peel meal in the diet of growing west African dwarf rams did not adversely affect protein or lipid metabolism and general health of the animals. Combination of maize and YPM at 33.3% and 66.6% respectively improved nitrogen utilization.

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SIGNIFICANCE STATEMENT

The study discovered that yam peel meal can be beneficial as a cheaper ingredient in sheep supplemental diets with considerable nitrogen utilization without posing health challenges to the animals. Thus, WAD rams should be fed supplements containing 33% maize and 66% yam peel meal for improved production performance.

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