Annals of Animal and Biological Research, 2024; 4(1)

Original Article

Nutrient, antinutrient intake and digestibility of West African Dwarf does fed sole diet containing wheat offal substituted with tiger nut

G. A. Ibhaze, T. O. Osilaja, T. S. Oso, C. T. Alade and G. E. Ogunjemite

Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State, Nigeria.

Article Information
Keywords
Digestibility, Goat, tiger nut, West African Dwarf does, antinutrient

Correpsonding author
G.A. Ibhaze
gaibhaze@futa.edu.ng

Article History
Received: March 10, 2024
Accepted: September 2, 2024
Published: October 14, 2024

Article can be accessed at
www.aabrjournalaaua.org.ng

Abstract
The scarcity of forages during the dry season of the year which leads to low productivity of ruminant animals has necessitated the search for alternative feed ingredients. Tiger nut is an energy and protein rich feed ingredient with potentials for improving feed utilization and promoting growth. Twenty West African Dwarf (WAD) does were allotted to five experimental diets and housed individually in metabolic cages to ascertain the effect of sole feeding of pelletized concentrate diets containing wheat offal substituted with tiger nut at (T1) 0.00 %, (T2) 5.00 %, (T3) 10.00 %, (T4) 15.00 % and (T5) 20.00 % on the nutrients, antinutrients intake and digestibility. Does were fed 430 g of the diets daily at 5 % body. The experimental design was the completely randomized design. The trial lasted for 21 days, while the faecal and urine samples were collected at the last seven days of the trial. Data generated were analyzed using ANOVA. Results showed that the substitution with tiger nut significantly ($P<0.05$) influenced nutrients and antinutrients intake with the highest dry matter intake (209.06 g/day) obtained from does fed diet T4. Alkaloid, tannin and oxalate intake decreased significantly ($p<0.05$) with increased tiger nut substitution. Dry matter intake and digestibility were utmost at 15 % tiger nut substitution for wheat offal. Due to the highest dry matter intake and digestibility obtained in animals fed T4, it can be concluded that tiger nut can be substituted for wheat offal at 15%.

INTRODUCTION

Goat farming remains a vital aspect of the ruminant industry in Nigeria as they are mostly managed by households and small-scale farmers serving as a source of food, income and employment (Lohani and Bhandari, 2021; Tsvuura *et al*., 2021).

However, one of the pressing challenges militating against goat production in Nigeria is the scarcity and poor nutrient quality of fodder during the dry season (Oni, *et al*., 2022; Anyanwu *et al*., 2021). At this point, the fodder becomes fibrous, scarce, and devoid of essential nutrients resulting in reduced intake, digestibility, and utilization (Patiga *et al*., 2020; Lamidi and Ologbose, 2014) which may lead to a

How to cite this article:
G. A. Ibhaze, T. O. Osilaja, T. S. Oso, C. T. Alade and G. E. Ogunjemite (2024). Nutrient, antinutrient intake and digestibility of West African Dwarf does fed sole diet containing wheat offal substituted with tiger nut. *Annals of Anim. Bio. Res.,* 4(1): 57-66

sharp drop in performance in terms of growth and production, and increased susceptibility to prevailing disease even death of such animal (Benoit and Mottet, 2023).

In response to this predicament, farmers and nutritionists has been exploring the use of alternative feed ingredients, focusing on lesser-known nontraditional feed ingredients (Suleiman *et al*., 2018). One of such promising option is tiger nuts, an edible tuber of the *Cyperus esculentus* plant (Adenowo and Kazeem, 2020). The tubers are rich in energy (1652.53 ME/kcal), protein (12.09 %), fat (8.94 %) fiber (7.02 %), ash (2.57 %), moisture (3.73%), and in essential minerals (Ca 7.66 mg/100 g, Cu 0.04 mg/100 g, Fe 0.09 mg/100 g, K 606.33 mg/100 g, Na 3383.33 mg/100 g, Zn 0.07 mg/100 g) (Aremu *et al*., 2015; Agbaje *et al*., 2015), making them an ideal ingredient for formulating concentrated diets. Additionally, tiger nuts possess prebiotic properties (Ayasan *et al*., 2020), promoting a healthy digestive system (Ukpadi *et al*., 2019) and improving feed utilization in ruminants (Belewu *et al*., 2007). Therefore, the study aimed at investigating the nutrient, antinutrients intake and digestibility of West African Dwarf (WAD) does placed solely on pelletized concentrate diet containing wheat offal substituted with tiger nut (*Cyprus esculentus*).

MATERIALS AND METHODS

Study site

The study was conducted at the Small Ruminant Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, in accordance with animal research ethical guidelines (NENT, 2018). The Experimental site lies between longitude 4.944055°E and 5.82864°E, and latitude 7.491780°N, characterized by 6 – 7 months of annual rainfall between 1300 and 1650 mm and annual daily temperature ranges between 27 and 38°C (Daniel, 2015).

Experimental does and formulation of experimental diets

Twenty (20) WAD goats, with average body weight of 8.54 and 8.90 kg, were used for the study. Does were purchased from reputable farm in Ondo State, Nigeria. The goats were acclimatized for two weeks in pens before moving them to the metabolic cages.

Dried tiger nut, cassava peels and other ingredients were cleaned of dirts and other contaminants and milled. Concentrate diets were then formulated as follows: T1 Control diet (0% Tiger nut), T2 (5.00% Tiger nut), T3 (10.00% Tiger nut), T4 (15.00% Tiger nut) and T5 (20.00% Tiger nut) (Table 1). Each diet was further processed into 6 mm pelletized diet to

Table 1. Ingredient composition (%) of experimental diets

Ingredients	T1	T2	T3	T4	T5
*Tiger nut	0.00	5.00	10.00	15.00	20.00
Wheat Offal	20.00	15.00	10.00	5.00	0.00
Cassava peel	55.00	55.00	55.00	55.00	55.00
Palm kernel cake	22.00	22.00	22.00	22.00	22.00
Dicalcium Phosphate	1.00	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00	1.00
Sulphur	1.00	1.00	1.00	1.00	1.00
Total	**100**	**100**	**100**	**100**	**100**

T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal; T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal, T5= 20% Tiger nut + 0% Wheat offal prevent segregation and sorting of ingredients by the does.

Experimental design and digestibility

The does were randomly allotted to five (5) treatment groups, (four animals /treatment) balanced for weight in a Completely Randomized Design (CRD). Does were placed in individual metabolic cage for separate collection of faeces and urine to determine digestibility in the does. A 430 g of the experimental diets was fed as 5% of the average body weight of the goats at 7:00 hr in the morning and fresh clean water was supplied *ad libitum*. The feeding trial spanned for 21days where the last 7 days were used for collection of faeces and urine daily. A 10 % of the daily collections of the feaces from each animal was oven dried at $105^{\circ o}$C for dry matter determination. The dried faeces collected from each animal were bulked and milled through 2mm screen sieve and stored in well labelled air tight bottles for chemical analysis. Total urine excreted by each doe was also collected and a few drops of 25% H_2SO_4 were added daily to prevent volatilization of ammonia from the urine. The Total volume of urine output per animal was measured and aliquots (10%) of daily output per animal were saved in stopper amber bottles, labeled, and stored in a deep freezer. The percentage apparent digestibility coefficient of the goats was calculated as:

$$\% \text{ Apparent digestibility} = \frac{NI - NO}{NI} \times 100$$

NI = Nutrient Intake

NO = Nutrient Output

Chemical analysis

Samples of the experimental diets, faeces and urine were analyzed for the proximate composition according to AOAC (2011). The metabolizable energy in the diets was calculated using the formula described by Peuzenga (1985);

ME (kcal/kg DM) = (37x %CP) + (81.8 x %EE) + (35.5 x % NFE)

Fibre fractions of the feed sample (neutral detergent fibre, acid detergent fibre and lignin) were determined as described by Van Soest *et al*. (1991). Cellulose, and hemicellulose were calculated by difference.

Statistical analysis

Data collected were subjected to one-way analysis of variance (ANOVA) using the general linear model procedure of SAS (2008). Where significant differences were observed, Duncan's Multiple Range Test (DMRT) was employed to separate the means. The level of significance was taken ($P<0.05$)

RESULTS

The Table 2 below is the chemical composition of the experimental diets fed to WAD does. The parameters investigated did not follow a particular trend. The Dry matter content ranged from 83.29 (T5) to 85.17 % (T4). However, diet T3 had the highest crude protein content (14.76 %) and the least (10.55 %) from diet T5 Ether extract and crude fibre of the diet were observed to increase progressively from diet T1 to T5 with values ranging from 2.87 to 3.91 % and 15.87 to 18.72 %, respectively.

Table 3 shows the anti-nutrient composition of the experimental diet fed to WAD does. There was a significant ($P<0.05$) difference across all parameters except for oxalate. Saponin concentration increased from 1.97 to 2.39 % as the substitution level increased. Contrary to this, alkaloid and tannin

Table 2. Chemical composition (%) of the experimental diets fed to WAD does

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Dry Matter (%)	84.79[a]	85.01[a]	83.66[b]	85.17[a]	83.29[b]	0.22	0.01
Crude Protein (%)	11.01[cd]	12.82[b]	14.76[a]	11.52[c]	10.55[d]	0.42	0.00
Ether Extract (%)	2.87[c]	2.95[c]	3.38[b]	3.45[b]	3.91[a]	0.11	0.01
Nitrogen free extract	42.35[b]	43.01[c]	39.98[d]	45.42[a]	42.86[b]	0.51	0.00
Crude Fibre (%)	15.87[c]	15.75[c]	16.82[bc]	17.38[b]	18.72[a]	0.32	0.03
Ash (%)	12.69[a]	10.49[b]	8.74[c]	7.41[d]	6.54[e]	0.59	0.00
ME (Kcal/kg)	2145.56[b]	2242.51[c]	2241.36[b]	2320.86[a]	2256.75[b]	15.25	0.00
Acid detergent fibre	15.17[a]	11.81[b]	9.18[d]	10.26[c]	9.55[d]	0.59	0.00
Acid detergent lignin	5.34[a]	4.39[b]	4.27[c]	4.04[d]	3.70[e]	0.16	0.00
Neutral detergent fibre	43.00[a]	39.42[b]	33.65[d]	37.39[c]	43.00[a]	0.95	0.00
Cellulose	9.84[a]	7.42[b]	4.91[d]	6.22[c]	6.08[c]	0.46	0.00
Hemicellulose	27.83[b]	27.62[b]	24.47[c]	27.14[b]	33.45[a]	0.80	0.00

[abcde:] Means with different superscripts along the same row are significantly different (P <0.05)
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

Table 3. Anti- nutrient composition (%) of the experimental diets fed to WAD does

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Saponin	1.97[c]	2.06[c]	2.27[b]	2.38[a]	2.39[a]	0.08	0.00
Alkaloid	1.90[a]	1.90[a]	1.84[a]	1.76[b]	1.62[c]	0.15	0.00
Tannin	3.21[a]	2.40[b]	1.93[c]	1.88[c]	1.83[c]	0.30	0.00
Oxalate	1.49	1.49	1.40	1.17	1.14	0.14	0.11

[abc:] Means with different superscripts along the same row are significantly different (P <0.05).
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

concentrations decreased across treatments, with the highest values (1.90 and 3.21%) from diet T1 and least (1.62 and 1.83 %) from diet T5.

Table 4 presents the nutrient intake (g/day) of WAD does fed the experimental diets. Significant (P<0.05) difference was observed across all parameters measured. The Dry matter intake was highest (209.06 g/day) in does fed T4 while the least (164.67 g/day) from does placed on diet T1. The crude protein intake was least in does fed diet T1 (21.38 g/day) while the highest (33.63g/day) from does fed diet T3. Ether extract intake significantly (P<0.05) increased along treatments, with the least value of 5.57 g/day in does fed diet T1 while the highest (8.47 g/day) in does fed diet T5. Crude fibre intake (g/day) by the does were observed to increase across treatments from 30.82 to 40.43 g/day from T1 to T5 respectively. The Acid detergent fiber was least (20.53%) in does fed T5.

Presented in Table 5 is the anti-nutrient intake (g/day) of WAD does fed the experimental diets. It was revealed that there were significant (p<0.05) differences among the parameters evaluated. The saponin intake was least in the does fed diet T1 having a value of 3.83 g/day while the highest (5.42 g/day) was observed in does fed diet T4. Alkaloid and oxalate intake were highest in does fed diet T2 with a value of 4.67 and 3.65 g/day and least intake from

Table 4. Nutrient intake (g/day) by WAD does fed experimental diets

Variables	T1	T2	T3	T4	T5	SEM	P-Value
Dry Matter	164.67[b]	193.84[a]	190.57[a]	209.06[a]	180.01[a]	5.19	0.05
Crude Protein	21.38[c]	26.19[b]	33.63[a]	31.53[a]	22.86[b]	1.38	0.00
Ether Extract	5.57[b]	7.85[a]	7.66[a]	7.24[a]	8.47[a]	0.31	0.01
Nitrogen free extract	82.25[b]	103.31[a]	91.09[a]	105.74[a]	94.12[a]	2.86	0.03
Crude Fibre	30.82[b]	39.61[a]	38.29[a]	38.76[a]	40.43[a]	1.23	0.04
Ash	24.62[a]	16.87[c]	19.91[b]	25.79[a]	14.12[d]	1.23	0.00
Metabolizable Energy	4167.05[b]	5278.71[a]	5104.54[a]	5512.64[a]	4879.66[a]	151.93	0.02
Acid detergent fiber	29.46[a]	23.35[b]	20.89[b]	29.01[a]	20.53[b]	1.09	0.03
Acid detergent lignin	10.86[a]	9.18[b]	9.72[a]	10.78[a]	7.49[c]	0.34	0.01
Neutral detergent fiber	83.50[a]	85.12[a]	76.61[b]	96.95[a]	93.03[a]	2.57	0.05
Cellulose	19.10[a]	14.16[b]	11.18[c]	18.23[a]	13.03[b]	0.85	0.04
Hemicellulose	54.04[c]	61.78[b]	55.72[c]	67.93[b]	72.49[a]	2.37	0.02

[abcd] Means with different superscripts along the same row are significantly different (P <0.05)
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

Table 5. Anti-Nutrient intake (g/day) by WAD does

Variables	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**	**P-Value**
Saponin	3.83[b]	5.07[a]	5.14[a]	5.42[a]	5.20[a]	0.93	0.03
Alkaloid	3.70[b]	4.67[a]	4.20[a]	4.01[a]	3.53[b]	1.31	0.02
Tannin	6.23[a]	5.89[a]	4.39[b]	4.27[b]	3.94[b]	0.28	0.00
Oxalate	2.89[a]	3.65[a]	3.17[a]	2.57[b]	2.56[b]	0.15	0.05

[abcd] Means with different superscripts along the same row are significantly different (P <0.05)
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

Table 6. Nutrient Digestibility (%) of WAD does fed the experimental diets

Parameters	T1	T2	T3	T4	T5	SEM	P-Value
Dry Matter	65.37	67.37	69.19	71.23	70.25	1.82	0.90
Crude Protein	76.91	80.95	81.01	78.21	80.53	1.19	0.77
Ether Extract	80.84[b]	81.89[b]	90.39[a]	94.22[a]	93.49[a]	1.69	0.00
Nitrogen free extract	78.05	86.23	81.75	83.73	81.54	1.67	0.69
Crude Fibre	65.62	66.46	76.99	77.35	79.39	2.22	0.11
Ash	84.15	73.46	73.45	73.49	62.20	3.06	0.29
Metabolizable Energy	79.02	85.27	83.41	84.99	83.46	1.36	0.67
Acid detergent fibre	84.02	82.35	79.74	84.38	84.71	1.05	0.61
Acid detergent lignin	87.60	87.13	85.88	84.62	85.82	0.74	0.78
Neutral detergent fiber	77.46	78.80	73.43	81.48	81.47	1.53	0.48
Cellulose	82.08	79.42	74.36	84.20	83.98	1.52	0.22
Hemicellulose	73.89	77.25	71.07	80.64	80.25	1.79	0.42

[abcd] Means with different superscripts along the same row are significantly different (P <0.05).
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

Table 7. Anti-nutrient Digestibility (%) of experimental diets fed to WAD does

Parameter	T1	T2	T3	T4	T5	SEM	P-Value
Saponin	96.71	97.15	96.99	97.13	95.71	0.29	0.56
Alkaloid	91.08	93.11	92.66	92.45	90.41	0.49	0.40
Oxalate	81.39	87.62	84.96	83.19	79.52	1.90	0.76
Tannin	84.93^{c}	88.38^{b}	88.87^{b}	94.09^{a}	94.79^{a}	1.21	0.02

$^{abcd:}$ Means with different superscripts along the same row are significantly different (P <0.05)
T1= 0% Tiger nut + 20% Wheat offal; T2= 5% Tiger nut + 15% Wheat offal;
T3= 10% Tiger nut + 10% Wheat offal; T4= 15% Tiger nut + 15% Wheat offal;
T5= 20% Tiger nut + 0% Wheat offal, ME: Metabolizable Energy.

does fed diet T5 at 3.53 and 2.56 g/day, respectively. Tannin intake was observed to decrease across treatments with the highest (6.23 g/day) intake from does fed diet T1 and the least (3.94 g/day) from does fed T5.

Table 6 presents the percentage digestibility coefficient of nutrients by WAD does fed the experimental diets. All the parameters observed were not significantly (P>0.05) influenced except ether extract. However, the dry matter and crude protein digestibility (%) were in the range of 65.37 to 71.25 % and 76.91 to 81.01%, respectively.

Shown in Table 7 is the anti-nutrient digestibility (%) of WAD does fed the experimental diets. Values obtained revealed that saponin, alkaloid, and oxalate were not significantly (P>0.05) different across treatments except tannin. Tannin digestibility was observed to increase as the substitution of tiger nut increased with the highest value of 94.79 % obtained in does fed diet T5 while the least (84.93 %.) was in does fed T1.

DISCUSSION

Dry matter content in a diet is dependent on some factors such as moisture, type, processing method, ingredient composition of the feed ingredients. The values obtained in this study were above 80 % dry matter, capable of retaining the quality, prolonging the shelf life, and inhibiting the growth of molds as deviation from those affecting the quality of the diet (Ajagbe *et al.*, 2020). Dry matter and crude protein in ruminant nutrition are of vital importance due to their impact on the quality of the diet, voluntary feed intake, digestibility, and rumen function (Anyanwu *et al.*, 2021). The values obtained in this study (83.29 -85.17 % and 10.55-14.76 % respectively) were relatively high and adequate to support rumen activities, as reported by Asaolu *et al.* (2012). This implies that the diets contained sufficient crude protein to meet the need of the does, having values above the requirement of 8% CP for maintenance and growth as reported by Ibhaze (2016). The increase in ether extract value as the substitution of tiger nut increased in the diets could be attributed to the high fat content in the raw tiger nut as reported by Aremu *et al.* (2015). However, the values obtained were lower than the range of 3.6 – 4.3 % obtained by Belewu *et al.* (2007).

The Nitrogen free extract, which represents the carbohydrate portion in the diet, was in the range of 39.98 to 45.42%, and it is capable of supporting metabolic processes and the physiological need of the does. Dietary ash is an indication of the mineral content in diet, which constitutes the integral portion of minerals needed for the proper development of the body cells. The values obtained in this study were slightly higher than the values (6.34- 9.34) reported by Odoemelan *et al.* (2015) in WAD bucks fed *Panicum maximum* supplemented concentrate containing Bambara nut meal. Energy has been a limiting factor in ruminant nutrition however, a larger portion of the energy required is produced solely by the action of the microbes inform of volatile fatty acids (Abdou, 2016). The high metabolizable energy obtained in this study for T2, T3, T4, and T5 could be linked to the high portion of carbohydrates and fat in the tiger nut (Ariyo *et al*., 2021). This suggested that tiger nuts could conveniently replace other conventional energy source feed materials in the diets of ruminant animals. Also, the fibre fractions obtained were below the 60% optimum critical level recommended by Oni *et al*. (2010). This implies that the diets have the potential to support intestinal movement, proper rumen function, stimulate digestive juices production and contribute to gut fill, as reported by Binumote *et al*. (2022) and Ajagbe *et al*. (2020) without adverse effects on feed intake, nutrient digestibility, and intestinal health.

Antinutrients, which are produced by different mechanisms in plants, have been observed to impact the utilization of nutrients in animals (Binumote *et al*., 2022). The relatively low antinutrient composition in the experimental dieats (T2, T3, T4 and T5) may be justified by the low concentration of antinutrients in tiger nut. Also, the low concentration might be a result of processing (heat generated during pelletizing). According to Ari and Ayanwale (2012) processing methods like fermentation, sun drying, boiling, heat treatment, and autoclaving are also able to reduce antinutrients in feed ingredients. However, ruminants are known to tolerate a threshold level of about 9 % dietary tannin but 3% has been established to have beneficial effects (Binumote *et al*., 2022), and values obtained in this study were below this recommendation. Tannins and saponins in the right concentrations in ruminant diets have been observed to help in methane mitigation due to their natural origin. However, at higher concentrations, saponin may be detrimental to protozoa by acting as a defaunating agent (Adeosun and Akindele, 2021) while tannins bind to proteins to form a tannin-protein complex (Zhang *et al*., 2023). The disparities in the nutrients and antinutrients composition of the diets in this study and those of earlier reports (Aremu, *et al.,* 2015; Ukpabi, *et al.,* 2019), could be due to variations in species of tiger nut and other feed ingredients used, climate, age and stage of maturity of feed ingredients, edaphic factor, methods of processing, and effect of storage on the feed ingredients (Ezimoha and Nsidinanya, 2021).

The nutrient intake was all observed to be influenced by tiger nut substitution in the diets. This is an indication that tiger nut influenced the palatability and voluntary feed intake of the does. This finding agrees with the report of Ibrahim *et al.* (2013) that stated the positive effect of tiger nut on improving daily dry matter intake in Zaraibi goats. It was also observed that there was a relationship between the crude protein content of the diets and the dry matter and crude protein intake. It could be said that all nutrient intake was adequate to meet their daily requirement for energy and effective rumen function as there was no manifestation of nutrient deficiency during the study. Antinutrient intake by the does was within the tolerable intake as this does not impair nutrient metabolism, digestion and utilization and no detrimental effect on the health status of the animals was observed. According to Vikram *et al*. (2020) excess daily intake or intake above the tolerable level of antinutrients is manifested in forms like metabolic disruptions, toxicity, restlessness, paralysis, neurological disorders, or death in ruminant animals. All these clinical manifestations were not observed during this study.

According to Putri *et al*. (2021), increased nutrient digestibility in ruminants indicates that the rumen is in a better condition, with increased activities of the rumen microbes leading to better fermentation, enzyme production, and improved dry matter degradation. The digestibility coefficient of nutrients obtained in this study was above 70% which indicated that a larger portion of nutrients in the diet were not lost from the rumen nor excreted, thus assumed to be available to the does to absorb from the digestive tract into their body system to improve their productivity, as reported by Sharif *et al*.(2019). The observed increase in digestibility of ether extract as the tiger nut substitution increased attest that the crude fat (ether extract) in the nut can increase energy supply and availability in the animal. This is similar to the opinion of Ezimoha and Nsidinanya, (2021). The improvement in digestibility might also be due to the abundance of nutrients in the diets, which were well above the requirements for maintenance. However, the digestibility of feed materials is largely influenced by factors such as age, feed palatability and nutrient composition, feeding condition, and rumen physiochemical status (Lamidi and Ologbose, 2014).

The high value of the antinutrients digestibility obtained indicated that a larger portion of it was degraded by rumen microbes within the rumen, pointing to the fact that tiger nut does not contain a high portion of antinutrients but contains a constituent that serves as digestive tonic alleviating the negative effect of antinutrients (Adenowo and Kazeem, 2020).

CONCLUSION

From this study, it could be concluded that substituting 15 % tiger nut for wheat offal in does' diet can be adopted by goat farmers as the highest nutrient intake and nutrient digestibility were recorded at this level and as such, the concentrate diet can be fed solely for improved and sustained goat production especially during the dry season when there is shortage of fodder.

Conflict of Interest: The authors declare that there is no conflict of interest.

REFERENCES

Abdou, N. (2016). Effect of roughage processing and feeding level on production, reproduction, and growth performance of the Red Maradi goat. A thesis submitted to University of KwaZulu-Natal, South Africa. 156pp.

Abdullahi, B. A., Saidu, H., Rogo, L. D., Ibrahim, A. Abdullahi, H. L., Jobbi, Y. D, Saleh, A. M., Saeed, S. A. and Saidu, A. (2020). *Pattern of serum zinc level, peripheral blood lymphocyte and neutrophil counts among patients with sickle cell disease. Bayero Journal of Medical Laboratory Science,* 5(2): 230 - 235.

Adenowo, A. F. and Kazeem, M. I. (2020). Tiger Nut as a Functional Food, Pharmacological and Industrial Agent: A Mini Review. *Annals of Science and Technology,* 5 (1): 31- 38.

Agbaje, R. B., Oyetayo, V. O. and Ojokoh, A. O. (2015). Effect of fermentation methods on the mineral, amino and fatty acids composition of *Cyperus esculentus. African Journal of Biochemistry Research,* 9 (7): 89-94.

Ajagbe, A. D., Oyewole, B. O., Aribido, S. O. and Oyibo A. (2020). Nutrient Intake of West African Dwarf (WAD) Goats Fed Cassava Peels Supplemented with Nitrogen Sources. *GSC Biological and Pharmaceutical Sciences.* 12(1): 189-195.

Anyanwu, N. J., Oji, U. I., Etela, I., Kalio, G.A. and Anegbeh, P.O. (2021). Voluntary feed intake and dry matter digestibility of multipurpose trees among sheep and goats in the humid zone of southeastern Nigeria. *Nigerian Journal of Agriculture, Food and Environment,* 17 (4): 22-29.

AOAC. (2011). Official Methods of Analysis. Association of Official Analytical Chemist, International, 18th edition, revision 4. In, Horwitz, W., Latimer, G.W. Jr. (eds). AOAC International Gaithersburg, Maryland, USA.

Aremu, M. O., Bamidele, T. O., Agere, H., Ibhram, H. and Aremu, S. O. (2015). Proximate composition and amino acid profile of raw and cooked black variety of tiger nut (*Cyperus esculentus* L.) grown in Northeast Nigeria. *Journal of Biology, Agriculture and Health Care*, 5(7): 213-221.

Ari, M. M. and Ayanwale, B. A. (2012). Nutrient retention and serum profile of broiler fed fermented African locust Beans (*Parkia filicoide*). *Asian Journal of Agricultural Research,* 6(3). 129-136.

Ariyo, O., Adetutu, O. and Keshinro, O. (2021). Nutritional composition, microbial load and consumer acceptability of tiger nut (*Cyperus esculentus*), date (*Phoenix dactylifera* l.) and ginger (*Zingiber officinale* Roscoe) blended beverage. *Journal of Tropical Agriculture, Food, Environment and Extension,* 20 (1): 72 – 79.

Asaolu, V., Binuomote, R., Akinlade, J., Aderinola, O. and Oyelami, O. (2012). Intake and growth performance of West African Dwarf goats fed *Moringa oleifera, Gliricidia sepium* and *Leucaena leucocephala* dried leaves as supplements to cassava peels. *Journal of Biology, Agriculture and Healthcare*,2(10): 76–88.

Ayasan, T., Sucu, E., Ulger, I., Hizli, H., Cubukcu, P. and Ozcan, B. D. (2020). Determination of *in vitro* rumen digestibility and potential feed value of tigernut varieties. *South African Journal of Animal Science*, *50*(5): 738-744.

Belewu, M. A., Orisameyiti, B. R. and Ajibola, K. A. (2007). Effect of feeding graded levels of tiger nut (*Cyperus esculentus*) seed meal on the performance characteristics of West African Dwarf goat. *Pakistan Journal of Nutrition,* 6 (6): 528-529.

Benoit, M. and Mottet, A. (2023). Energy scarcity and rising cost: Towards a paradigm shift for livestock. *Agricultural System,s* (205). https://doi.org/10.1016/j.agsy.2022.103585.

Binuomote, R. T., Muftaudeen, N. and Adekunle, C. A. (2022). Rumen parameters of West African Dwarf sheep fed *Panicum maximum* supplemented with varying levels of *Gmelina arboreal* leaves. *Journal of Animal Health,* 3 (2):1-20.

Daniel, O. A. (2015). Urban extreme weather: a challenge for a healthy living environment in Akure, Ondo State. *Niger Climate,* 3(4):775–791.

Ezimoha, C. O. and Nsidinanya, N. O. (2021). Apparent digestibility and nitrogen utilization by West African Dwarf goats fed tiger nut meal as replacement for maize offal. *Nigerian Journal Animal Science*, 23 (2): 240-246.

Ibhaze, G. A. (2016). Reproductive performance of intensively managed primiparous gravid West Dwarf goats fed pulverized bio-fibre waste-based diets. *Nigerian Journal of Animal Production, 43(2): 133-138.*

Ibrahim, F.A., Ayad, K. M. K., Ahmed, M. E. and. El-Kholeny, M. E. (2013). Effect of using Chufa tubers (*Cyprus esculentus L.*) in Zaraibi goats diets on the resultant milk and labenh. *Egyptian Journal of Sheep and Goat Sciences* 8 (1), 201-210

Lamidi, A. A. and Ologbose, F. I. (2014). Dry season feeds and feeding: a threat to sustainable ruminant animal production in Nigeria. *Journal of Agriculture and Social Research,*14 (1):17-30.

Lohani, M. and Bhandari, D. (2021). The importance of goats in the world. *Professional Agricultural Workers Journal,* 6 (2): 9-21.

NENT (2018). National Committee for Research Ethics in Science and Technology. Ethical guidelines for the use of Animals in research.

Odoemelam, V.U, Ahiwe, E. U., Ekwe, C.C., Obikaonu, H.O. and Obi, J.I (2015). Dry matter intake, nutrient digestibility and nitrogen balance of West African Dwarf (WAD) bucks fed *Panicum maximum* supplemented concentrate containing Bambara nut (*Vigna subterranean*) meal *Nigerian Journal of Agriculture, Food and Environment* 11(2):59-65.

Oni, A. O., Arigbede, O. M., Oni, O. O., Onwuka, C. F. I., Anele, U. Y., Oduguwa, B. O. and Yusuf, K. O. (2010). Effects of feeding different levels of dried cassava leaves (*Manihot esculenta,* Crantz) based concentrates with *Panicum maximum* basal on the performance of growing West African Dwarf goats. *Livestock Science*, 129(1): 24 –30.

Oni, O. O., Ibhaze, G.A., Ogunwande, I. O. and Onibi, G. E. (2022). Socioeconomic characteristics of farmers, profitability and militating factors affecting small ruminant production in Ondo State, South-West, Nigeria. *International Journal of Environment, Agriculture and Biotechnology,* 7(2); 69 -77.

Patiga, E. M., Bestil, L. C. and Mondejar, H. P. (2020). *In situ* digestibility of cogon grass (*Imperata cylindrica* L.) in various forms and harvesting intervals in rumen-fistulated Brahman Cattle. *Mindanao Journal of Science and Technology*, 18(2): 73-83.

Peuzenga, U. (1985). Feeding parent stock. *Zooteenical International,* 19985: 22-24.

Putri, E. M., Zain, M., Warly, L. and Hermon, H. (2021). Effects of rumen-degradable-to-undegradable protein ratio in ruminant diet on *in vitro* digestibility, rumen fermentation, and microbial protein synthesis. *Veterinary World*, 14(3): 640-648.

SAS (2008). SAS/STAT User's Guide Version 8. 3rd Edition, Statistical Analysis Systems (SAS) Institute Incorporated, Cary, North Carolina, USA.

Sharif, M., Qamar, H. and Wahid, A.A. (2019). Effect of rumen degradable protein concentrations on nutrient digestibility, growth performance and blood metabolites in Beetal kids. *Concepts Dairy Veterinary Science,* 2 (5):249–253.

Suleiman, M. S., Olajide, J. E., Omale, J. A., Abbah, O. C. and Ejembi, D. O. (2018). Proximate composition, mineral and some vitamin content of Tiger nut (*Cyperus esculentus*). *Clinical Investigation*, 8(4). 162-165.

Tsvuura, S., Mudhara, M. and Chimonyo, M. (2021). Gender-differentiated contribution of goat farming to household income and food security in Semi-arid Areas of Msinga, South Africa. *Journal of Agricultural Science*, 13 (9): 73-92.

Ukpabi, U. H., Mbachu, C. L. and Igboegwu, C. M. (2019). Growth performance, carcass and organ characteristics of grower pigs fed varying levels of Tiger nut (*Cyperus esculentus*) seed meal. *Nigeria Journal of Animal Science,* 21 (1): 214-221.

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

Vikram, N., Katiyar, S. K., Singh, B. C., Husain, R. and Gangwar K. L. (2020). A review on anti-nutritional factors. *International Journal of Current Microbiology and Applied Sciences, 9*(5):1128-1137.

Zhang, L., Guan, Q., Zhang, H. and Tang, L. (2023). Effect of metal ions on the interaction of condensed tannins with protein. *Foods*, *12*(4): 829.