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Nutrient digestibility, Nitrogen utilization, and growth performance of West African Dwarf (WAD) does fed diets containing wheat offal replaced with Tiger nut seed meal

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ABSTRACT

The decrease in nutrient digestibility and general performance of ruminant animals has been a persistent challenge during the dry season in Nigeria, and the use of less competitive alternative feed ingredients could be a remedy. Hence, a sixty-three (63)-day study was conducted to evaluate the nutritional potential and growth response of West African Dwarf (WAD) does fed diets containing wheat offal replaced with tiger nut seed meal. Five (5) experimental diets were formulated to contain 0.00, 5.00, 10.00, 15.00, and 20.00% tiger nut seed meal and were thus designated as diets T1, T2, T3, T4, and T5, respectively. Twenty (20) WAD does were randomly assigned to the experimental diets with four (4) replicates per treatment in a completely randomized design (CRD) experiment. Parameters evaluated include the chemical composition of formulated diets and wilted Panicum maximum, nutrient intake, digestibility, nitrogen utilization, and growth response of the does. Significant ($p < 0.05$) differences were observed in the chemical composition of the diets with the highest dry matter, nitrogen-free extract, and metabolizable energy obtained from diet T4. The highest crude protein content in diet, intake, and digestibility were observed for the does fed diet T3. The results obtained from nitrogen utilization revealed a significant ($p < 0.05$) difference across all parameters with superior nitrogen intake, balance, and percentage retention for the does feed diet T3. Similarly, the highest weight gain, daily weight gain, total dry matter intake, protein efficiency, and least feed conversion ratio were recorded from does fed diet T3. Conclusively, incorporating tiger nut seed meal as a replacement for wheat offal at 10.00% in WAD does diet has the potential to improve feed digestibility and the general performance of does, thus can be adopted by goat farmers.

Keywords: West African Dwarf does, digestibility, utilization, growth, tiger nut seed meal

INTRODUCTION

Availability of quality nutrition remains a major limiting factor in ruminant enterprises in Nigeria, especially during the dry season, due to scarcity of feed materials and low pasture production (Rocha Filho et al., 2021). During which the nutritive value, quality, and quantity diminished significantly, leading to high fibrous materials, lower forage intake, digestibility, and utilization (Gabriel et al., 2018). Thus, supplementing ruminant animals' diets with nutrient-rich ingredients or formulating a concentrate diet is considered a remedy for the low digestibility, weight loss, metabolic imbalance, or possible death experienced during this period. However, the use of conventional feed resources for ruminants has led to increased cost and scarcity as a result of competition, necessitating a continuous search for alternative feed materials (Omotoso et al., 2023). According to Omotoso et al. (2023) and Oso and Ibhaze (2023), interest has shifted to the use of by-products, farm residues, underutilized seeds, pulp, and nuts, which are less expensive, readily available, and help decrease environmental pollution. Using these materials may provide adequate nutrition at the least possible cost for ruminant animals (Amit, 2018).

Tiger nut *(Cyperus esculentus*) seed is considered an underutilized edible perennial tuber of the family *Cyperaceae*. Studies have affirmed that it is highly nutritious with numerous health benefits (Abiola and Mutiu, 2020), containing protein (9.70%), carbohydrate (41.22%), crude fibre (5.62%), crude fat (35.43%), ash (4.25%), with good portion of minerals adequate to support growth, development, and health status in humans and animals (Malashree et al., 2021; Sabah et al., 2019). Considering its nutritional and health benefits, its inclusion in the diets of livestock can help improve digestibility, utilization, and growth performance, thus salvaging the deficiency of nutrients lacking in forages during the dry season. The thrust of this study is to evaluate the nutrient intake, digestibility, nitrogen utilization, and growth response of West African Dwarf (WAD) does fed varying levels of tiger nut seed meals as a replacement for wheat offal.

MATERIALS AND METHODS

Experimental Site

The feeding trial of this study was carried out at the Small Ruminant Unit of the Teaching and Research Farm, while laboratory analyses were conducted at the Nutrition Laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State. 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 daily temperature ranges between 27 and 38°C (Daniel, 2015).

Experimental Feed Formulation

Dried tiger nut (*Cyperus esculentus*) seed was sourced from Shasha Market, Akure, Ondo State, while cassava peel and other ingredients were sourced from the cassava processing industry and a reputable feed mill within Akure, Ondo State, Nigeria. Dirt and foreign materials were removed from the dried tiger nut seed, milled, and used as replacements for wheat offal at 0.00%, 5.00%, 10.00%, 15.00%, and 20.00%, designated as diets T1, T2, T3, T4, and T5, respectively (Table 1). The five experimental diets were pelletized into 6 mm diameters to prevent the segregation of ingredients. Fresh *Panicum maximum* was harvested within the University community and allowed to wilt before chopping for easy mastication.

Experimental Animal Management

Twenty (20) West African Dwarf does of an initial weight between 8.53 and 8.65 kg were randomly assigned to the experimental diets with four (4) replicates per treatment in a completely randomized design (CRD) experiment. The goats were housed intensively in an open-sided pen with individual enclosures measuring 6 x 5 feet, with litter, elevated platforms for resting and sleeping, and designated areas for feeding and drinking. Prior to the experimental phase, the goats underwent a one-week acclimatization period to adjust to the new environment and diet. The does were fed 300 g/head/day of the allotted experimental diet in the morning (7:00hrs) and 400 g/head/day of the wilted *Panicum maximum* in the afternoon (14:00hrs) throughout the 63-day experimental period. Fresh and clean water was provided *ad libitum.* This study was approved by the Departmental Research Ethical Committee of the Department of Animal Production and Health, Federal University of Technology Akure, Nigeria (No: R/2022/12), all operations were carried out in accordance with animal research ethical guidelines (Gross and Tolba, 2015).

Table 1: Ingredient composition (%) of experimental diets

	T1	T2	T3	T4	T5
Tiger nut seed meal	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= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

Chemical Analysis

Samples of the experimental diets, *Panicum maximum*, faeces and urine were analyzed for nutrient composition according to AOAC (2011). Fibre fractions (neutral detergent fibre, acid detergent fibre and lignin) were determined by the procedure described by Van Soest et al. (1991). Cellulose and hemicellulose were estimated as differences between ADF and lignin and NDF and ADF respectively. Metabolizable Energy (ME) was calculated using the formula described by Peuzenga (1985).

Cellulose (%) = (Acid detergent fibre – Acid detergent lignin

Hemicellulose (%) = (Neutral detergent fibre – Acid detergent fibre)

ME (kcal/kg DM) = (37 x %CP) + (81,8 x %EE) + (35.5 x %NFE)

Feed Intake

The daily feed intake of the experimental diets and *Panicum maximum* were determined by subtracting the leftovers from the quantity given; these were then pulled to calculate the total feed intake.

Digestibility Trial and Nitrogen Retention

Three (3) experimental does per treatment were transferred to the metabolic cage for a fourteen (14) days digestibility trial. Samples of faeces and urine were collected in the morning, void faeces were weighed, and 10%

of the samples were oven dried at 105 °C for 3 hours for dry matter (DM) determination. The faecal samples from each experimental does were thoroughly mixed, milled to pass a 0.2 mm sieve, and sealed in polythene bags. These were stored in a cupboard at room temperature until required for chemical analysis. The volume of urine excreted from each does was collected in a plaque bucket under each cage, and a few drops of 25% H_2SO_4 were added daily to prevent the volatilization of nitrogen, as described by Ahamefule et al. (2016). Total volume of urine output per animal was measured, and aliquots (10%) of daily output per animal were collected in amber-stoppered bottles, labelled, and stored in a deep freezer until it was required for chemical analysis.

At the end of the digestibility trial, total nutrient intake (from experimental diets and *Panicum maximum*), apparent digestibility, and nitrogen utilization were determined using the formula below.

$$\text{Apparent digestibility (\%)} = \frac{[\text{Nutrient intake (g/day)} - \text{Nutrient faeces(g/day)}]}{\text{Nutrient intake (g/day)}} \text{ X } \frac{100}{1}$$

$$\text{Nitrogen retained (g/day)} = \text{Nitrogen intake (g/day)} - [\text{Faecal nitrogen (g/day)} + \text{Urinary nitrogen (g/day)}]$$

Growth Performance

The initial weight of the experimental does was determined at the onset of the experiment, and weekly weight changes were monitored using a weighing balance. Daily weight gain was determined by dividing total weight gain by the number of days, while the feed conversion ratio (FCR) was determined by dividing feed consumed (g) by weight gain (g). The protein efficiency was calculated by dividing the daily weight gain by daily crude protein intake as seen in the formula below.

$$\text{Protein efficiency} = \frac{\text{Daily weight gains (g/day)}}{\text{Daily crude protein intake (g/day)}}$$

Statistical Analysis

All the data generated were subjected to a one-way analysis of variance (ANOVA) using the general linear model procedure of Statistical Package for Social Sciences (SPSS) version 25, and significant differences were separated using the Duncan's Multiple Range Test (DMRT) of the same package. The level of significance was taken as 95% ($P<0.05$).

RESULTS

Chemical composition (%) of guinea grass (Panicum maximum) fed to WAD does

Dry matter, crude protein, ether extract, nitrogen-free extract, and crude fibre were found to be 26.83%, 8.30%, 3.79%, 53.93%, and 16.09%, respectively in the wilted *Panicum maximum* used in this study. The ash content of 6.76% and metabolizable energy of 2531.04 kcal/kg were obtained. The fibre fraction revealed that the acid detergent fibre, acid detergent lignin, neutral detergent fibre, cellulose, and hemicellulose content were to be 38.50%, 28.89%, 72.48%, 9.61%, and 33.98%, respectively.

Table 2: Chemical composition (%) of guinea grass (*Panicum maximum*) fed to WAD does

Nutrients	**Mean**	**SEM**
Dry matter	26.83	0.13
Crude protein	8.30	0.11
Ether extract	3.79	0.22
Nitrogen free extract	53.93	0.83
Crude fibre	16.09	0.19
Ash	6.76	0.34
Metabolizable energy (Kcal/kg)	2531.04	2.50
Fibre fraction		
Acid detergent fibre	38.50	0.50
Acid detergent lignin	28.89	0.11
Neutral detergent fibre	72.48	1.76
Cellulose	9.61	0.23
Hemicellulose	33.98	2.04

Values are mean of triplicates samples, n=3. SEM= Standard Error of Mean

Nutrient composition (%) of diets containing wheat offal replaced with tiger nut seed meal fed to WAD does

Table 3 represents the nutrient composition of the concentrate diets containing wheat offal replaced with tiger nut seed meals. Significant ($p < 0.05$) difference was observed across all parameters. The highest dry matter, nitrogen-free extract, and metabolizable energy content were obtained from diet T4, while the highest crude protein from diet T3. Ether extract, crude fibre and hemicellulose content of the diets increased progressively as the replacement level of tiger nut seed meal increased while ash, acid detergent fibre and acid detergent lignin decreased.

Table 3. Nutrient composition (%) of diets containing wheat offal replaced with tiger nut seed meal fed to WAD does

Parameters	Diets					SEM	p-value
	T1	T2	T3	T4	T5		
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	<0.01
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^{c}	43.01^{b}	39.98^{d}	45.42^{a}	42.86^{c}	0.51	<0.01
Crude fibre	15.87^{c}	15.75^{c}	16.82^{bc}	17.38^{b}	18.72^{a}	0.32	0.05
Ash	12.69^{a}	10.49^{b}	8.74^{c}	7.41^{d}	6.54^{e}	0.59	<0.01
Acid detergent fibre	15.17^{a}	11.81^{b}	9.18^{d}	10.26^{c}	9.55^{d}	0.59	<0.01
Acid detergent lignin	5.34^{a}	4.39^{b}	4.27^{c}	4.04^{d}	3.70^{e}	0.16	<0.01
Neutral detergent fibre	43.00^{a}	39.42^{b}	33.65^{d}	37.39^{c}	43.00^{a}	0.95	<0.01
Cellulose	9.84^{a}	7.42^{b}	4.91^{d}	6.22^{c}	6.08^{c}	0.46	<0.01
Hemicellulose	27.83^{b}	27.62^{b}	24.47^{c}	27.14^{b}	33.45^{a}	0.80	<0.01
Metabolizable energy (Kcal/kg)	2145.56^{b}	2241.92^{c}	2241.36^{b}	2320.09^{a}	2256.75^{b}	15.25	<0.01

Values are mean of quadruplicate samples, n=4
Means within the same row with different superscripts are significantly different ($P < 0.05$)
SEM= Standard Error of Mean
T1= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

Total nutrient intake (g/day) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Presented in Table 4 is the total nutrient intake (g/day) of WAD does fed concentrate diets containing varying levels of tiger nut seed meals as a replacement to wheat offal. Values obtained revealed significant ($p < 0.05$) difference except for the grass dry matter intake. The highest total dry matter, crude protein, and metabolizable energy intake were observed in does fed diet T3 while the least nitrogen-free extract and neutral detergent fibre intake were also obtained from does fed this diet. Does fed diet T5 had the highest crude fibre, ether extract, acid detergent lignin and hemicellulose intake. Ash and acid detergent fibre intake decreased as the replacement levels of tiger nut seed increased in the diets.

Table 4. Total nutrient intake (g/day) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

	Diets						
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**	**p-value**
Concentrate dry matter intake	212.36^{c}	220.45^{a}	220.97^{a}	216.55^{b}	207.70^{d}	1.22	<0.01
Grass dry matter intake	91.77	91.73	91.70	91.59	91.56	0.31	1.00
Total dry matter intake	304.13^{c}	312.18^{ab}	312.67^{a}	308.14^{bc}	299.26^{d}	1.28	0.01
Crude protein intake	55.96^{cd}	61.617^{b}	67.32^{a}	57.60^{c}	54.61^{d}	1.10	<0.01
Crude fibre intake	128.97^{b}	130.01^{b}	133.58^{a}	133.22^{a}	135.72^{a}	0.66	<0.01
Nitrogen-free extract intake	290.52^{b}	295.91^{ab}	289.87^{b}	299.60^{a}	292.69^{b}	1.13	0.04
Ether extract intake	20.13^{c}	20.57^{c}	21.87^{b}	21.67^{b}	22.67^{a}	0.23	<0.01
Ash intake	54.89^{a}	50.29^{b}	46.20^{c}	41.91^{d}	39.39^{e}	1.30	<0.01
Metabolizable energy intake (Kcal/kg/day)	13779.52^{c}	14215.36^{a}	14319.89^{a}	14287.95^{a}	14014.92^{b}	52.21	<0.01
Acid detergent fibre intake	169.68^{a}	162.22^{b}	155.84^{c}	157.47^{c}	155.21^{c}	1.30	<0.01
Acid detergent lignin intake	182.75^{d}	198.61^{c}	209.21^{b}	209.21^{b}	215.82^{a}	2.78	<0.01
Neutral detergent fibre intake	355.62^{a}	350.09^{ab}	336.52^{c}	342.57^{ab}	354.53^{a}	2.57	0.02
Cellulose intake	57.50^{a}	52.09^{b}	45.81^{d}	48.61^{c}	47.96^{c}	0.97	<0.01
Hemicellulose intake	185.94^{ab}	187.87^{ab}	180.68^{b}	185.10^{ab}	199.32^{a}	2.53	0.01

Values are mean of quadruplicate samples, n=4
[abcd] Means within the same row with different superscripts are significantly different ($P < 0.05$)
SEM= Standard Error of Mean
T1= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

Nutrient Digestibility (%) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

The percentage nutrient digestibility of diets containing wheat offal replaced with tiger nut seed meals is presented in Table 5. Parameters were significantly ($P < 0.05$) influenced except for dry matter, metabolizable energy and nitrogen-free extract digestibility. The highest crude protein, crude fibre, and cellulose digestibility were observed in does fed diet T3. Does fed diet T5 had the highest metabolizable energy, nitrogen free extract, acid detergent lignin digestibility. However, does placed on diet T1 had superior ash, neutral detergent fibre, acid detergent fibre, and hemicellulose digestibility.

Table 5. Nutrient Digestibility (%) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Parameters	Diets					SEM	p-value
	T1	T2	T3	T4	T5		
Dry matter	65.85	63.46	66.15	65.60	65.13	0.54	0.59
Crude protein	79.22^{ab}	72.16^{c}	80.84^{a}	80.23^{a}	75.26^{bc}	0.96	<0.01
Crude fibre	86.21^{a}	84.39^{b}	87.50^{a}	86.11^{a}	87.36^{a}	0.32	<0.01
Ether extract	77.88^{a}	81.54^{a}	72.44^{b}	77.43^{a}	81.02^{a}	0.91	<0.01
Ash	80.59^{a}	73.96^{b}	67.87^{c}	73.26^{b}	64.59^{c}	1.34	<0.01
Metabolizable Energy	78.97	78.46	79.51	79.37	79.91	0.31	0.69
Nitrogen free extract	78.89	78.78	79.95	79.05	80.02	0.35	0.72
Neutral detergent fibre	82.15^{a}	75.52^{d}	78.57^{bc}	80.61^{ab}	77.62^{cd}	0.63	<0.01
Acid detergent fibre	71.02^{a}	61.14^{b}	70.97^{a}	69.62^{a}	68.91^{a}	1.11	0.02
Acid detergent lignin	84.25^{b}	80.10^{d}	81.87^{c}	86.12^{a}	87.44^{a}	0.66	0.01
Hemicellulose	92.37^{a}	87.99^{ab}	84.92^{b}	90.02^{a}	84.44^{b}	0.92	0.01
Cellulose	64.48^{b}	54.79^{b}	84.04^{a}	61.37^{b}	55.90^{b}	3.03	<0.01

Values are mean of quadruplicate samples, n=4
^{abcd} Means within the same row with different superscripts are significantly different ($P < 0.05$)
SEM= Standard Error of Mean
T1= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

Nitrogen utilization (g/day) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Table 6 depicts the nitrogen utilization of WAD does fed diets containing wheat offal replaced with tiger nut seed meal. All parameters were significantly (P < 0.05) influenced by dietary treatments. Total dry matter intake, crude protein intake, nitrogen intake, nitrogen balance and percentage retention were superior in does fed diet T3. However, faecal and urinary nitrogen output was obtained from does fed diet T2.

Table 6. Nitrogen utilization (g/day) of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Parameters	Diets					SEM	p-value
	T1	T2	T3	T4	T5		
Total dry matter intake	304.13^{c}	312.18^{ab}	312.67^{a}	308.14^{bc}	299.26^{d}	1.28	0.02
Crude protein intake	55.96^{cd}	61.617^{b}	67.32^{a}	57.60^{c}	54.61^{d}	1.10	<0.01
Nitrogen intake	8.96^{cd}	9.86^{b}	10.77^{a}	9.22^{c}	8.74^{d}	0.18	<0.01
Faecal nitrogen	1.54^{b}	2.25^{a}	1.64^{b}	1.39^{b}	1.67^{b}	0.08	<0.01
Urinary nitrogen	0.30^{b}	0.49^{a}	0.43^{a}	0.43^{a}	0.49^{a}	0.02	<0.01
Nitrogen balance	7.11^{bc}	7.11^{bc}	8.71^{a}	7.40^{b}	6.58^{c}	0.19	<0.01
Nitrogen retention (%)	79.22^{ab}	72.16^{c}	80.84^{a}	80.23^{a}	75.26^{bc}	0.96	<0.01

Values are mean of quadruplicate samples, n=4
^{abcd}Means within the same row with different superscripts are significantly different (P < 0.05)
SEM= Standard Error of Mean
T1= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

Growth performance of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Table 7 presents the growth performance of WAD does fed diets containing wheat offal replaced with tiger nut seed meal. There was significant (P < 0.05) difference in all parameters except the initial, final weight and percentage survivability. The highest weight gain, daily weight gain, total dry matter intake and protein efficiency were recorded from does feed diet T3. However, does fed diet T1 had the highest feed conversion ratio and the least in does fed diet T3.

Table 7. Growth performance of WAD does fed diets containing wheat offal replaced with tiger nut seed meal

Parameters	Diets					SEM	p-value
	T1	T2	T3	T4	T5		
Initial weight (kg)	8.63	8.65	8.53	8.55	8.50	0.46	1.00
Final weight gain (kg)	10.98	11.38	11.88	11.10	11.03	0.42	0.97
Total weight gain (Kg)	2.35[b]	2.73[ab]	3.35[a]	2.55[b]	2.53[b]	0.12	0.04
Daily weight gain (g/day)	37.30[b]	43.25[ab]	53.18[a]	40.48[b]	40.08[b]	1.84	0.04
Total dry matter intake (g/day)	304.13[c]	312.18[ab]	312.67[a]	308.14[bc]	299.26[d]	1.28	0.02
Feed conversion ratio	8.15[a]	7.21[ab]	5.87[b]	7.61[ab]	7.47[ab]	0.20	<0.01
Protein efficiency	0.67[d]	0.70[c]	0.79[a]	0.70[c]	0.73[b]	0.01	0.04
Survivability	100.00	100.00	100.00	100.00	100.00	0.00	-

Values are mean of quadruplicate samples, n=4
[abcd] Means within the same row with different superscripts are significantly different ($P < 0.05$)
SEM= Standard Error of Mean
T1= 0.00% Tiger nut seed meal with 20.00% Wheat offal: (0.00% replacement) (Control diet)
T2= 5.00% Tiger nut seed meal with 15.00% Wheat offal: (25.00% replacement)
T3 = 10.00% Tiger nut seed meal with 10.00% Wheat offal (50.00% replacement)
T4 = 15.00% Tiger nut seed meal with 5.00% Wheat offal (75.00% replacement)
T5 = 20.00% Tiger nut seed meal with 0.00% Wheat offal (100.00% replacement)

RESULTS AND DISCUSSION

The low dry matter content (26.83%) obtained from the wilted *Panicum maximum* fed to WAD does in this study is likely due to its lush growth and early harvest maturity. Ajayi (2007) noted that dry matter content in pasture grass increases with maturity and lignification. The crude protein content of the grass was found to be 8.30%, which falls within the acceptable range for optimal ruminant performance and rumen function (Norton, 1994), though it is slightly lower than the value reported by Odedire and Babayemi (2016), and may reduce beyond this during dry season necessitating supplementation. The ash content, indicative of the mineral content in the grass, was found to be

6.76%, which is lower than the 12.00% reported by Odedire and Babayemi (2016) for Guinea grass. This discrepancy may be due to differences in soil nutrients, agronomic practices, stage of harvest, and post-harvest handling (Hornick, 1992). The nitrogen-free extract (53.93%) and crude fibre (16.09%) levels observed are sufficient to support rumination and provide energy to small ruminants (Castrillo, 2013). Fibre components, including acid detergent fibre, acid detergent lignin, neutral detergent fibre, cellulose, and hemicellulose, play a crucial role in feed intake, nutrient digestibility, and energy supply (Odedire and Babayemi, 2016). The hemicellulose (33.98%) and cellulose (9.81%) contents obtained align with the findings of Gillespie (1998) and it is more desirable to have higher hemicellulose content than cellulose, as it is more digestibility and utilized.

The dry matter content in the formulated diets was lower than the 89.60% reported by Belewu et al. (2007) when feeding graded levels of tiger nut seed. High dry matter content in diets is beneficial as it inhibits microbial growth and spoilage, thereby extending it shelf life with reduced nutrient deterioration. Crude protein content increased as wheat offal decreased up to diet T3 but declined when replacement level was below 10% in diets T4 and T5. This supports the findings of Usman et al. (2020) that wheat offal inclusion level below 10% result in lower crude protein levels in animal diets. However, the crude protein content in the diets exceeded the 7.00% critical requirement for maintenance in goats (NRC, 2007), with values above 10.00%, which is sufficient to support effective rumen microbial proliferation and activity, as suggested by Ibhaze (2016). The ether extract increased with the inclusion of tiger nut seed meals, and this is consistent with the findings of Belewu et al. (2007) who attributed this to the rich deposition of oil in raw tiger nut seed. The nitrogen-free extract which consist of monosaccharides, disaccharides, and starch ranged from 39.98% to 45.42%, providing readily available energy within the rumen. Crude fibre is essential for ruminant nutrition, having impact on rumination, salivation, rumen ecology, and rate of passage. Value obtained increase from 15.87% to 18.72%. These values are similar to those reported by Belewu et al. (2007) and exceed the minimum recommended 12.00% crude fibre for goats (Mamoon, 2008). The increase in crude fibre with higher levels of tiger nut seed meal is attributed to the high fibre content of raw tiger nut, as reported by Ogunlade et al. (2015). Ash content, ranging from 6.54% to 12.69%, decreased with higher replacement levels of tiger nut seed meal in this study, contrary to Abdullahi et al. (2020) observation. However, the mineral content remained adequate to support essential biological and physiological processes (McDowell, 1992). The metabolizable energy, ranging from 2145.56 to 2320.09 kcal/kg, increased with the substitution of tiger nut, providing sufficient energy for metabolic activities (Belewu et al. 2007). Notably, hemicellulose was higher than the cellulose content in the diets, which is favourable as hemicellulose is more digestible and provides more energy than cellulose (Gillespie, 1998).

Nutrient intake is influenced by factors such as protein quality, antinutrients in feed, palatability, and the form of presentation. In this study, the total dry matter intake (comprising both concentrate and grass) ranged from 299.26 to 312.67 g/day, which aligns with the range of 291.55 to 313.42 g/day reported by Ukanwoko et al. (2009). The protein intake across all treatments was sufficient to support microbial growth and proliferation, attributed to the high quality and quantity of crude protein in the experimental diets. This observation is consistent with Asaolu et al. (2012), who reported that an increase in dietary crude protein results in higher dry matter and crude protein intake. The increased intake of crude fibre can be linked to the active microbial degradation process, which produces volatile fatty acids (VFAs) and keto acids absorbed in the abomasum and small intestine (Ali et al., 2014). Goats as been reported to consume feed to meet their energy requirements, usually influence by nitrogen-free extract and ether extract intake, which are critical for better overall feed intake. The high nitrogen-free extract and ether extract obtained could be attributed to the presence of non-drying oil in the rhizome of tiger nuts (Tigernut and Health, 2005). The high intake of fibre fractions may be due to the lignocellulose content of the feed materials with neutral detergent fibre and acid detergent fibre intake increasing with higher dry matter and crude protein intakes, corroborating the findings of Erika and Anurga (2015). However, nutrient intake is also influenced by factors such as the age of the goats, weather condition, the efficiency and activity of rumen microbes, nutrient composition of the diet, and lot more (Asaolu et al., 2012).

The digestibility of feeds indicates the percentage of nutrients that are available and utilized by animals. In this study, both dry matter and crude protein digestibility increased with higher crude protein intake. This finding was inline with the report of Omotoso et al. (2017), who reported a positive relationship between dry matter and crude protein digestibility and the quality and intake of crude protein in ruminants. The improved digestibility can be attributed to the enhanced activity of microorganisms, which thrive on high-protein diets and thus more effectively degraded. According to Fapohunda et al. (2022), the digestibility of cell wall components and cellulose is influenced by the feed's lignification level, as high lignification impedes the optimal performance of rumen microbial flora. In this study, fibre fraction digestibility exceeded 50.00%, indicating a relatively high level of utilization. This suggests that the feed contained a significant amount of digestible material and organic matter, which was effectively broken down by rumen microbes, facilitating nutrient utilization. This high digestibility supports the animals' body maintenance and growth, as noted by Ezimoha and Nsidinanya (2021).

Evaluating nitrogen utilization provides insights into both the quantity of crude protein and its retention rate (Ibhaze and Fajeminsin, 2015). In this study, does with higher nitrogen intake also had higher dry matter and crude protein intake, which may imply a positive correlation. Does fed diet T3 exhibited the highest daily nitrogen intake and utilization, likely due to balanced inclusion of tiger nut seed meal and wheat offal in this diet. Thus, enhancing protein quality and nitrogen availability in the diet as against other test diets. According to Chukwu et al. (2022), diets with balanced crude protein supply promote crude and dry matter intake, resulting in improved nitrogen utilization and retention efficiency. Ibhaze and Fajemisin (2015), opined that increased crude protein in diets boosts nitrogen intake, thereby supporting microbial growth and protein synthesis in the rumen. The urinary and fecal nitrogen values observed in this study differ from those reported by Zhu et al. (2020), which indicated lower dry matter and crude protein intake leading to reduced nitrogen excretion and lower nitrogen levels in urine. The high nitrogen retention (80.84%) in does fed diet T3 suggests that the nitrogen content in the diet was efficiently digested, absorbed, and utilized for physiological activities. Therefore, incorporating tiger nut seed meal at a 10% level can enhance nitrogen intake, utilization, and retention in WAD does.

Weight gain and overall performance in livestock are influenced by feed palatability, protein quality and quantity, dry matter intake, nutrient digestibility, anti-nutrient composition, and nitrogen utilization (Ibhaze and Fajeminsin, 2015). The highest weight gain (3.35 kg) was observed in does fed diet T3, this can be attributed to the optimal nutrient availability and crude protein content in the diet (Ibhaze et al., 2022; Omotoso et al., 2019). It can be inferred that the inclusion of tiger nut seed meal at a 10.00% replacement level significantly contributed to weight gain. However, beyond this level, weight gain decreased, this is consistent with the findings of Ukpadi et al. (2019), who reported that tiger nut substitution above 12% does not significantly enhance the weight of grower pigs. Thus, feeding tiger nut seed meal at a 10.00% replacement level to wheat offal can enhance voluntary feed intake, nutrient digestibility, metabolism, and total weight gain in West African Dwarf (WAD) goats. The feed conversion ratio (FCR) indicates the efficiency of an animal in converting feed into body weight. Does on diet T3 exhibited the lowest FCR (5.87), demonstrating their ability to utilize a smaller amount of feed to gain a unit of weight (Oderinwale et al., 2020). Protein efficiency ratio (PER) measures the effectiveness of protein utilization for weight gain, with does on diet T3 showing the highest protein efficiency (0.79). Factors influencing FCR, PER and overall animal performance include breed, age, production status, sex, nutrition, and environment (Gaillard et al., 2020). The absence of mortality during the study indicates that the diets were not containing harmful constituent or high antinutrients, thus safe and able to support their maintenance and growth without any health complications.

Conclusion

The results of this study revealed that higher nutrient intakes, digestibility, nitrogen utilization and growth performance could be achieved and sustained by replacing wheat offal for tiger nut seed meal at 10.00% on a weight-to-weight bases. Therefore, incorporating tiger nut seed meal when formulating diets for goat would serve as a better alternative feed resource during the dry season and could be adopted by goat farmers in Nigeria.

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