Research Article

Growth Performance and Carcass Characteristics of West African Dwarf Goats Fed Cassava Peel-based Ration Supplemented with Enzymes

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Abstract | The study was conducted to evaluate African dwarf (WAD) goats' growth performance and carcass features fed cassava peel-based rations supplemented with three different fibrolytic enzymes. A total of 48 WAD goats, weighing 6.55±0.09 Kg on average, were procured and randomly allocated to eight treatment groups, based on a 2 x 4 factorial experimental design. The two factors were sex (buck and doe) and experimental diet (D1, D2, D3 and D4). All the experimental diets had equal composition of feed ingredients except for type of enzyme. The feeding trial lasted for 90 days. Data was collected on growth performance and carcass characteristics of the experimental animals. The results indicated that diet and sex had a significant effect (P<0.05) on average daily weight gain (ADWG) and feed conversion ratio (FCR). Among the goats, those on Diet 4 (D4) exhibited the highest ADWG (60g) and the lowest FCR (5.09), while bucks showed higher ADWG (49g) and lower FCR (6.70) compared to does. Additionally, both diet and sex significantly influenced dressing percentage, with goats in D4 (61.24%) and bucks (55.29%) having the highest percentages. Diet did not have a significant effect (P>0.05) on the weight of meat cuts as a percentage of warm carcass weight but did have a significant effect (P<0.05) on the weights of edible offal and organs as percentages of empty body weights. The study concludes that feeding WAD goats with cassava peel-based rations supplemented with exogenous enzymes results in significantly higher (P<0.05) ADWG, low FCR and high dressing percentages with Diet 4 [containing beta-glucanase (6,157 U/g), cellulose (2,222 U/g) and xylanase (23,222 U/g)] that given the best results. It further confirms that buck performs better than does because they have higher ADWG, lower FCR and higher dressing percentage.

Keywords | Cassava peels, Elephant grass, Fibrolytic enzymes, Growth performance, Carcass characteristics

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INTRODUCTION

Goat is believed to be the first ruminant to be domesticated and this happened about 10,000 years ago, in the western mountains of Iran (Pérez-Barbería, 2020). Since then, the goat population has increased with the increase in human population, probably because poor smallholder farmers find it suitable for diversifying sources of their income and nutrition. Goats exhibit a very high productivity potential that, if well promoted, can easily help to improve the rural economy within a very short time (Chiejina and Behnke, 2012). Unfortunately, the goat industry has not followed the same path of development and intensification as other livestock, because the subsistence farmer's mindset is yet to be transformed from the traditional practice of using it as a "savings asset" to managing goats as a "productive asset". The most important component of managing goats as productive assets is feed and maximum profit is dependent on feeding high quality, fresh, and nutritious feed (Adekanbi et al., 2020). The seasonal fluctuation in quality and quantity of fodder and roughage, along with the rising cost of conventional feed ingredients, has led farmers to turn to cost-effective alternatives such as agricultural waste. Cassava peel meal has shown favorable comparisons with spent grain, corn husk meal, and plantain peel meal when utilized in livestock feeds (Sorhue et al., 2022). According to Amole, (2024), cassava peels has desirable prospects as source of fiber and other important nutrients needed for livestock production, especially ruminants, however, the processing methods, deficiencies in storage patterns, and the chances of been contaminated by aflatoxin, limits its usage, though when treated efficiently, acceptable aflatoxin levels below of 18-20ppm can be obtained. Cassava peel meals contains between 4-5.5% crude protein, 77-78% starch, and 0.8-1.7% crude fat, 1.26-2.74% ash (Otache et al., 2017; Amole, 2024). Research have shown that supplementing agricultural waste with fibrolytic enzymes improves nutrient absorption, feed utilization, and ruminant animal performance (Wahyuni, 2012; Mendoza et al., 2014; Thammiah et al., 2017), but research data on growth performance and carcass characteristics of WAD goats fed cassava peel-based rations supplemented with different locally available fibrolytic enzymes is scanty, thus justifying this study. The study was therefore designed to evaluate the growth performance and carcass characteristics of WAD goats fed cassava peel-based rations supplemented with three different fibrolytic enzymes.

MATERIALS AND METHODS

Experimental Site, Design, Animals and Management

The study was conducted at the Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Delta State University, Abraka, Delta State, Nigeria. The experimental design was a 2 x4 Factorial Experimental Design in a completely randomized design (CRD). The two factors were sex (buck and doe) and experimental diet (4 types). The experimental diets includes: D1= control diet (without enzyme); D2= experimental diet with enzyme product containing protease (1000 U/g), phytase (5000 U/g), xylanase (2000 U/g), mannanase (10 U/g) and amylase (1000 U/g); D3= experimental diet with enzyme product containing protease (1000 U/g), beta-glucanase (6,157 U/g), cellulose (2,222 U/g) and xylanase (23,222 U/g); and D4 = experimental diet with enzyme product containing beta-glucanase (6,157 U/g), cellulase (2,222 U/g) and xylanase (23,222 U/g).

A total of 48 WAD goats, weighing 6.55±0.09 Kg, were procured and quarantined for 21 days after which they were randomly allocated to 8 treatment groups based on the 2 x 4 factorial design. The feeding trial lasted for 90 days.

Collection and Preparation of Experimental Ration

The exogenous enzymes were obtained from feed supplement companies. The cassava peels were gathered from cassava processing plants in Abraka. They were washed and sun dried to constant weight, for a period of 5 days. The elephant grass was harvested from the surroundings too and sun-dried to constant weight for 5 days. Other components of the ration were procured from local feed dealers. The cassava peels and elephant grass were ground coarsely in a hammer mill that was locally fabricated to produce one tone of feed per hour, and, thereafter, measured out with other feed ingredients, in accordance with their various inclusion rates. The resultant mixture was ground smoothly in a hammer mill, thoroughly mixed for 30 minutes, and pelleted at an average of 8mm diameter and 20mm length. The gross composition of the experimental diets is shown in Table 1.

Data Collection

Growth performance: The following growth performance data were collected and/or computed:

i. Initial body weight: Weight of the goats taken at the beginning of the experiment.

ii. Weekly weight gain: Weights taken weekly (on Saturday morning before feeding) minus that of preceding.

iii. Final body weight: Weight taken at the end of the experiment.

iv. Total body weight gain: Final body weight minus initial body weight for each animal.

v. Average daily weight gain: Total body weight gain divided by 90 (experimental days).

vi. Daily feed intake/animal: Weight of feed offered minus weight of leftover feed divided by 2 (number of animals/replicate).

vii. Total feed intake/animal: Summation of daily feed intake for 90 days.

viii. Average daily feed intake: Total feed intake divided by 90.

ix. Feed conversion ratio: This was computed as the ratio of feed intake to weight gain.

$$FCR = \frac{\text{Total feed intake}}{\text{Total weight gain}}$$

Carcass evaluation: At the end of the 90 days feeding trial, 24 goats (three per treatment group) whose body weights are close to the mean of each treatment groups were selected for carcass evaluation. They were fasted for 24 hours during which they were given plenty of water. Just before slaughtering they were weighed to obtain the live weight. Slaughtering was done as described by Anya and Ozung (2018). The goats bled by slitting the throats with a sharp knife and then articulation with the atlas bones. The following carcass parameters were evaluated:

i.Live weight at slaughter, empty body weight, warm carcass weight, and dressing percentage. Dressing percentage was computed using the following formula:

$$\frac{\text{Warm carcass weight}}{\text{Live weight}} \times 100$$

ii. Meat cuts (leg/thigh, loin, shoulder, sets and ends) were obtained by joining the carcass according to the procedure described by Anya and Ozung (2018). This involved the division of the dressed warm carcass down the spinal column by means of a meat saw. Each half was weighed separately, and the left half divided into various meat cuts as follows:
a.The Thigh (leg) was cut out at the attachment of the femur to the acetabulum,
b. the Loin consist of the lumbar region plus a pair of ribs,
c. the Shoulder consist of the scapula, humerus, radius, ulna and carpals,
d. the Sets was made up of the breast and the neck and
e. the Ends (spareribs plus belly) consist of six (6) abdominal ribs,
Each of the cuts were weighed and the weights doubled before being expressed as percentages of the warm carcass weights.

iii. Offal weights (head, skin, feet, empty guts, and genitals) were taken and expressed as percentages of empty body weights.
iv.Organ weights (liver, lungs, kidneys, heart, and spleen) was taken and expressed as percentages of empty body weights.
v. Bone to meat ratio. The leg and loin cuts were dissected into muscles and bone, weighed and the weights pooled to obtain the bone to meat ratio.
Statistical analysis
Data obtained from the study were statistically analyzed using the general linear model procedure for two-way analysis of variance (ANOVA) adopted by IBM SPSS Statistics for windows (IBM, 2017) according to the following model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}$$

Where: Y_{ijk} = dependent variable (parameter under analysis), μ=population mean, α_i = main effect of factor A (experimental diet),β_j = main effect of factor B (sex),$(\alpha\beta)_{ij}$ = interaction effect of both factors,ϵ_{ijk} = experimental or residual error.

Duncan's multiple range test in the same statistical package was used to separate significantly different means at 5% level of significance.

RESULTS

Growth performance of the experimental animals

The main effect of experimental diets and sex on growth performance of experimental animals is presented in Table 2. The results show that diet had significant effect ($P<0.05$) on final body weight (FBW), total body weight gain (TBWG), average daily weight gain (ADWG), average daily feed intake (ADFI) and feed conversion ratio (FCR). FBW, TBWG, ADWG increased significantly ($P<0.05$) from D1 to D4 with D4 being the highest, while FCR decreased significantly ($P<0.05$) from D1 to D4. The FBW of goats in D4 (11.93kg) was significantly higher ($P<0.05$) than D1, D2, and D3 (10.4 to 10.73). The TBWG of goats in D4 (5.55kg) was significantly higher than D1 (3.61kg), D2 (4.28 kg), and D3 (4,24kg) while D2 and D3 were not significantly different ($P>0.05$) from each other, but were significantly higher ($P<0.05$) than D1 (3.61kg). Similarly, the ADWG of goats in D4 (0.060kg or 60g) was significantly higher ($P<0.05$) than those on D2 (0.046kg or 46g) and D3 (0.045 or 45g), both of which were significantly higher ($P<0.05$) than D1 (0.039 or 39g). The results show that TBWG, ADWG, and FCR varies significantly ($P<0.05$) with sex, bucks had higher TBWG and ADWG, and lower FCR than does.

The interaction effect of experimental diet and sex on growth performance of WAD goats is shown in Table 3. The result shows that diet and sex had no interaction effect ($P>0.05$) on growth performance parameters.

Carcass characteristics

The main effect of the experimental diet and sex on carcass characteristics of WAD goats is on Table 4. The results show that diet had significant effect ($P<0.05$) on practically all carcass characteristics measured (live weight, bled weight, empty body weight, warm carcass weight, dressing percentage, leg, shoulder, loins, sets, ends, head, skin, feet, tail, liver, kidney, heart, spleen, lung and trachea, bone, muscle and fat and bone to meat ratio). Goats in D4 had the highest values for all parameters except for bone-to-meat ratio where they were next to the lowest after D3. Sex varied significantly ($P<0.05$) with warm carcass weight, dressing percentage, leg, loins, sets and ends with bucks having higher values than does.

The interaction effect of experimental diet and sex on carcass characteristics of the experimental animals is presented in Table 5. The results shows that diet and sex had no interaction effect on carcass characteristics of WAD goats except for bone to meat ratio ($P<0.05$).

The main effect of the experimental diet and sex on weight

Table 1: Gross composition of Experimental diets

Feed ingredients	Inclusion (percentage)			
	D1	D2	D3	D4
Cassava peels	35	35	35	35
Elephant grass	20	20	20	20
Rice bran	13.5	13.465	13.465	13.465
Palm kernel meal	15	15	15	15
Soybean meal (SBM)	3	3	3	3
Urea	1.5	1.5	1.5	1.5
Limestone	5	5	5	5
Salt	1	1	1	1
Premix	1	1	1	1
Molasses	5	5	5	5
Exogenous enzyme	0	0.035	0.035	0.035
Total (%)	100	100	100	100

Note: D1 = control diet (without enzyme).
D2 = experimental diet with enzyme product containing protease (1000 U/g), phytase (5000 U/g), xylanase (2000 U/g), mannanase (10 U/g) and amylase (1000 U/g).
D3= experimental diet with enzyme product containing protease (1000 U/g), beta-glucanase (6,157 U/g), cellulose (2,222 U/g) and xylanase (23,222 U/g).
D4 = experimental diet with enzyme product containing beta-glucanase (6,157 U/g), cellulase (2,222 U/g) and xylanase (23,222 U/g).

Table 2: Main effect of the experimental diets and sex on growth performance of WAD goats

Parameters	Experimental diets						Sex			
	D1	D2	D3	D4	±SEM	P-value	Buck	Doe	±SEM	P-value
Initial body weight (kg)	6.84	6.48	6.50	6.39	0.19	0.397	6.50	6.60	0.14	0.616
Final body weight (kg)	10.46[b]	10.69[b]	10.73[b]	11.93[a]	0.19	0.000	11.12	10.78	0.14	0.103
Total body weight gain (kg)	3.61[c]	4.28[b]	4.24[b]	5.55[a]	0.04	0.000	4.65[a]	4.19[b]	0.03	0.000
Total feed intake (kg)	29.84	29.99	27.95	27.50	0.73	0.055	29.07	28.07	0.51	0.497
Average daily weight gain (kg)	0.04[c]	0.46[b]	0.045[b]	0.06[a]	0.00	0.000	0.049[a]	0.046[b]	0.00	0.004
Average daily feed intake (kg)	0.33[a]	0.34[a]	0.31[b]	0.31[b]	0.01	0.036	0.322	0.319	0.00	0.762
Feed conversion ratio	8.28[a]	7.41[b]	6.97[b]	5.09[c]	0.22	0.000	6.70[b]	7.17[a]	0.00	0.048

Values are presented as means ± standard error

[abcd]Means in the same row with different superscript differ significantly ($P<0.05$)

Table 3: Interaction effect of the experimental diet and sex on growth performance of WAD goats

Parameters	Experimental diets									
	D1 (Control)		D2		D3		D4		±SEM	P-value
	Buck	Doe	Buck	Doe	Buck	Doe	Buck	Doe		
Initial body weight (kg)	6.85	6.83	6.31	6.64	6.50	6.48	6.34	6.44	0.27	0.904
Final body weight (kg)	10.63	10.29	10.72	10.66	11.01	10.44	12.11	11.75	0.27	0.829
Total body weight gain (kg)	3.76	3.46	4.53	4.02	4.53	3.95	5.79	5.31	0.06	0.134
Total feed intake (kg)	30.23	29.45	30.29	29.70	28.43	27.46	27.34	27.67	1.03	0.922
Av. daily weight gain (kg)	0.040	0.039	0.049	0.043	0.047	0.042	0.061	0.059	0.00	0.324
Av. daily feed intake (kg)	0.333	0.323	0.333	0.343	0.313	0.303	0.307	0.307	0.01	0.792
Feed conversion ratio	8.27	8.29	6.76	8.05	6.77	7.18	5.01	5.17	0.311	0.212

Note: Values are presented as means ± standard error.

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Table 4: Main effect of the experimental diets and sex on carcass characteristics of WAD goats

Parameters	Experimental diets						Sex			
	D1	D2)	D3	D4	SEM±	P-value	Buck	Doe	±SEM	P-value
Live weight (kg)	10.51[b]	10.74[b]	10.91[b]	11.85[a]	0.21	0.002	11.11	10.89	0.15	0.309
Bled weight (kg)	10.04[b]	10.28[b]	10.56[b]	11.54[a]	0.21	0.001	10.66	10.54	0.15	0.572
Empty body weight (kg)	8.04[b]	8.18[b]	8.48±[b]	9.26[a]	0.17	0.000	8.50	8.49	0.12	0.949
Warm carcass weight (kg)	5.17[d]	5.62[c]	5.96[b]	7.25[a]	0.11	0.000	6.17[a]	5.83[b]	0.08	0.008
Dressing percentage (%)	49.23[d]	52.30[c]	54.65[b]	61.24[a]	0.73	0.000	55.29[a]	53.42[b]	0.51	0.020
Leg (kg)	1.73[c]	1.88[c]	2.02[b]	2.46[a]	0.05	0.000	2.09[a]	1.95[b]	0.03	0.010
Shoulder (kg)	1.47[d]	1.59[c]	1.68[b]	2.00[a]	0.03	0.000	1.71±	1.66	0.02	0.061
Loins (kg)	0.76[c]	0.83[b]	0.85[b]	1.07[a]	0.02	0.000	0.90[a]	0.87[b]	0.01	0.015
Sets (kg)	0.62[c]	0.67[bc]	0.73[b]	0.86[a]	0.02	0.000	0.74[a]	0.69[b]	0.02	0.046
Ends (kg)	0.61[d]	0.66[c]	0.70[b]	0.851[a]	0.01	0.000	0.72[a]	0.68[b]	0.01	0.006
Head (kg)	0.81[c]	0.80[c]	0.89[b]	1.03[a]	0.02	0.000	0.88	0.89	0.02	0.813
Skin (kg)	0.64[b]	0.65[b]	0.64[b]	0.76[a]	0.02	0.000	0.67	0.67	0.01	0.823
Feet (kg)	0.26[c]	0.26[bc]	0.28[b]	0.32[a]	0.010	0.000	0.28	0.28	0.00	0.559
Tail (kg)	0.02[b]	0.02[b]	0.02[b]	0.05[a]	0.00	0.000	0.03	0.03	0.00	0.593
Empty gut (kg)	0.94	1.04	1.05	1.02	0.05	0.468	1.06	0.97	0.04	0.109
Liver (kg)	0.141[c]	0.15[bc]	0.16[b]	0.20[a]	0.01	0.000	0.16	0.16	0.01	0.900
Kidney (kg)	0.05[c]	0.06[c]	0.06[b]	0.07[a]	0.00	0.000	0.06	0.06	0.00	0.866
Heart (kg)	0.06[c]	0.06[c]	0.06[b]	0.07[a]	0.00	0.000	0.06	0.06	0.00	0.389
Spleen (kg)	0.01[c]	0.01[c]	0.013[b]	0.01[a]	0.00	0.000	0.01	0.01	0.00	0.301
Lung + trachea	0.12[d]	0.14[c]	0.15[b]	0.17[a]	0.00	0.000	0.14	0.15	0.00	0.577
Bone (kg)	0.40[b]	0.41[b]	0.43[b]	0.46[a]	0.01	0.001	0.43	0.42	0.01	0.590
Muscle + fat (meat) (kg)	2.11[c]	2.18[c]	2.35[b]	2.56[a]	0.05	0.000	2.30	2.30	0.04	0.949
Bone : meat ratio	0.19[a]	0.19[ab]	0.18[b]	0.18[b]	0.00	0.027	0.19	0.18	0.00	0.320

Values are presented as means ± standard error
[abcd] Means in the same row with different superscript differ significantly (P<0.05).

Table 5: Interaction effect of the experimental diet and sex on carcass characteristics of WAD goats fed experimental diets

Parameters	Experimental diets								SEM±	P-value
	D1 (Control)		D2		D3		D4			
	Buck	Doe	Buck	Doe	Buck	Doe	Buck	Doe		
Live weight (kg)	10.66	10.35	10.63	10.84	11.06	10.76	12.10	11.61	0.30	0.680
Bled weight (kg)	10.10	9.99	10.19	10.37	10.70	10.35	11.64	11.44	0.29	0.827
Empty body weight (kg)	8.01	8.07	8.05	8.31	8.65	8.31	9.27	9.24	0.24	0.646
Warm carcass weight (kg)	5.26	5.07	5.60	5.63	6.34	5.59	7.46	7.03	0.16	0.124
Dressing percentage (%)	49.35	49.11	52.69	51.91	57.29	52.01	61.83	60.64	1.03	0.094
Leg (kg)	1.76	1.69	1.87	1.88	2.14	1.90	2.58	2.35	0.07	0.193
Shoulder (kg)	1.49	1.44	1.59	1.60	1.78	1.58	1.99	2.01	0.04	0.050
Loins (kg)	0.77	0.74	0.83	0.82	0.89	0.81	1.10	1.04	0.02	0.400
Sets (kg)	0.63	0.60	0.66	0.67	0.80	0.66	0.87	0.84	0.03	0.130
Ends (kg)	0.62	0.59	0.65	0.66	0.74	0.66	0.87	0.83	0.02	0.109
Head (kg)	0.83	0.79	0.78	0.82	0.87	0.91	1.04	1.02	0.03	0.549
Skin (kg)	0.64	0.63	0.64	0.66	0.64	0.64	0.76	0.76	0.02	0.867
Feet (kg)	0.26	0.25	0.25	0.27	0.29	0.26	0.32	0.32	0.01	0.092
Tail (kg)	0.02	0.01	0.03	0.02	0.02	0.03	0.05	0.04	0.00	0.246

Empty gut (kg)	1.01	0.87	1.00	1.07	1.12	0.99	1.10	0.94	0.08	0.411
Liver (kg)	0.14	0.14	0.15	0.15	0.16	0.16	0.20	0.20	0.01	0.962
Kidney (kg)	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.00	0.836
Heart (kg)	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.00	0.925
Spleen (kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.910
Lung + trachea	0.12	0.13	0.13	0.14	0.15	0.15	0.17	0.17	0.01	0.624
Bone (kg)	0.41	0.40	0.40	0.42	0.44	0.42	0.47	0.46	0.01	0.350
Muscle + fat (meat) (kg)	2.07	2.14	2.18	2.17	2.39	2.32	2.54	2.57	0.07	0.809
Bone : meat ratio	0.20	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0.00	0.014

Note: Values are presented as means ± standard error
[abcd] Means in the same row with different superscript differ significantly (P<0.05).

Table 6: Main effect of the experimental diets and sex on weights of meat cuts as percentage of warm carcass weight and weights of edible offal and organs as percentages of empty body weight

Parameters	Experimental diets						Sex			
	D1	D2	D3	D4	±SEM	P-value	Buck	Doe	SEM±	P-value
Meat cuts as percentage of warm carcass weight										
Leg (kg)	33.40	33.39	33.81	33.80	0.19	0.247	33.68	33.52	0.14	0.403
Shoulder (kg)	28.36	28.41	28.16	28.13	0.16	0.533	28.13	28.40	0.11	0.118
Loins (kg)	14.68	14.69	14.29	14.79	0.19	0.277	14.55	14.68	0.13	0.516
Sets (kg)	11.91	11.90	12.34	11.80	0.17	0.140	12.06	11.91	0.12	0.367
Ends (kg)	11.71	11.67	11.71	11.73	0.05	0.843	11.69	11.72	0.04	0.489
Edible offal as percentage of empty body weight										
Head (kg)	10.09^{bc}	9.82^{c}	10.48^{b}	11.14^{a}	0.20	0.002	10.34	10.42	0.14	0.717
Skin (kg)	7.94^{a}	7.98^{a}	7.57^{b}	8.21^{a}	0.10	0.004	7.90	7.95	0.07	0.611
Feet (kg)	3.19^{b}	3.20^{b}	3.26^{b}	3.50^{a}	0.05	0.001	3.30	3.27	0.03	0.486
Tail (kg)	0.23^{c}	0.32^{b}	0.25^{bc}	0.48^{a}	0.02	0.000	0.32	0.31	0.02	0.710
Empty gut (kg)	10.24	12.59	12.37	11.00	1.23	0.494	11.65	11.45	07	0.868
Organs as percentage of empty body weight										
Liver (kg)	1.72^{b}	1.75^{b}	1.78^{b}	2.14^{a}	0.09	0.014	1.836	1.86	0.06	0.735
Kidney (kg)	0.67^{c}	0.68^{c}	0.72^{b}	0.76^{a}	0.09	0.000	0.70	0.71	0.01	0.575
Heart (kg)	0.70	0.69	0.56	0.76	0.06	0.149	0.68	0.67	0.04	0.942
Spleen (kg)	0.15	0.151	0.16	0.16	0.01	0.430	0.15	0.15	0.04	0.520
Lung + trachea	1.52^{c}	1.65^{b}	1.79^{a}	1.85^{a}	0.04	0.000	1.69	1.72	0.03	0.472

Values are presented as means ± standard error
[abcd] Means in the same row with different superscript differ significantly (P<0.05).

Table 7: Interaction effect of the experimental diet and sex on meat cuts as percentage of warm carcass weight and edible offal and organs as percentages of empty body weight

Parameters	Experimental diets									
	D1 (Control)		D2		D3		D4		SEM±	P-value
	Buck	Doe	Buck	Doe	Buck	Doe	Buck	Doe		
Meat cuts as percentage of warm carcass weight										
Leg (%)	33.37	33.42	33.43	33.35	33.68	33.93	34.23	33.36	0.30	0.211
Shoulder (%)	28.37	28.35	28.43	28.38	28.05	28.27	27.67	28.58	0.27	0.162
Loins (%)	14.69	14.67	14.75	14.63	14.01	14.56	14.75	14.83	0.27	0.608
Sets (%)	11.91	11.91	11.84	11.97	12.80	11.87	11.71	11.89	0.23	0.096

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Ends (%)	11.72	11.71	11.66	11.67	11.67	11.75	11.69	11.76	0.07	0.909
Edible offal as percentage of empty body weight										
Head (%)	10.39	9.79	9.78	9.87	10.02	10.94	11.19	11.08	0.29	0.716
Skin (%)	8.03	7.85	7.95	7.98	7.41	7.74	8.20	8.23	0.15	0.401
Feet (%)	3.22	3.15	3.15	3.25	3.35	3.17	3.49	3.50	0.07	0.250
Tail (%)	0.28	0.18	0.33	0.30	0.20	0.30	0.48	0.48	0.03	0.052
Empty gut (%)	9.71	10.76	12.25	12.92	12.88	11.86	11.76	10.24	1.74	0.852
Organs as percentage of empty body weight										
Liver (%)	1.73	1.71	1.80	1.70	1.63	1.93	2.16	2.12	0.13	0.414
Kidney (%)	0.66	0.67	0.68	0.68	0.71	0.72	0.75	0.76	0.01	0.980
Heart (%)	0.71	0.68	0.70	0.67	0.54	0.58	0.76	0.7	0.08	0.971
Spleen (%)	0.15	0.15	0.15	0.15	0.15	0.16	0.15	0.16	0.01	0.932
Lung + trachea (%)	1.46	1.58	1.66	1.64	1.77	1.81	1.86	1.84	0.05	0.530

Note: Values are presented as means ± standard error

[abcd] Means in the same row with different superscript differ significantly (P<0.05)

of meat cuts as percentage of warm carcass weight and weights of offal and organs as percentages of empty body weight is shown in Table 6. Diet had no significant effect (P>0.05) on the weight of meat cuts as percentage of warm carcass weight. Diet had significant effect (P<0.05) on the weight of most of the edible offals (head, skin, feet, and tail) as percentage of empty body weight. Goats in D4 had the highest values for most of the meat cuts viz head (11.14kg), skin (8.21kg), feet (3.50kg) and tail (0.48kg). Diet had significant effect (P<0.05) on the weights of some organs (liver, kidney and lung and trachea) as percentages of empty body weight with goats in D4 having higher values than others.

The interaction effect of diet and sex on weights of meat cuts as percentage of warm carcass weight and offal and organs as percentage of empty body weight is presented in Table 7. Diet and sex had no interaction effect (P>0.05) on the weight of meat cuts as percentage of warm carcass weight and no interaction effect (P>0.05) on weights of edible offals and organs as percentages of empty body weights.

DISCUSSION

Growth performance of the experimental animals

The ADWG of 60g obtained for WAD goats in D4 was higher than the maximum ADWG of 44.44g reported by Adekanbi et al. (2020) for goats fed graded levels of malted sorghum sprouts with enzyme supplementation, and 30.51g reported by Saka et al. (2016) for goats given meals that included varying amounts of fermented and raw roasted sorghum seed. It was, however, comparable to the value of 60g reported by Imasuen and Ogendegbe (2014) for intensively raised goats but lower than the maximum value of 68.20g reported by Oyewole and Aderinola (2019) for WAD goats fed varying mixtures of grass-legume pellet. Wahyuni et al. (2012) reported that goats fed enzyme supplemented oil palm frond-based diet did not show significant differences (p>0.05) in dry matter intake (DMI) and average NH3-N concentration but higher ADG and better feed per gain ratio as compared with control. The results obtained in this study indicates that the use of enzymes in goat feed when feeding poor quality forage have positive effect on weight gain, which in line with report that fibrolytic enzymes increased weight gain in steers (Adekanbi et al., 2020). The FCR for WAD goats in D4 (5.09) was better than the values of 13.11-14.83 reported by Adekanbi et al. (2020), 7.89-15.90 by Saka et al. (2016), 11.95 by Yousuf and Adeloye (2011) and 12.6-14.66 by Imasuen and Ogedegbe (2014). It was also better than the best value of 6.47 reported by Oyewole and Aderinola (2019). This shows that supplementing goat ration with enzyme product containing beta-glucanase cellulose and xylanase (D4) at 0.35g/kg DM will result in better growth performance and better feed conversion efficiency than supplementing with D2 (containing protease, phytase, xylanase and mannanase) and D3 (containing beta-glucanase, cellulase and xylanase).

Birteeb et al. (2015) reported that sex of goat kid had no significant effect (p>0.05) on birth weight, yearling weight, and post-weaning growth rate for growth performance of WAD goats reared in the transitional zone of Ghana. Both male and female kids were very comparable in these traits. From birth to one year of age, Abergele goat kids in Ethiopia showed statistically identical male and female offspring (Deribe and Taye, 2013). Nonetheless, there are notable birth disparities amongst male and female goats, according to Akusu and Ajala (2000). Male kids' pre-weaning growth rates were substantially (p = 0.036) greater than those of female kids, and this translated into male kids' weaning weights being significantly (p = 0.031) higher. Concerning Ghanaian WAD goats, this subsequent paper concurs with Turkson et al. (2004) results. Males are superior in this instance because they are more active than females, which give them more access to their mother's milk and cause them to develop faster.

The better growth performances of goats on diet 3 and diet 4 was because the diets contained the major fibrolytic enzymes (xylanase, beta-glucanase and cellulase) and a combination of them is expected to have a synergistic effect on the nutritive improvement of the diets (Thammiah et al., 2017).

According to Mendoza et al. (2014), fibrolytic enzymes were originally restricted to usage on pigs and chickens to eliminate certain antinutritional components and break down the pericarp that covers the endosperm of the grain, which is made up of cellulose, xylan, and beta-glucans, because it was believed that rumen proteases would quickly break down fibrolytic enzymes and because ruminal microbes can break down fibrous substrates, fibrolytic enzymes were not employed in ruminants (Beauchemin et al., 2001). Nevertheless, NDF's ruminal digestibility is seldom more than 50%, and it is often much lower when rumen conditions are unfavorable for sufficient fibrolytic activity, as is the case with diets heavy in grains (Beauchemin et al., 2001). Thus, adding enzymes to ruminant diets may improve feed utilization and profitability while also increasing the digestibility of fibrous feeds and lowering feeding costs by reducing the number of grains that are often used in rations (Beauchemin and Holtshausen, 2010).

Carcass characteristics

The values for dressing percentage obtained from D2 to D4 (52.30 to 61.24%) were higher than the general range of 35 - 50% reported by Steele (1996). The values for D3 (54.65%) and D4 (61.24%) were higher than the range of 51.90 to 53.40% reported by Anya and Ozung (2018) for WAD goats fed cassava peel meal-based diets supplemented with African yambean concentrate and 54.42% reported by Jiwuba et al. (2018) for WAD goats fed yellow root cassava peels with 30% centrosema-based diets. The result of this study shows that enzyme inclusion in the diet of growing goats gives better dressing percentage with the best result obtained from diets supplemented with D4 (containingbeta-glucanase, cellulose and xylanase). The results observed for bone to meat ratio with D1 being significantly higher than diets supplemented with enzyme (D2 to D4) is an indication of better feed conversion efficiency of the different enzymes. High feed conversion ratios usually indicate poor ability of animals to maximize feed intake by failure to optimally utilize feed for meat production (Anya and Ozung, 2018) resulting in a high bone to meat ratio. This shows that enzyme inclusion in goat diet gives more meat that bone. The results also show that sex had significant effect (P<0.05) on warm carcass weight, dressing percentage, leg, loins, sets and ends with bucks having significantly higher values than does.

Enzyme inclusion does not alter the proportions of meat cuts, and this is because diet had no significant effect (P>0.05) on the weight of meat cuts as percentage of warm carcass weight. The values obtained were leg (33.40 to 33.81%), shoulder (28.12 to 28.41%), loins (14.28 to 14.79%), sets (11.80 to 12.34%) and ends (11.65 to 11.71%). The percentages are comparable to the range for shoulder (26.39 – 28.4%), loin (13.65 – 17.7%), sets (12.9 – 14.55%) and ends (11.18 – 16.99%) reported by (Anya and Ozung, 2018) for goats fed cassava peel-meal based diet supplemented with African yambean concentrate. They were however different from the range for leg (20.00 – 21.91%), shoulder (23.01 – 23.38), loin (19.00 – 22.11%), set (15.28 – 16.64) and end (16.17 – 19.30) reported by Jiwuba et al. (2018). These proportions vary within and between breeds probable due to interactions between genetics and environment (Hassan and Idriss, 2002; Anya and Ozung, 2018).

Diet had significant effect (P<0.05) on the weight of most of the edible offals (head, skin, feet and tail) as percentage of empty body weight. Goats in D4 had the highest values for head (11.14kg), skin (8.21kg), feet (3.50kg) and tail (0.48kg). The weights of edible offals expressed as percentage of empty live weight were consistent with the range of 9.79 – 15.62% (head), 8.84 – 13.01% (skin), 2.55 – 4.11% (feet), 0.12 – 0.17% (tail), 1.37 – 1.70% (genitals) and 10.54 - 13.64 (empty guts) by Anya and Ozung (2018). They were however inconsistent with the range 8.53 – 8.87% (head), 7.41 – 8.42% (skin), 3.91 – 4.27% (feet), 0.11 – 0.14% (tail), 0.69 – 0.97% (genitals) and 8.02 – 8.70% (empty guts) report by Jiwuba et al. (2018). These differences may also be due to genetics/environment interaction within and between breeds (Hassan and Idriss, 2002; Anya and Ozung, 2018). Though the results show significant effect (P<0.05) of diet, no definite trend was observed or established.

Diet had significant effect (P<0.05) on the weights of some organs (liver, kidney and lung and trachea) as percentages of empty body weight with goats in D4 having higher values for these organs. Again, no definite trend was established. This means that there was no danger of toxicity in the diets. The proportions obtained were comparable with the range of 1.67 – 2.11% (liver), 0.30 – 0.43% (kidney), 0.57 – 0.70% (heart), 0.12 – 0.19% (spleen) and 1.16 to 1.72% (lung+trachea) reported by Jiwuba et al. (2018).

Toxic elements in feed usually lead to abnormalities in the weights of some internal organs and these abnormalities, especially of the liver and kidney, are indicators of feed toxicity (Ahamefule, 2005). An increase in the size of the liver, for example, is usually associated with an increase in metabolic activities during detoxification (Akinmutimi, 2004; Akinmutimi, 2007; Anya and Ozung, 2018). Absence of abnormalities in the sizes of these organs implies that the drying method used for processing the cassava peels in this study was adequate to reduce the anti-nutritional factors to a safe level in the experimental diets. Drying cassava peels does not completely eliminate, but only reduces the concentration of anti-nutritional properties to a tolerable level in feedstuff. The remnants are further brought to non-lethal levels in the body by the dual actions of the liver and the kidney (Akinmutimi, 2004).

CONCLUSION

The study concludes that WAD goats fed cassava peel-based rations supplemented with enzyme product containing beta-glucanase (6,157 U/g), cellulase (2,222 U/g) and xylanase (23,222 U/g) results in significantly better average daily weight gain, feed conversation ratio and dressing percentage without distorting the proportions of meat cuts, than locally available enzyme products containing beta-glucanase, cellulase and xylanase or products containing protease, phytase, xylanase, mannanase and amylase. It concludes further that bucks perform significantly better than does in all parameters and are therefore preferable for goat fattening operations.

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CONFLICT OF INTEREST

The authors hereby declare that there is no conflict of interest from conceptualization to the final publication of the manuscript.

NOVELTY STATEMENT

This article gives a novel insight into small ruminants feeding based on concentrate rations. The paper is one of very few attempts made towards intensive goat production systems in the tropics with enzyme supplemntation to enhance feed utilization.

AUTHORS CONTRIBUTION

Conceptualization: OO
Methodology: OO, CJO, UGS
Execution: OO, CJO, UGS
Data Analysis: LB
Original Draft: CJO, OO
Supervision: LB
Editing & Reviewing: UGS, LB

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