PJN
ISSN 1680-5194
ansinet.com/pjn

Pakistan Journal of Nutrition

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2022.1.11

Research Article
Effect of *Andropogon gayanus* and *Centrosema pubescens* Leaf Meals as Feed Ingredients on Growth Performance, Carcass Characteristics and Cost-Benefit of Growing Rabbits

[1]O.O. Ekwe, [2]O.C. Onwudike and [1]C.C. Nwali

[1]Department of Animal Science, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, Nigeria
[2]Rhema University, Aba, Abia State, Nigeria

Abstract
Objective: A study was conducted to evaluate the effect of *Andropogon gayanus* (Ag) and *Centrosema pubescens* (Cp) leaf meals on the growth performance, carcass characteristics and cost benefits of growing rabbits. **Materials and Methods:** A total of 24 growing rabbits of mixed sex aged between 8-10 weeks were used in a 63 days feeding trial. The rabbits were randomly assigned to four treatment groups in a completely randomized design (CRD). Each treatment was replicated three times having two rabbits per replicate. T1 (Control) contained 0% leaf meal. T2, T3 and T4 contained 5, 10 and 15% leaf meals, respectively. The data such as feed intake, weight gain, feed conversion ratio, protein consumption, protein efficiency and cost benefit ratios were generated. Carcass and organs characteristics were evaluated. The feed cost-benefit analysis was performed on the following: feed cost kg^{-1} weight gain, total cost of production and net returns. All the data generated were subjected to statistical analysis using One-way analysis of variance (ANOVA). Mean values were separated using Least significant difference (LSD). **Results:** No significant (p>0.05) difference was observed in all the growth performance parameters except the final body weight. The feed cost per kg weight gain decreased as the inclusion levels of Ag and Cp leaf meals increased. The total revenue and net returns increased as the inclusion levels of Ag and Cp leaf meals increased. **Conclusion:** It was observed that 15% inclusion level of Ag and Cp leaf meals is adequate for growing rabbit without any adverse effect on their normal growth and development. It is relatively cheaper to feed rabbits with Ag and Cp leaf meal based diets rather than the diet containing maize as energy source ingredient alone.

Key words: *Andropogon gayanus*, *Centrosema pubescens*, growing rabbits, growth performance, carcass characteristics

Citation: O.O. Ekwe, 2022. Effect of *Andropogon gayanus* and *Centrosema pubescens* leaf meals as feed ingredients on growth performance, carcass characteristics and cost-benefit of growing rabbits. Pak. J. Nutr., 21: 1-11.

Corresponding Author: O.O. Ekwe, Department of Animal Science, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, Nigeria Tel: +2347035054649

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

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

INTRODUCTION

The high costs of conventional vegetable protein and energy ingredients such as groundnut cake, soybean meal and maize, sorghum and millet have largely contributed to the existing high prices of animal feeds and products in Nigeria. Rabbits though often neglected, are one of the sources of animal protein in Nigeria. To improve its production and consumption in Nigeria where per capita animal protein intake is much below the recommended levels, there is need to source for readily available, high quality alternative vegetable protein and energy sources that are cheaper and can reduce the production cost of feeds. The problem can be solved by using the known but neglected tropical grass and legume species such as *Andropogon gayanus* (Ag) and *Centrosema pubescens* (Cp). These two forages are under-utilized but they can be used as major source of protein and energy grass and legume species are not consumed by humans and do not have direct competition with industries in Nigeria and also they are all seasonal tropical forage plants[1]. They are hardy, drought and disease resistant and bloom in the rainy season. The grass is called "*Egbe Oku*" while the legume is called "*Onori*". Currently, Nigeria is plagued with food crisis which is partly due to the unprecedented rise in population and the drastic drop in per caput food production particularly in the last decades. Food such as garri, beans and rice are not affordable, the animal protein intake in Nigeria is very low because of very high cost of animal feed leading to very high cost of finished animal products. The shortage of protein, particularly those of animal origin is prevalent in most parts of Africa including Nigeria where it is estimated that an average of 10 g of animal protein is consumed per day compared to a recommended daily intake of 35 g. The resulting high cost of feed, especially feed for monogastric animal species has brought about a low supply of animal products such as meat, milk, eggs and their by-products. The short supply of livestock products had been attributed to many factors including the problem of competition between man, industries and other livestock for the available feedstuffs. This competition has increased the cost of essential feed ingredients in our market thereby putting animal farmers at great disadvantage as they can hardly make ends meet in their business[2]. This situation has led to the closing down of so many of the livestock farms as well as the production of poor quality feed by the feed mill operators in their attempt to make profit. Based on this precarious economic condition of low animal protein intake, animal nutritionists/researchers are calling for an urgent need for ways of ameliorating the food insecurity through the use of non-conventional sources such as Ag and Cp in place of maize and the rabbit can use these products so as to increase the animal protein intake of Nigerians[3]. Energy feedstuffs constitute 45-60% of finished feeds for monogastric animals and as at present, maize constitutes the bulk of energy component of various rations. Between 1982 and 2008, the price of maize rose from N270 t^{-1} to over N60, 000 t^{-1} - an increase of over 200%. Feed cost for livestock can only be reduced by incorporating cheaper and alternative sources of nutrients in the feed and which are not directly consumed by man. Grass and legume species should fit logically as grain replacers in livestock feeds by virtue of their high caloric values with several agronomic advantages. The nutritional value of some of these plants had already been reported[4]. Rabbits are known to perform better when fed with a mixture of forages and concentrate diets. Ag and Cp are found in great quantity in our environment, their effective use in rabbit production will contribute greatly to improve the animal protein intake of Nigerians[5]. This study aimed to evaluate Ag and Cp leaf meals as feed ingredients and their effects on growth performance, carcass characteristics and cost benefit in rabbit production.

MATERIALS AND METHODS

Study site: This study was conducted at the Rabbitry Unit of the Department of Animal Science Teaching and Research Farm, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, Nigeria from 12th March to 16th July, 2018. Ebonyi State is partly located in the rainforest and derived savanna region of Nigeria. Abakaliki lies approximately on latitude 6°45'Nand longitude 8°30'E with an average temperature of 27.7°C and average rainfall of between 1500-1800 mm[6].

Source of rabbits and forage plants: The rabbits used in this study were purchased from *Akwa Ibom*, Nigeria while Gamba grass and Centro (Ag and Cp) were harvested from the Ebonyi State University Teaching and Research Farm, Faculty of Agriculture and Natural Resource Management, Abakaliki, Nigeria.

Forage processing: Ag and Cp were harvested and washed separately in a trough using clean water to remove dirt. The leaves were washed once again with 1% salt water and rinsed with clean water. The forages were kept on top of a platform to drain off water and thereafter were cut into shorter lengths (2-5 cm) and spread on the cellophane for drying. They were air-dried for a period of 4 days, milled and bagged.

Milling and bagging: The forages were milled separately using a hammer mill with screen size 2.0 mm. This screen size was used to allow for proper milling. *Andropogon gayanus* and *C. pubescens* leaf meals strongly attract moisture and the product can reabsorb moisture during and after milling. For this reason, the leaf meals were stored in separate air-tight plastic containers and kept ready for use.

Chemical analysis: A fraction of each of the two milled samples was collected and used for chemical analysis to determine the proximate composition, Acid detergent fibre (ADF), Neutral detergent fibre (NDF), energy values, anti-nutritional factors tannin, trypsin inhibitor, saponin and oxalates and mineral composition.

Proximate and energy composition: Dried and ground samples of each of the diets were analyzed for their proximate composition: crude protein, fat, ash, fiber and total carbohydrate contents. These were carried out in triplicates according to standard methods of Horwitz and Albert[7]. The energy-values of the diets were calculated using the Atwater factors 4, 9 and 4 for protein, fat and carbohydrate, respectively. The Metabolizable Energy value (ME) of *Ag* and *Cp* leaf meal diets was calculated using the following formula as described by Folorunso *et al.*[8]:

$$ME = 35\times CP\%+81.8x\ E.E\%+35.5\times NFE$$

Anti-nutritional factors/phytochemical composition: Ground samples of feed and forages were analyzed for proximate and phytochemical components. The samples were screened for tannin, cyanide and saponin. Quantitative determination of phenols and trypsin inhibitors were carried out in triplicates using the methods of Horwitz and Albert[7] and Spectrophotometry method as described by Avula *et al.*[9], respectively.

Fibre analysis:

Neutral detergent fiber (NDF): The method of Gidenne[10] was used. The weight of the filter paper was subtracted from the total weight to obtain the weight of the residue:

$$NDF=\frac{w_2-w_1}{w_0}\times\frac{100}{1} \quad (1)$$

W_0 = Weight of the sample used
W_1 = Weight of filter paper
W_2 = Weight of filter paper+residue after drying

Acid detergent fiber (ADF): The acid detergent fraction was taken as the difference in weigh t.

$$ADF=\frac{w_2-w_1}{w_0}\times\frac{100}{1} \quad (2)$$

Acid detergent lignin: The acid detergent lignin was taken as the difference in weight[7].

$$Lignin = w_2\text{-}w_1\times\frac{100}{1} \quad (3)$$

Cellulose: The cellulose was estimated from the difference between ADF and lignin.

$$Cellulose = Eqn.2 - Eqn.3\times\frac{100}{1}$$

Hemicellulose: The difference between the NDF and ADF was estimated as hemicelluloses.

$$NDF = Eqn.1\text{-}Eqn.2\times\frac{100}{1} \quad (4)$$

Dietary fiber (%) = NDF + ADF + Lignin + cellulose + Hemicellulose[7].

NDF = Neutral detergent fiber
ADF = Acid detergent fiber

Tannin: The tannin content was calculated as follows:

Tannin (%) - An/AsxCx100/w×five

Where:
An = Absorbance of test sample
As = Absorbance of standard solute
C = Concentration
W = Weight of sample used
Vf = Total volume of extract
Va = Volume of extract analyzed

Oxalate: The Calcium oxalate content was calculated as:

$$\frac{T\times(Vme)[DF]\times 10^5}{(ME)\times MF}\left(\frac{mg}{100\,g}\right)$$

Where:

T = Titre of $KMnO_4$ (mL)

Vme = Volume-mass equivalent (i.e. 1 cm^3 of 0.05M $KMnO_4$ solution is equivalent to 0.00225 g anhydrous oxalic acid)

Df = Dilution of factor Vt/A (2.4 where Vt is the total volume of titrate (300 mL) and A is the aliquot used (125 mL)

ME = Molar equivalent of $KMnO_4$ in oxalate ($KMnO_4$ redox reaction)

Ms = Mass of sample used

Trypsin inhibitor activity: The trypsin inhibitor activity was tested using the spectrophotometric method as described by Emmanuel and Deborah[11]. The trypsin inhibitor activity was expressed as the number of trypsin units inhibited (TU) per unit weight (g) of the sample analyzed:

$$\text{TU1 mg}^{-1} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times 0.01\text{F}$$

$$\text{TU1 mg}^{-1} = \frac{\text{b} - \text{a}}{0.01} \times \text{F}$$

Where:

b = Absorbance of test sample solution

A = Absorbance of the blank (control)

F = Experimental factor, given by

$$\text{F} = \frac{1}{\text{w}} \times \frac{\text{Vf}}{\text{Va}} \times \text{D}$$

Where:

w = Weight of sample

Vf = Total volume of extract

Va = Volume of extract used in the assay

D = Dilution factor

Minerals: Minerals such as calcium, phosphorous, sodium, chlorine, magnesium and some micro mineral elements (Zinc, Iron, manganese, iodine, selenium and chromium) of the leaf meals and experimental diets were determined using Atomic Absorption spectrophotometer[12].

Experimental rabbits/design: A total of 24 crossbred growing rabbits of mixed sex, aged between 8 and 10 weeks were used for the experiment. They were randomly assigned to four dietary treatments in a Completely Randomized Design (CRD). Each treatment group has 6 animals replicated three times with 2 animals per replicate. Only100 g of feed was offered per rabbit while fresh cool water was served *ad libitum* to the animals throughout the period of the experiment. The study lasted for 63 days.

Experimental diets: Four experimental diets were formulated such that *Andropogon gayanus* and *Centrosema pubescens* leaf meals were included at 0, 5, 10 and 15% dietary levels representing T1, T2, T3 and T4, respectively. The T1 (0% leaf meal) served as the control of the experiment. As the leaf meals increased in the diets, the maize components of the diets decreased proportionately. The energy and protein levels of the diets were kept within the National Research Council (NRC) nutrient requirement recommendation for grower rabbits. Other feed ingredients included in the diets were soybean meal, wheat offal, brewers spent grain, bone meal and salt and vitamin/mineral premix (Table 1).

Housing and management: In this experiment, animals were housed in 3 single tier wood/wire meshed cages (61×45×40 cm) consisting of 8 cells (pens) each. Each cage had a feed trough and water trough. The cages were kept in a well-ventilated asbestos roofed building with dwarf wall and wire mesh traversing the whole length of the wall. This was to facilitate proper ventilation and proper dissipation of heat as fast as possible. The floor of the house was prepared with concrete, this is to ensure easy and proper cleaning.

Parameters measured: The parameters measured were initial weight, feed intake, weight gain. Total weight gain, daily weight gain, Total feed intake, Feed conversion ratio, Protein intake, Protein efficiency ratio were calculated. Carcass, organs evaluation and cost-benefits of production were determined. With the data collected on feed intake and weight gain other performance indices such as Feed conversion ratio and Protein efficiency ratio were calculated.

Carcass and organ evaluation: At the end of the 63 days feeding trial, 3 rabbits per treatment (total 12 rabbits) were sacrificed to study the carcass traits. The animals were deprived of feed overnight but with free access to water. They were weighed prior to slaughter and the weights were recorded as pre-slaughter live weights. The slaughtered rabbits were hanged for proper bleeding. The remaining carcass from each slaughtered animals was weighed with a digital weighing balance of 5 kg capacity (model: 5 kg/11 lb, d = 1 g/oz.) and expressed as a percentage of the live

Table 1: Percentage composition of experimental diets (grower diets)

Ingredients	Graded levels of *A. gayanus* and *C. pub* leaf meal			
	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)
Maize	38.00	28.00	18.00	8.00
A. *gayanus* (leaf meal)	-	5.00	10.00	15.00
C. pubescens (leaf meal)	-	5.00	10.00	15.00
Soybean meal	10.00	10.00	10.00	10.00
Wheat offal	23.50	23.50	23.50	23.50
Brewers spent grain	25.50	25.00	25.00	25.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25
*Vit/min premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Nutrient composition				
Energy (ME kcal kg^{-1}))-calculated	2216.39	2081.54	2074.69	2061.84
Crude protein (%)	22.89	23.02	25.85	28.75
Crude fiber (%)	9.25	11.85	16.55	18.75
Ether extract (%)	5.06	5.94	4.81	4.69
Nitrogen free extract	51.29	49.48	40.37	59.80
Phosphorus (%))-calculated	1.70	1.75	1.79	1.85
Calcium (%))-calculated	3.19	3.24	3.29	3.34

*Vitamin/mineral premix: content per kilogram ration: vit. A: 1251 IU, vit. D3: 2750 IU, vit E: 151 IU, vit. K: 0.002 g, vit. B_2: 0.006 g, Nicotinic acid: 0.035 g, Calcium D-pantothenate: 0.01 mg, vit. B_6: 0.0035 g, vit. B_{12}: 0.02 g, Folic acid: 0.001 g, Biotin: 0.0005 g, vit C: 0.025 g, Choline chloride: 0.39 g, Zinc bacitracin: 0.02 g, Methionine: 0.2 g, Avatec (lasolocid): 0.09 g, Manganese: 0.1 g, Iron: 0.05 g, Zinc: 0.04 g, Copper: 0.002 g, Iodine: 0.00153 g, Cobalt: 0.000225 g, Selenium: 0.0001 g

weight to obtain the dressing percentage. The carcass was cut into primal cuts according to the harmonized standard of world rabbit Science Association (WRSA).

Cost-benefit analysis: Per kg cost of diet was calculated by multiplying the percentage composition of the feedstuffs with the price per kg and summing all. Total feed intake x cost per kg feed gave the total feed cost. Feed cost per kg weight gain was calculated as FCR×Cost per kg diet. Total feed intake (TFI) is the total feed consumed in each treatment for the duration of the experiment. Total weight gain (TWG) is the total weight gained in each treatment for the duration of the experiment. Total variable cost (TVC) is the cost of inputs during the experiment. Total revenue (TR) is the amount realized from the sales of the carcass after slaughter. Gross margin (GM) is the difference between total revenue (TR) and the total variable cost (TVC).

Digestibility trial: After a week, faecal samples were collected from each of the treatments, oven dried at 105°C to a constant weight to determine the dry matter. At the 7th and 8th week another batch of faecal samples were collected from each of the four treatments for laboratory analysis. Total collection procedure was employed for the faecal collection. Mosquito nets were used underneath the cages (7.5 cm above the floor). The collected samples were dried in a forced air circulation oven at 65°C. The samples of each of the replicates were allowed to cool in a glass desiccator to prevent further absorption of moisture from the atmosphere. The 3 days samples were pooled ground and then assessed for proximate analysis, fibre and ether extract according to the method of Horwitz and Albert[7].

Digestibility co-efficient: Digestibility co-efficient was calculated as:

$$DC = \frac{\text{(Wt. of feed x \% Nutr. in feed)- (Wt. of faeces x \% Nutr. in faeces)}}{\text{Weight of feed} \times \text{\% nutr. in feed}} \times 100$$

Nutrient digestibility/utilization: Nutrient digestibility/ utilization is a fraction of a total nutrient digested and utilized in the body. Nitrogen free extract was calculated by subtracting the sum of percentages of all the nutrients already determined from 100.

Statistical analysis: The statistical model for the experiment is as follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} = Any observation taken

μ = Population mean

T_i = Treatment effect of diet

i = Number of treatment

j = Number of replicate

e_{ij} = Random error

Table 2: Minerals composition of the forages and the experimental diet (%) (experiment 1)

Sample ID	Ca	Mg	Na	Fe	Zn	Mn
C. pubescens	0.36	2.55	2.05	0.22	0.0005	0.0115
A. gayanus	0.24	1.61	1.34	0.22	NIL	0.01
D_1	1.03	1.26	1.36	0.17	NIL	0.01
D_2	1.15	1.61	1.41	0.50	NIL	0.01
D_3	1.21	1.65	1.59	0.52	NIL	0.01
D_4	1.27	1.68	1.91	0.56	NIL	0.005

The random error is independent, identical and normally distributed with zero mean and constant variance. Data collected were analyzed using one-way analysis of variance (ANOVA). Significant differences between treatment means where they occur were separated using new Duncan's Multiple range Test[13].

RESULTS AND DISCUSSION

Experiment 1: The results of the proximate composition and mineral contents of the two forages (*A. gayanus* and *C . pubescens* leaf meals) are presented in Table 1 and 2 while the phytochemical analysis of both the forages and the experimental diets are presented in Table 3 and 4, respectively.

Proximate composition: The proximate composition of *A. gayanus* and *C. pubescens* gave the following results: 13.83% crude protein, 32.75 crude fibre, 0.88% ether extract 19.20% ash, 30.45% nitrogen free extract while for *C. pubescens* the results were -25.03% crude protein, 13.10% crude fibre, 1.0% ether extract, 14.75% ash and 49.48% nitrogen free extract, respectively (Table 5). Rabbits require a high amount of crude fibre content from different forages to manage normal digestion transit. Forages generally contain appreciable amount of protein, fibre, fat and minerals and that can support growth and production. The mineral composition analysis of the two forages and the experimental diets are presented in Table 1. Table 2 shows that *Centrosema pubescens* contains calcium (0.36%), magnesium (2.55%), sodium (2.05%), iron (0.22%), zinc (0.0005%) and manganese (0.00115%) and *Andropogon gayanus* contains calcium (0.24%), magnesium (1.61%), sodium (1.34%), iron (0.22%), manganese (0.01%). However, these results disagree with those of Peiretti[14] and Waziri *et al.*[4]. The values reported in this study were lower than those of Waziri *et al.*[4]. These variations could be due to a number of factors such as soil type, the plant parts, the period of the year and the processing method. Results of the current study clearly showed that legume has higher mineral content than that of the grass species. It is noteworthy that minerals are very important in the diets of animals, they play important roles in their body functions. The result of the analysis showed that the forages are used in the diet to meet the energy requirements of the growing rabbits.

Table 3: Qualitative analysis of the forages and the experimental feed (experiment 1)

Sample ID	Solvent	Tannin	Saponin
C. pubescens	N-Hexane	+++	-
	H_2O	++	+
A. gayanus	N-Hexane	++	+
	H_2O	+	-
D_1 (0%)	N-Hexane	+	++
	H_2O	-	++
D_2 (5%)	N-Hexane	++	+
	H_2O	+	++
D_3 (10%)	N-Hexane	+ +	++
	H_2O	+ +	+
D_4 (15%)	N-Hexane	++	++
	H_2O	++	+

D_1: (0% forage), D_2: (5% forage), D_3: (10% forage), D_4: (15% forage), -: (nil), +: (low), ++: (high), +++: Very high = Concentrations of each of the solvents with the two forages, respectively

Table 4: Quantitative analysis of the forages and the experimental diets (experiment 1)

Sample ID	Saponin (%)	Tannin (%)
C. pubescens	0.36	2.50
A. gayanus	0.64	8.20
D_1 (0%)	0.10	4.63
D_2 (5%)	0.34	4.82
D_4 (10%)	0.52	4.92
D_3 (15%)	0.64	4.98

D_1: 0% forage meals, D_2: 5% forage meals; D_3: 10% forage meals, D_4: 15% forage meals

Phytochemical analysis: Table 3 and 4 show the results of the photochemical analysis in both the qualitative and the quantitative fractions. The tannin contents of *A. gayanus* and *C. pubescens* were 8.2 and 2.5%, respectively while the saponin contents were 0.64 and 0.36%, respectively. It is clear from this result that tannin and saponin contents of *A. gayanus* was higher than that of the *C. pubescens*. The values however reflected positively with those reported by Apory[15], Ojiako and Igwe[16]. The results of this study confirmed earlier reports that forage/legume leaf meals contain anti-nutritional factors. The tannins and saponin contents in these two forages also increased the tannin and the saponin contents of the diets. (Table 3 and 4). This also meant that the diets contained

Table 5: Proximate composition *of A. gayanus* and *C. pubescens*

Sample	DM	CP	CF	EE	ASH	NFE	G E (kcal kg^{-1})
A. gayanus	90.7	13.83	32.75	0.88	19.2	30.45	4911.03
C. pubescens	99.9	25.03	13.10	1.02	14.75	49.48	3090.33

DM: Dry matter, CP: Crude protein, CF: Crude fibre, EE: Ether extract, ASH: Ash, NFE: Nitrogen free extract, GE: Gross energy, kcal kg^{-1}: kilo calorie/kilogram weight

anti-nutritional factors which are protease inhibitors. Protease inhibitors are widely distributed within the plant kingdom, including the seeds of most cultivated legumes. Protease inhibitors have the ability to inhibit the activities of photolytic enzymes within the gastrointestinal tract of animals. Trypsin inhibitors, chymotrypsin inhibitors and protease inhibitors are found in raw legume seeds. Protease inhibitors are the most commonly encountered class of anti-nutritional factors of plant origin. These inhibitors have been reported to be partially responsible for the growth-retarding property of raw legumes. The retardation has been attributed to inhibition of protein digestion but there is evidence that pancreatic type enzyme activity increased the production of trypsin and chymotrypsin with consequent loss of cysteine and methionine. Trypsin inhibitors had been implicated in reducing protein digestibility and in pancreatic hypertrophy. Trypsin inhibitors are polypeptides that form well characterized stable complexes with trypsin on a one-to-one molar ratio, obstructing the enzymatic action. Table 6 shows the result of the carcass (head, neck, rib, fore leg and shoulder, loin, hind leg and rump) and organs-(heart and lungs, intestine with content, empty intestine, spleen, caeca with content, empty caeca and colon) evaluations for grower rabbits fed diets containing *A. gayanus* and *C. pubescens* leaf meal at 0, 5, 10 and 15% levels of inclusion. There were no significant (p>0.05) differences in the live weights (LW), carcass weights (CW) (fore parts-FP, Mid parts-MP and hind parts –HP) among the dietary treatment groups. In the present study the live weight at slaughter was 1155.28-1284.12 g. In the present study the average carcass yield of the rabbit in various treatment groups (T_1 to T_4) ranged from 640-807 g which translate the average percentages of the fore part (44.71-52.42%), mid part (20.47-26.52%) and hind part (21.06-30.62%) respectively. In the present study the dressing percentage (carcass yield) was 48.04-62.84%. This result disagrees with that of Oteku and Igene[17], who reported values ranging from 43. 24-53.83%, 48.70-49.45% and 52.05-53.36% but agrees with Abubakar *et al.*[18] who reported the values ranging from 50.70-58.5%, 51.61-59.00% and 52.00-59.00%. This variation in the present results could be due to the disparity in the nutrition, live and slaughter weights, age and breeds of the experimental rabbits. Significant improvement was observed in T4 (15%), T3 (10%) and T2 (5%) when compared to T1 (0%-control), T4 (15%) and T3 (10%) showed more promising effect when compared with the control (0%) treatment. This result agrees with a previous study conducted by Olafadehan[19] who observed values for dressing percentage ranging from 50.03-58.51% and live weight ranging from 1640.00 to 1860±34.89 g, slaughter weight from 1594.57-1794.57 g. In this study, the hind part values ranged from 21.06-31.72. However, little differences were observed in most carcass parameters among different breeds of rabbits. Difference in the meat quality due to different breeds or live weight seems to be small, implying certain consistency in rabbit meat. The carcass traits observed used for carcass quality evaluation differ significantly due to difference in fat and dressing percentages. Dressing percentage is an important economic variable in the meat market and the commercial criterion used in rabbits and the dressing percentage of rabbits ranged from 56-58%. This result is consistent with previous reports about dressing percentages ranging from 55.56-59.72% for growing rabbits[20]. This study also revealed that feed type was more influential on carcass quality due to the low fat content in the carcass. The general effect of diet containing *A. Gayanus* and *C. pubescens* leaf meal on the carcass characteristics was a clear indication that the diet has no deleterious effect on the growth and development of the growing rabbits.

Internal organs: Table 6 shows the internal organs results. The parameters studied showed no significant (p>0.05) differences in different treatment groups (T_1-T_4). The values observed in the present study (internal Organs) were lower than the result of a previous study conducted by Marounek *et al.*[21] who recorded higher values for caeca with content (156.7±18.4 g) and caecas without content (68.6±13.5 g). The non-significant (p>0.05) effects reported in all the carcass and internal organs indices were clear indications that Ag and Cp leaf meals can be included up to 15% to replace maize in the growers diets without any adverse effects on the carcass and internal organs characteristics. There were no significant (p>0.05) differences in live weights and carcass weights, (fores parts, mid parts and hind parts) in the various treatment groups.

Economic analysis: The growth performance of growing rabbits is summarized in Table 7. The results of the economic analysis of growing rabbits fed experimental diets is presented

Table 6: Carcass and organs characteristics of growing rabbits fed experimental diets

Parameters	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM±
Av. L/Weight	1284.12	1155.28	1302.05	1181.43	0.46
Av. Carcass yield	807.00	555.00	760.000	640.00	0.54
Head (g)	135.00^a	96.00^c	109.00^b	115.00^b	0.62
Neck (g)	30.00^a	23.00^b	23.00^c	22.00^c	0.47
Rib (g)	123.00^a	71.00^c	87.00^b	85.00^b	1.35
Fore leg and shoulder (g)	135.00^a	75.00^c	94.00^b	91.00^b	0.62
Loin (g)	214.00^a	128.00^b	172.00^b	131.00^c	0.68
Hind legs and rumps g	170.00^c	162.00^c	215.00^a	196.00^b	1.03
Fore part (%)	52.42^a	47.75^b	44.71^c	48.91^b	0.66
Mid part (%)	26.52^a	23.06^c	24.57^b	20.47^c	1.18
Hind part (%)	21.06^c	29.19^a	31.72^a	30.62^a	8.50
Dressing percentage (%)	62.84^a	48.04^c	53.76^b	54.17^b	-
Internal organs (g)					
Stomach with content	41.00	33.00	50.00	59.00	1.08
Stomach without content	14.00	12.00	16.00	17.00	1.14
Liver	26.00	23.00	24.00	24.30	1.08
Kidneys	9.00	9.00	9.00	8.00	0.44
Hearts and lungs	13.00	8.00	9.00	9.00	0.88
Intestine with content	56.00	67.00	56.00	45.00	0.71
Intestine without content	46.00	46.00	42.00	37.00	0.76
Spleen	1.00	1.00	1.00	1.00	0.00
Caeca with content	118.00	92.00	98.00	112.00	4.11
Caeca without content	35.00	24.00	32.00	37.00	1.75
Colon	15.00	12.00	14.00	15.00	0.85

^{abc}Mean in the same row with different superscripts are statistically ($p<0.05$) different, SEM: std error of mean

Table 7: Growth performance of growing rabbits fed experimental diets (63 days)

	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM
Initial body weight (g)	629.83	630.00	663.83	651.00	0.11
Final body weight (g)	1077.33^b	1147.17^a	1119.50^a	985.17^c	0.45
Total body weight gain (g)	447.50	517.17	455.67	334.17	0.35
Av. Daily weight gain (g)	7.10	8.21	7.23	5.30	1.15
Total feed intake (g)	2397.00	3098.33	2971.00	2924.00	2.05
Daily feed intake (g)	38.05	49.18	47.16	46.41	3.01
Feed conversion ratio	5.36	5.99	6.52	8.75	0.88
Protein intake (g)	4.69	8.19	7.88	7.74	1.49
Protein efficiency ratio	1.14	1.01	1.00	0.69	0.14

^{abc}Means within a row with different superscripts are significantly ($p<0.05$) different

Table 8: Cost: benefit analysis of growing rabbits fed experimental diets

	Parameters	T_1 (0%)	T_2 (5%)	$T_{3\,(10}$%)	T_4 (15%)
A	Cost/rabbit(₦)	1200.00*	1200.00	1200.00	1200.00
B	Cost of feed kg^{-1} (₦)	74.25	62.50	53.42	45.38
C	Cost of medication	35.00*	35.00	35.00	35.00
D	Total feed cost (₦ kg^{-1})	177.98*	193.65	158.71	132.69
E	Feed cost kg^{-1} weight. gain rabbit^{-1}	79.65*	100.15	72.32	44.34
F	Total feed consumed rabbit^{-1} (g)	2397.00	3098.33	2971.00	2924.00
G	Total weight gain (g)	447.50	517.17	455.67	334.17
H	Total variable cost (₦)	1412.98	1428.65	1393.71	1367.69
I	Total revenue (₦)	1800.00	1800.00	1800.00	1,800.00
J	Gross margin/rabbit (₦)	387.02	371.35	406.29	432.31
K	Cost-benefit ratio	1.04	1.00	1.09	1.16

*D: ($b\times f/1000$), H: (a+c+d) J: (I-h) E: ($g/1000\times d$)

in Table 8. The production cost to raise rabbits in T_1 and T_2 was significantly ($p>0.05$) higher than those of T_3 and T_4. The initial weights of the rabbits were not significantly ($p>0.05$) different. The result (Table 8) however indicate that it is more profitable to raise rabbit using T_4 diet because of its cost benefit ratio (1.16) which is not significantly ($p>0.05$) different from T3 (1.09). The analysis showed that discounting the fixed costs and other variable costs such as labour and milling of forage, the cost (N kg^{-1}) of concentrates (leaf meal diets) were ₦74.25, ₦62.50, ₦53.42 and ₦45.38 for T_1, T_2, T_3 and T_4, respectively. However, the feed costs kg^{-1} weight gain/rabbit were ₦79.65, ₦100.15, ₦72.32 and ₦44.34 for T_1, T_2, T_3 and T_4, respectively. There were no significant (p>0.05) differences among treatments; since the main objective of feed formulation is to maximize profit [the difference between the returns (growth response) and cost. However, total revenue and net returns (₦N406.29 and ₦432.31) of rabbits in T_3 and T_4 was higher than those of T_1 (control) and T_2 (₦387.02 and ₦371.35), respectively.

Growth performance of growing rabbits

Weight gain: Rabbits fed diet 2 (5% inclusion rate) showed a higher total weight gain (517.17 g) than rabbits fed diets 1 (0%-control) (447.50 g), 3 (10%) (455.67 g) and 4 (15%) (334.17 g). Also rabbits fed diet 3 (10%) had a better total weight gain than those fed diets 1 (0%) and 4 (15%). The level of crude fibres usually recommended for the ration of all-purpose rabbits is 12-14%. This level is not practical due to the high fibre diet which is difficult to pelletize and usually associated with poor performance because of its low energy content (diet 4) and lower fibre diet (diets 1 and 2) which was associated with digestive troubles, mortality and low feed intake during the first two weeks of the experiment. These explained the need of relatively high fibre diet for the young and growing rabbits. The contribution of fibre is small in diet of rabbits due to low digestibility but identification of the constituents of the crude fibre fraction may help to point out the requirements of rabbits. In all the studies relating to fibre, the requirements are expressed as a proportion (usually%) of the ration. Feeding diets containing 5% or less of crude fibre are associated with digestive disorders. Growth performance of young rabbits may be satisfactory on such diets but mortality is often higher than normal. Some possible physical dietary requirements for the functioning of the digestive tract may not be satisfied by low fibre levels. Best performance in terms of health, growth and feed conversion in 6-12 weeks old rabbits was obtained on a diet containing 8-9% crude fibre, raising the fibre level up to 13-14% caused a decrease in feed conversion efficiency (125) and no improvement in health. The present study showed different results as a high fibre levels produced a better feed conversion ratio (11.85-16.55%) than low fibre (9.25%) in diet 1 and a high fibre level (18.75%) in diet 4. The low FCR observed among the rabbits in T_1 and T_4 could be attributable to level of fibre in their diets and efficiency of feed utilization among others. Fibre is known to reduce levels of other nutrients in the diet and also decreases digestibility of other nutrients especially energy and crude protein. Feed intake and digestion were affected in diet 4, which may be due to increased fibre level. Digestive transit time was found to be shorter with barley straw than purified wood cellulose diets. It was found that the level of cell wall constituents and not crude fibre, might be responsible for differences in transit time. The physical form of the fibre also influences digestive transit. As rise in the crude fibre level up to 5-20%, increased the feed intake to maintain a constant energy level of rabbits but decreased the feed conversion ratio and carcass fat content. Rations in which nearly all the fibre is highly digestible (usually from root crops such as sugar beet or beet root pulp) can cause a severe diarrhea probably because of excessive caeca fermentation. When such diets were fed successfully, increase was noted in gastro intestinal motility and in the volume of the stomach and caecum. As in other species, benefits of feeding rations that are high in easily fermentable carbohydrates may depend on their gradual introduction into the diet. It appears that in rabbit diet the fibre content should mainly consist of indigestible material if the possibility of digestive disorders is to be minimized; the proportion of indigestible material in the fibre becomes important, if fibre levels below than recommended are to be fed to young rabbits to increase growth rate. The acid detergent fiber (ADF) (indigestible fraction) in diet 3 was higher (22.95%) than that of the diet 4 (19.93%) which may increase feed conversion ratio of the rabbits in T_3 at 7.5% inclusion level which explains the role of indigestible fiber in the diet of rabbits. A lower fibre level (5-6%) resulted in hypo motility among the rabbits. However, high level of digestible and highly fermentable carbohydrate (cell content fraction) may also lead to enteritis especially in young and growing rabbits.

Feed intake: The average daily feed intake of grower rabbits fed diets l, 2, 3 and 4 was 38.05, 49.18, 47.16 and 46.41 g, respectively. There was no significant (p>0.05) difference in all the growth performance except final weight. The high fibre content in diet 4 increased the feed intake, because rabbits, like every other animal, attempt to maintain their energy balance. Thus as the level of the wheat offal, brewers spent grain and the two forage meals increased in the diets the feed intake of the animals increased. This increase in the fibre levels of the feed also increases the total voluntary feed intake in order to maintain a constant energy balance.

Protein intake: With respect to the effect of dietary protein, intake was slightly lower. Palatability played a major role since diets were not supplemented with protein ingredients such as fish meal and soybean meal. Kanyinji and Moonga[22] reported higher feed intake and efficiency for animals fed on high protein diets.

Feed conversion ratio: There were no significant (p>0.05) differences in feed conversion ratio (FCR) as well as in other growth performance. Increased fibre levels in diets increased FCR. The animals may have met their amino acid requirements at 5, 10, 15% inclusion level of fibre contents. High fiber diets improved gut motility and increased digestion and availability of amino acids although there was no significant (p>0.0) difference in the feed conversion ratio among the treatments, it numerically favored diet 1 (0%), since the lower the value of feed conversion ratio, the better the quality of the diet. This was due to moderate feed intake and optimum weight gain. The non-significant differences in all the FCR imply that any of the diets could be chosen.

CONCLUSION

The two forages (*A. gayanus* and *C. pubescens*) contain appreciable amount of protein, fibre, fat and minerals. Legume and grass (Centro and Gamba) have higher energy content than those of the grains. The minerals contents (Ca, Ma, Na, Fe and Mn) of the two forages were high enough as to support growth and development of rabbits. The anti-nutritional factors (tannin and saponin) were found to be tolerable to the animals throughout the experimental periods. The results from this study if adopted would reduce the production cost of rabbit. The results of this investigation indicated that 15% dietary inclusion level of *A. gayanus* and *C. pubescens* leaf meals are considered adequate for growing rabbits without any adverse effect on their normal growth and development.

ACKNOWLEDGMENT

The authors thank Prof. O.C. Onwudike, the Vice Chancellor of Rhema University, Aba, Nigeria, for his numerous advice and support during the course of this research.

REFERENCES

1. Onyeonagu, C.C, P.N. Obute and S.M. Eze, 2013. Seasonal variation in the anti-nutrient and mineral components of some forage legumes and grasses. Afr. J. Biotechnol., 12: 142-149.
2. Mengesha, M., 2012. Issue of feed-food competition and poultry production for the demands of foods of animal origin. Asian J. Poultry Sci., 6: 31-43.
3. Iyeghe-Erakpotobor, G.T., C.U Osuhor and T.S. Olugbemi, 2006. Performance and digestibility of weaner rabbits fed graded levels of soybean cheese waste/maize offal diet and brachiaria grass hay. Afr. J. Biotechnol., 5: 1579-1583.
4. Waziri, A.F., A.Y. Bala, S.A.A. Anka and H. Shehu, 2013. A comparative analysis of nutrients and mineral elements content of *Andropogan gayanus* Kunth and *Pennisetum pedicellatum* Trin. Niger. J. Basic Applied Sci., 21: 60-64.
5. Amuda, A.J., B.O. Alabi and S.A. Jonah, 2020. Nutritional quality of ensiled gamba grass (*Andropogon gayanus*) fortified with graded levels of centro (*Centrosema pascourum*). Niger. J. Anim. Prod., 47: 234-245.
6. Ofomata, G.E.K., 1975. Nigeria in maps : eastern states. Ethiope Publishing House, Benin, Nigeria, Pages: 146.
7. Horwitz, W. and R. Albert, 2006. The horwitz ratio (Horrat): A useful index of method performance with respect to precision. J. Aoac Int., 89: 1095-1109.
8. Folorunso, L.A., A.E. Falaye and S. Duru, 2016. Misrepresentation: Case study of metabolizable energy determination in feed and ingredient samples. Niger. J. Anim. Prod., Vol. 43,
9. Avula, B., Y.H. Wang, M. Wang, C. Avonto and J. Zhao *et al*., 2014. Quantitative determination of phenolic compounds by UHPLC-UV–MS and use of partial least-square discriminant analysis to differentiate chemo-types of Chamomile /*Chrysanthemum* flower heads. J. Pharm. Biomed. Anal., 88: 278-288.
10. Gidenne, T., 2015. Dietary fibres in the nutrition of the growing rabbit and recommendations to preserve digestive health: A review. Animal, 9: 227-242.
11. Emmanuel, E. and S. Deborah, 2018. Phytochemical and anti-nutritional studies on some commonly consumed fruits in Lokoja, Kogi State of Nigeria. Gen. Med. Open, Vol. 2, 10.15761/GMO.1000135.
12. Sahito, A., T.G. Kazi, M.A. Jakhrani, G.H. Kazi, G.Q. Shar and M. A. Memon, 2002. Elemental investigation of *Momordica Charantia* Linn. and *Syziginm Jambolana* Linn. using atomic absorption spectrophotometer. The Nucleus., 39: 49-54.
13. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
14. Peiretti, P.G., 2005. Prediction of the gross energy value of Mediterranean forages. J. Food Agric. Environ., 3: 102-104.
15. Walach, H., 2000. Theory and Apory in healing research: ''Influence'' ~RSUS "Correlational" models. Subtle Energies Energy Med. J. Arch., 11: 190-206.
16. Ojiako, O.A. and C.U. Igwe, 2008. The nutritive and hepatotoxic properties of *Trichosanthes anguina* (snake tomato) fruits from Nigeria. Pak. J. Nutr., 7: 85-89.
17. Oteku, I.T. and J.O. Igene, 2006. Effect of diet types and slaughter ages on carcass characteristics of the domestic rabbits in humid Southern Nigeria. Pak. J. Nutr., 5: 1-5.
18. Abubakar, M., U. Ibrahim, A.U. Yusuf, A.S. Muhammad and N. Adamu, 2016. Growth performance, carcass and organ characteristics of growing rabbits fed graded levels of *Moringa oleifera* leaf meal in diets. Bayero J. Pure Appl. Sci., 8: 7-9.

19. Olafadehan, O.A., 2011. Carcass quality and cost-benefit of rabbits fed cassava peel meal. Archivos Zootecnia, 60: 757-765.
20. Ouyed, A., J. Rivest and J.M. Brun, 2011. Heterosis, direct and maternal additive effects on rabbit growth and carcass traits from a Canadian experiment. World Rabbit Sci., 19: 31-41.
21. Marounek, M., J. Mrázek, Z. Volek, E. Skřivanová and J. Killer, 2016. Pregastric and caecal fermentation pattern in Syrian hamsters. Mammalia, 80: 83-89.
22. Kanyinji, F. and M. Moonga, 2014. Effects of replacing maize meal with rumen filtrate-fermented cassava meal on growth and egg production performance in Japanese quails (*Cortunix japonica*). J. Adv. Vet. Anim. Res., 1: 100-106.