ADAN J. Agric. 2024, 5: 74-83 **DOI:10.36108/adanja/4202.50.0190**

ISSN 2736-0385

Effects of *Andropogon gayanus* and *Centrosema pubescens* leaf meal diets on the reproductive performance and economic efficiency of crossbred (New Zealand white ♀and black Chinchilla♂) rabbits

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Abstract
Two forages plants (Andropogon gayanus (Ag) and Centrosema pubescens (Cp) were analysed for their anti - nutritional factors, proximate composition as well as mineral composition to establish their nutritional potentials. A feeding trial was conducted to also evaluate the effect of (Ag) and (Cp) leaf meal-based diets on the reproductive performance and economics of production of Crossbred (New Zealand White ♀ X Chinchilla black♂) rabbits. Thirty-two breeder rabbits with average initial weight of 1800.00 ± 0.01g and age between 24 and 32 weeks were used for the study. The rabbits were randomly assigned into treatments 1, 2, 3, and 4 in a Completely Randomized Design (CRD). Each treatment was replicated four times with two rabbits per replicate. T_1 contained 0% leaf meal. T_2, T_3, and T_4 contained 4%, 8% and 12% dietary levels of Ag and Cp leaf meals, respectively. Data were collected on feed intake, initial body weights of does and bucks, weights of bunnies, litter size, birth rate, weight at pregnancy (14 days) and infant mortality rate were collected. The data were analysed using one way analysis of variance (ANOVA). Results showed that there were no significant (P>0.05) differences in all the parameters except on weight gain of bunnies (9.54 - 14.53g) and birth rate of the does (3.30 – 5.00). Mortality (dead bunnies) recorded were T_1 (25%), T_2 (25%), T_3 (12.5%), and T_4 (37.5%). The result of the feed cost analysis showed that feed cost per kg weight decreased as the inclusion levels of Ag and Cp leaf meals increased. The total revenue and net returns increased with the increasing levels of inclusion of Ag and Cp leaf meals. It was therefore concluded that 12% inclusion level of Ag and Cp leaf meals each is adequate for breeder rabbits without any adverse effect on their normal reproductive performance.

Keywords: *Andropogon gayanus, Centrosema pubescens, breeder rabbits, reproductive performance, cost-benefit.*

Introduction
The high costs of conventional vegetable protein and energy ingredients such as groundnut cake, soybean meal, maize, sorghum and millet have largely contributed to the current high price of animal feeds and products in Nigeria. 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 *Andropogon gayanus and Centrosema pubescens* in place of maize and the rabbit which can use these products so as to increase the animal protein intake of

Nigerians. Rabbits though often neglected, are one of the sources of animal protein in Nigeria. To improve its production and consumption in Nigeria where per caput animal protein intake is much below recommended levels, there is need to source for readily available, high quality alternative vegetable protein and energy sources that are cheaper and capable of reducing production cost of feeds. They are hardy, drought and disease resistant and blossom more in the rainy season. 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 brought about a rising cost of essential feed ingredients in our market thereby putting Livestock farmers at great disadvantage as they can hardly make ends meet in their business. This situation has led to the closing down of so many of the livestock farms as well as the production of sub-standard feed and feed ingredients by the feed mill operators in their attempt to make profit. Energy feedstuffs constitute between 45 and 60 percent of finished feeds for monogastric animals and at present maize constitutes the bulk of energy component of various rations. The search for new and alternative feedstuffs for livestock rations aims at reducing the cost of production of compounded feed by incorporating into such feeds cheap sources of nutrients that preferably do not qualify for direct consumption by man. Grasses and legumes species should fit logically as grain replacers in livestock feeds by virtue of their high caloric values with several agronomic advantages (Ekwe *et al.*, 2004 Akinmutimi, 2004; Odimba, 2006; Ogunbode *et al.*, 2011). Rabbits are known to perform better when fed with a mixture of forages and concentrate diets (Taiwo *et al.*, 2005) given the abundance of *Andropogon gayanus* and *Centrosema pubescens* in Nigeria. Their effective use in rabbit production will contribute greatly to improving the animal protein intake of Nigerians. The aim of this research is to evaluate *Andropogon gayanus* and *Centrosema pubescens* leaf meals as feed resources which could partially maize in the diets of breeding rabbits and as well its cost effectiveness.

Materials and Methods

Experiment 1:

Phytochemical/Proximate composition of *A. gayanus* and *C. Pubescens* Determination

Forage processing

Washing and Drying: *A. gayanus* and *C. pubescens* were harvested and rinsed separately in a trough using clean water to remove dirt. The leaves were rinsed again with 1% salt water and then with clean water. The forages were kept on top of a platform to drain off water and after were cut into shorter lengths (2 to 5 cm) and spread on the cellophane for drying. They were air-dried for 4 days and thereafter milled and bagged till it was used for feed formulation.

Milling and Bagging: The forages were milled separately using a hammer mill with screen size 2.0mm. This screen size was used to allow for proper milling. *Andropogon gayanus* and *Centrosema pubescens* leaf meals strongly attract moisture and the product can reabsorb moisture during and after milling.

Chemical Analysis: A fraction of each of the two milled samples were collected and used for chemical analysis involving proximate contents (AOAC, 2006) in

triplicate values, fibre fractions and photochemical constituents as presented in Tables 1, 2 and 3 and 4, respectively. The energy-values of the diets were calculated using the Atawordi factors 4, 9, and 4 for protein, fat,-and carbohydrate, respectively.

Anti-nutritional factors /Phytochemical analysis: Ground samples of feed and forages were sent to the laboratory in polythene bags for phytochemical analysis. The samples were screened for tannin, cyanide and saponin. Quantitative determination of phenols and trypsin inhibitors were carried out in triplicates using AOAC (2006) and spectrophotometric method as described by Artfield *et al*. (1985), respectively.

Tannin: This was determined by the Folin-Dennis spectrophotometric method described by Pearson (1976). The tannin content was calculated as follows:
%Tannin –An /AsxCx100/w x Five.
Where: An=Absorbance of test sample
As =Absorbance of standard solution
C= concentration
W=weight of sample used
Vf =total volume of extract
Va=volume of extract analysed.

Acid detergent fiber (ADF): Saura-Calixto *et al*. (1983) method was used. The acid detergent fraction was taken as the difference in weight.

$$ADF = \frac{w2 - w1}{wo} \; X \; \frac{100}{1} \quad Equation\ 2(Eqn.2)$$

Acid detergent Lignin: The acid detergent lignin was taken as the difference in weight.

$$\text{Lignin} = w2 - w1 \; X \; \frac{100}{1} \quad Equation\ 3(Eqn\ 3)$$

Cellulose: The method of Silva *et al.* (2005) was used. The cellulose was estimated from the difference between ADF and lignin.

$$\text{Cellulose} = Eqn.2 - Eqn.3 \; X \; \frac{100}{1}$$

Hemicellulose: The difference between the NDF and ADF was estimated as hemicelluloses (Silva *et al.* 2005).

$$NDF = Eqn.1 - Eqn.2 \; X \; \frac{100}{1}$$

% Dietary fiber = NDF + ADF+ Lignin+ Cellulose+Hemicellulose.
NDF=Neutral detergent fiber
ADF =Acid detergent fiber.
The

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.

Table 1: Proximate composition (%) *of A. gayanus* nd *C. pubescen* (Experiment 1)

S/No	Parameters	DM	CP	CF	EE	Ash	NFE	GE (kcal/kg)
1.	*A. gayanus*	90.7	13.83	32.75	0.88	19.2	30.45	4911.03
2.	*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); NFE = (nitrogen free extract); GE = gross energy, kcal/kg = kilo calorie/kilogram weight

Table 2: Qualitative analysis of anti-nutritional factors of forages and breeder diets. (Experiment 1)

Parameters	Solvent	Tannin	Saponin
C. pubescens	N-Hexane	+ + +	-
	H_2O	+ +	+
A. gayanus	N-Hexane	+ +	+
	H_2O	+ +	-
T_1 (0%)	N-Hexane	+	+ +
	H_2O	-	+ +
T_2 (5%)	N-Hexane	+ +	+
	H_2O	+	+ +
T_3 (10%)	N-Hexane	+ +	+ +
	H_2O	+ +	+
T_4 (15%)	N-Hexane	+ +	+ +
	H_2O	+ +	+

T_1= (0% forage), T_2= (5% forage); T_3= (10% forage); T_4 = (15%forage); - = (nil); + = (low); ++ = (high); +++ = (very high) = concentrations of each of the solvents with the two forages, respectively.

Table3: Quantitative analysis of anti-nutritional factors of forages and experimental diets

Sample	Saponin (%)	Tannin (%)
C. pubescens	0.36	2.50
A. gayanus	0.64	8.20
T_1 (0%)	0.10	4.63
T_2 (5%)	0.34	4.82
T_4 (10%)	0.52	4.92
T_3 (15%)	0.64	4.98

T_1= (0% forage meals); T_2 = (5% forage meals$_{)}$; T_3= (10% forage meals); T_4= (15% forage meals)

Table: 4 Mineral composition of the forages and the breeder's diets. (Experiment 1)

S/no	Parameters	Ca	Mg	Na	Fe	Mn
1	*C. pubescens*	0.36	2.55	2.05	0.22	0.0115
2	*A. gayanus*	0.24	1.61	1.34	0.22	0.01
3	$T_{1\ (0\%)}$	1.03	1.26	1.36	0.17	0.01
4	$T_{2\ (5\%)}$	1.15	1.61	1.41	0.50	0.01
5	$T_{3\ (10\%)}$	1.21	1.65	1.59	0.52	0.01
6	$T_{4\ (15\%)}$	1.27	1.68	1.91	0.56	0.005

T_1 = (0% forage meals), T_2= (5% forage meals), T_3 = (10% forage meals) and T_4 = (15% forage meals) Ca = (Calcium); Mg = (Magnesium); Na = (Sodium); Fe = (Iron); Mn = (Manganese).

Feeding trial (Experiment 2)

Experimental site

The study was carried out 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. Ebonyi State is partly located in the rainforest and derived Savanna regions of Nigeria. It has a mean annual rainfall between 1500 mm and 1800 mm and mean temperature of 30^{o}C during very hot weather (February to April) and 21^{o}C during the coldest period of the year - December to January (Ofomata, 2008).

Source of Rabbits and Forage Plants

The rabbits used for this study were purchased from Federal College of Agiculture, Ishiagu Ebonyi State, Nigeria while Gamba (grasses) and Centrosema (legumes) were harvested from Ebonyi State University Pasture Farm, Faculty of Agriculture and Natural Resources Management, Abakaliki, Nigeria.

Experimental Animals/Design

Thirty two (32) crossbred, sexually matured female rabbits of age between 24 and 28 weeks of age were used for this experiment. The animals were divided into 4 groups and randomly assigned to four treatments. The dietary treatments comprised of varying levels of *Andropogon gayanus* and *Centrosema pubescens* leaf meal inclusion ranging from 0%, (T_1-control), 2, 4, and 6 each for T_2, T_3, and T_4 respectively in a completely randomized design (CRD). Each treatment has 8 rabbits replicated 4 times with 2 rabbits per replicate. Each of the four treatments groups were crossed mated with a matured male (buck). There were four bucks which were used interchangeably at different times to avoid possible case of sterility which may occur among the animals during the mating period. The study lasted for 84 days.

Experimental Diets

Table 5: Percentage Composition of experimental feed (Breeder rabbit) (%).

	Graded levels of *A.gayanus and C. pub* leaf meal			
Ingredients	$D_{1\ (0\%)}$	$D_{2\ (2\%)}$	$D_{3\ (4\%)}$	$D_{4\ (6\%)}$
Maize	39.00	35.00	31.00	27.00
A.gayanus (leaf meal)	-	2.00	4.00	6.00
C. pubescens	-	2.00	4.00	6.00
Soybean meal	10.00	10.00	10.00	10.00
Palm kernel	2.00	2.00	2.00	2.00
Fish meal	0.50	0.50	0.50	0.50
Wheat offal	21.00	21.00	21.00	21.00
Brewers spent grain	24.00	24.00	24.00	24.00
Bone meal	3.00	3.00	3.00	3.00
Salt (NaCl)	0.25	0.25	0.25	0.25
*Vitamin/Min.Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Nutrient composition:				
Energy (ME Kcal/kg))–calculated	2948.11	2971.87	2995.63	3019.39
Crude protein (%)	19.73	20.07	20.41	20.75
Crude fiber (%)	10.92	11.97	13.03	14.08
Ether extract (%)	7.54	7.49	7.44	7.39
Neutral detergent fibre (%)	22.9	32.18	37.59	37.57
Acid detergent fibre (%)	17.70	20.71	22.96	19.93
Phosphorus (%)) -calculated	4.23	4.27	4.29	4.33
Calcium (%))–calculated	2.09	2.10	2.11	2.12

*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 0.01mg, 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, Cholin 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 0.04 g, Copper 0.002 g, iodine 0.00153 g, Cobalt 0.000225 g, Selenium 0.0001 g.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) as described by (Steel and Torrie, 1980) and significant means were separated using (Duncan, 1955).

Results and Discussion

Performance characteristics of breeder rabbits

The result of the performance characteristics of breeder rabbits is presented in Table 6. There were significant ($P<0.05$) differences in some of the reproductive indices such as average initial weight of bunnies (birth weight), average birth rate of does, average weight of does before pregnancy. Treatment 1 (0% -without leaf meal) and 3 (with 4% leaf meal) had significant differences ($P< 0.05$) in their initial weights but treatment 2 (with 2% leaf meal each) differs ($P<0.05$) from T4 (with 6% leaf meal each) in their initial weights. Treatments 1 (0% leaf meal each), 2 (2% leaf meal each) and 3 (4% leaf meal each) differs ($P>0.05$) significantly. The initial weights (birth weights) of the bunnies showed significant ($P<0.05$) differences. At early weaning (4 to 6 weeks), five (5 times) birth rate could be achieved but with late weaning period (6 to 8 weeks), the doe could litter up to four (4) times. The weights of bunnies at birth (birth weight) across the treatments increased with increase in the level of the leaf meals from T_2 to T_4 and the lower the litter size the higher the birth weight but the higher the litter size the the birth weight. At higher litter size (6 - 8 bunnies), the average birth weight ranged from 32 to 38g whereas at a lower litter size, the average weight of bunnies ranged from 48 to 65g. Treatment 3 (with 4% leaf meal) showed a higher intake than the control (0%), 2 (with 2% leaf meal) and 4 (with 6% leaf meal). Palatability may have contributed to the higher feed intake of the animals in treatment 3 among others. In the average litter size, treatment 3 (with 4% leaf meal) was the best with an average litter size of (6.25), followed by treatments 4 (5.50), 1 (4.25) and 2(4.0) in that order. The birth rate of the rabbits in the various treatments showed that treatment 3 had the higher value compared to the control. Treatment 1 (with 0%leaf meal) had a value of 4.0 while 2 (2% leaf meal) and 4 (with 6%leaf meal) had values of 3.80 and 3.30 kindling per annum per doe respectively. However, the average kindling rate observed in this study was 4-5 times per annum per doe. The average weight of doe during pregnancy (14 days) and the average weight of doe before kindling (28 days) showed no significant ($P>0.05$) difference among the animals in the various treatment groups. There was no clear indication as to whether to attribute this effect to the leaf meal in the diets since there was no regular pattern in the variations among the treatment groups. The higher value recorded in the average litter size in treatment 3 and 4 (6.25), and (5.50) over T_2 (4.00) and T_1 (4.25) may be attributed to the higher feed intake. The cost of feeding grower rabbits could be lowered by supplementing concentrate diets with *Stylosanthes* leaf meals. Ikurior *et al.* (2009) reported that *Tridax procumbens* can be included in cassava based diets for rabbits and nutrient digestibility can be maximized at 10% level of inclusion. The reports of this study are in agreement with the findings of Aduku *et al.* (2001) who reported that some forages such as *Tridax procumbens, Desmdium scripiums, Luffa egyptiaca, and macroptillium atropurpureum, Leucaena*

leucocephala, *musa spp.* remains green throughout the year and are well accepted by rabbits as feed. Abubakar *et al.* (2011) reported that weaned rabbits can utilize varying levels of *Moringa oleifera (*leaf meal up to 45%) level in diets without adverse effects on growth performance, carcass yield, organ and gut characteristics. However, in this study, the higher weights of some bunnies at birth could be attributed to the higher weight of the doe both during (14 days) and before kindling (28 days). The weight of does in T_3 and T_4 during pregnancy (2088) g and (2098.25) g as well as their weights (2320.75 and 2321.75) when compared with their litter sizes were good indicators that the dietary nutrients were better utilized at T_3 (4%) and T_4 (6%) compared to T_1 (0%) and T_2 (2%) levels of inclusion, respectively.

Table 6: Performance of breeder rabbits fed experimental diets containing *Ag* and *Cp*.

Parameters	T_1 (0%)	T_2 (2%)	T_3 (4%)	T_4 6%)	SEM±
Number of Does	8	8	8	8	-
Initial Weight of Does	1850.00[a]	1750.00[b]	1850.00[a]	1750.00[b]	0.1
Initial wt. of bunnies (birth wt.) g	53.50[a]	57.75[a]	50.75[b]	43.25[c]	1.99
Feed consumed (g)	16500.75	16312.80	16539.60	15952.65	1.08
Litter size (No. of young at birth)	4.25	4.00	6.25	5.50	0.36
Daily wt. gain of bunnies (g)	11.20[b]	11.11[b]	14.53[a]	9.54[c]	0.94
Birth rate (No. Of time Does littered)	4.00[b]	3.80[b]	5.00[a]	3.30[c]	0.49
Weight of Doe at pregnancy(14days) g	2128.75	2134.00	2088.00	2098.25	0.21
Weight of Doe before kindly (28 days)g	2330.00	2408.00	2320.75	2321.75	0.43
Total mortality	2	2	1	3	0.32
Survivability %	66.67	66.67	87.50	62.5	0.46

[abc]- means in a row with different superscript are significantly ($P<0.05$) different. SEM ± = standard error of mean

Feed cost-benefit analysis

The result of feed cost-benefit of production of breeder rabbits fed Gamba grass (*A. gayanus*) and Centrosema (*C. pubescens)* leaf meal diets is presented in Table 7. There were no significant ($P>0.05$) differences in all the parameters studied except in the gross margin (GM) among rabbits in different treatments (T1 – T4). Diet 1 (T1 – control) with 0% leaf meal had the highest cost per kg feed (₦65.00) followed by diets 2, (4% leaf meal) diet 3 (8 % leaf meal) and diet 4 (12% leaf meal) and the values were ₦54.00, ₦50.00, ₦ 48.00, respectively. The highest cost of feed per kg in diet 1 was as a result of the higher content of maize grain (39.00kg) as against 35.00kg, 31.00kg and 27.00kg for diets 2, 3 and 4, respectively. Maize grain is more expensive compared to other conventional energy feed ingredients sources. The price per kg feed reduced as the level of the leaf meals increased progressively in diets 2, 3, and 4, respectively. The total cost of feed consumed in the dietary treatments showed that treatment 1 had the highest cost (₦318.50) when compared to the dietary treatments 2, 3 and 4 which were (₦264.60), (₦ 245.00) and (₦230.00), respectively. Table 7 showed that the cost of feed used to produce the bunnies (kg weight) in each treatment had values which decreased progressively from treatment 1 (₦348.00), to treatment 2, 3 and 4 (₦294.60, ₦ 275.00, and ₦260.00), respectively. The result on the cost of feed

per kg showed significant (P<0.05) differences among the various dietary treatments. The gross margin (GM) showed significant (P<0.05) differences among the various dietary treatment groups. There was no significant (P>0.05) difference between dietary treatments 3 (8% leaf meal) and 4 (12% leaf meal) but there was a significant (P<0.05) difference between dietary treatments 4 and 3, when compared to 2 and 1 (control without a leaf meal). It is economically efficient to produce weaned rabbits with 12% inclusion of *A. gayanus* and *C. pubescens* leaf meals diets. Therefore, the inclusion of *A. gayanus* and *C. pubescens* leaf meals diets with the cost-benefit ratio of 1.20 had the best economic merit and therefore could be chosen by the rabbit farmer for more profitability.

Table 7: Feed cost-benefits analysis of breeder rabbits fed experimental diets

Total cost of production	$T_{1\ (0\%)}$	$T_{2\ (4\%)}$	$T_{3\ (8\%)}$	$T_{4\ (12\%)}$	SEM
Feed consumed (g)	4950.00	4893.84	4961.70	4785.79	1.03
Cost of feed (₦/kg)	65.00	54.00	50.00	48.00	2.01
Total cost of feed consumed (₦)	*318.50	*264.60	*245.00	*230.00	3.14
Number of bunnies generated	5.00	5.00	4.00	3.00	0.65
Number of bunnies survived/weaned	4.00	5.00	3.00	3.00	I.28
Number of weaners sold	4.00	5.00	3.00	3.00	3.01
Medication (₦)	30.00	30.00	30.00	30.00	2.01
Total variable Cost (TVC) (₦)	348.50	294.60	275.00	260.00	0.48
Total revenue (TR) (₦)	800.00	800.00	800.00	800.00	2.05
Gross margin (GM) (₦)	451.50^{c}	505.40^{b}	525.00^{a}	540.00^{a}	0.19
Cost :benefit ratio	1.10	1.12	1.16	1.20	1.12

^{abc}= Means on the same role with different superscripts are significantly different **(P<0.05) * =** Total cost of feed consumed plus Cost of medication = (Total variable cost); TVC =Total variable cost; TR= Total revenue; GM = Gross margin; Cost: benefit ratio (CBR) = The lowest gross margin was used to divide the gross margin in each of the treatments T_1= (0% forage meals); T_2 = (4% forage meals) T_3 = (8% forage meals); T_4 = (12% forage meal) . SEM= standard error of mean.

Conclusion

The results of this investigation revealed that 12% inclusion level of *Andropon gayanus* and *Centrosema pubescence l*eaf meals is adequate for breeder rabbits without any adverse effect on their normal reproductive performance. It was also observed that 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**.**The results of this investigation indicated that 12% of *A. gayanus* and *C. pubescens* leaf meals can be incorporated into diets of breeder rabbits without any deleterious effect on the growth performance, reproduction and proper development.

Acknowledgement

We wish to thank Prof. O.C. Onwudike (the Vice Chancellor of Rhema University Aba, Nigeria) for his guidance and support during the course of this research.

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