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Effect of dietary inclusion levels of locust (*Zonocerous variegatus*) meal on growth performance and carcass characteristics of grower rabbits

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Target Audience: *Farmers, Scientists, Feed producers, Technologists*

Abstract

An experiment was conducted to evaluate the effect of feeding inclusion levels of locust meal on growth performance and carcass characteristics of grower rabbits, with four dietary inclusion levels of locust meal (LM) at 0, 5, 10 and 15% respectively. Twenty eight (28) weaned rabbits aged 6 weeks of different breeds and sex were used for the study and randomly assigned to four dietary treatment groups with seven (7) rabbits per treatment in a completely randomized design (CRD). Parameters measured include: initial and final weights, weight gain, feed intake and feed conversion ratio, respectively. The trial lasted for eight (8) weeks. Data generated were set for analysis of variance (ANOVA) using SAS (2005) software package. The average daily weight gain (ADWG g/d) of rabbits fed the control diet, 5 and 15% LM were within the same level but higher (P<0.05) than those fed 10% level of inclusion. Average daily feed intake of rabbits fed 5% level of inclusion was higher (P<0.05) than those fed the control diet. However, the feed conversion ratio of rabbits fed the control diet, 5 and 15% levels of inclusion of LM was similar (5.39) but lower than those fed 10% LM (6.40). Rabbits fed 10% and 15% levels of inclusion of LM had higher (P<0.05) dressing percentage and carcass weight respectively, than those fed the control diet. In conclusion, dietary replacement of Soya bean meal with 5% locust meal improved growth performance and carcass characteristics.

Key words: Rabbit breeds; Diet; Carcass quality; Locust;

Description of problem

The increased desire for proteins like meat and milk is assumed to be 58% and 70% higher in 2050 than they were in 2010. This increase will come mostly from developing countries [1]. New ideas on rearing short cycled animals like rabbits will pave way on reaching this gap [2]. Rabbits are highly prolific and for optimum performance; good quality feed is required [2]. However, the conventional feed resources available are expensive and away from the low-income farmers, due to increasing costs of these feed resources [3]. Reports have shown that feeding cost constitute over 70-80% cost of production Akinmutimi and Ezea [4] resulting in higher price of producing animals and subsequently the value of materials derived from animals like meat.

Consumers are getting more curious on the type of food they consume such as meat [5]. Health wise, rabbit meat has some quality attributes when compare with other meat like beef due to its higher protein content, low unsaturated fats richer in polyunsaturated ones, absence of uric acid and purines, compared to beef [6]. However,

annual consumption of rabbit meat remains limited worldwide (0.30 kg per person) when compare to beef (6.4kg), pork (12.5 kg) and poultry with 13.5 kg [5].

Abanikannda [7] reported the substitution of 25% fish meal by migratory locust (*Locusta migratoria*) meal in an iso-protein diet of Nile tilapia fingerlings; it shows no adverse effect on the nutrient digestibility, growth performance and haematological parameters. In another study, broiler birds fed diet containing desert locust meal (*Schistocerca gregaria*) substituting 50% fish meal (1.7% in the diet), resulted in higher body weight gain, feed intake and feed conversion ratio [8]. Presently, there is a growing interest in the use of some protein rich insect species as a low-cost protein ingredient in livestock ration because, they may reduce production cost by reducing competition for conventional feed resources like soya [9]. According to Rafi Ullah *et al.* [10], they grow and reproduce very fast; feed conversion efficiency is high and can be fed on bio-wastes materials. In Nigerian livestock industry, limited work was done on the nutritional value of insect meal on rabbit.

Therefore, this research was done to evaluate the effect of feeding inclusion levels of locust meal on growth performance and carcass characteristics of grower rabbits.

Materials and methods

Experimental location:

The research was done at the rabbitry unit of the Teaching and Research Farm, Department of Animal Science, Ahmadu Bello University, Zaria. Zaria is located in the Guinea Savanna Zone of Nigeria at (Latitude 11^0 9' 46" N and Longitude 7^0 37' 45" E), an altitude of 610m above sea level (Institute for Agricultural Research, 2020). Temperature varies from 26^0C-40^0C determined by the season while the relative humidity during the dry and rainy seasons varied from 21% to 72%, respectively. The rainy season in Zaria begins between May and October with annual rainfall of about 1500mm [11].

Experimental design:

Twenty eight (28) weaned rabbits aged 6 weeks with (average weight 500±12g) of different sex and breeds (Dutch and New Zealand White); purchased from a free market in Samaru were used for this study. On arrival, the rabbits were weighed one at a time before randomly allocated to four dietary treatment groups with seven rabbits (7) for each treatment and each serve as a replicate in a completely randomized design (CRD).

The rabbits were let to adjust for seven days with the environment and the feed. Fresh feed and clean drinking water was provided *ad libitum* throughout the experimental period. Any disease sign observed was treated accordingly.

Experimental diets and feeding trial:

The locust (*Zonocerous variegatus*) was sourced from a free market in Sabon Gari, Zaria, North West Nigeria cleaned, milled and incorporated into the experimental diets. Four iso-nitrogenous diets were formulated containing inclusion levels of locust meal (LM) at 0, 5 (1.20), 10 (2.40) and 15 (3.60) %, respectively (Table 1) as a substitute to soya bean meal. They were formulated to meet NRC [12] nutritional requirements of rabbits. Initial weights were recorded and thereafter, weighed weekly. Total left over feed for each rabbit was bulked and the weight subtracted from the total weight of feed given and the amount of feed intake was calculated. Each day, the volume of remnant water was taken and subtracted from the total volume of water given the previous day

in order to measure the volume of water consumed. The volume of water given to each rabbit was also kept in an empty cage. The remaining left water was taken and subtracted from the total volume of water given earlier was used to determine the water dissipated through evaporation. The research lasted for 8
weeks

Table 1: Ingredient composition of experimental diets containing Inclusion levels of Locust Meal as Replacement for Soyabean Cake

Ingredients	Replacement levels of Soyabean Meal (%)			
	0	5	10	15
Maize	20.00	20.00	20.00	20.00
Maize offal	23.45	23.45	23.45	23.45
Rice offal	30.00	30.00	30.00	30.00
Locust Meal	0.00	1.20	2.40	3.60
Soya meal	24.00	22.80	21.60	20.40
Common salt	0.60	0.60	0.60	0.60
Bone meal	2.00	2.00	2.00	2.00
Total (%)	100	100	100	100
Calculated Analysis				
ME (kcal/kg)	2523.10	2519.40	2515.70	2512.00
Crude Protein (%)	16.30	16.50	16.70	17.00
Crude fiber (%)	13.23	13.20	13.17	13.14
Ether extract (%)	3.86	3.86	3.85	3.85
Dry matter (%)	90.50	90.50	90.60	90.60
Cost/kg diet (₦)	93.67	107.23	120.79	133.67

The initial and weekly weight of the rabbits was used to determine weight gains. Daily feed intake, weight gain, water consumption (ml), feed conversion ratio, and cost per kilogram weight gain (₦) were calculated from the data obtainable. The final live-weight was taking at the end of the experiment. The research lasted for eight (8) weeks.

Carcass evaluation:
All the animals were kept off feed for twelve hours before slaughter at the end of the research. They were slaughtered according to the method of Amenan *et al.*, [5]. The animals were bled by turning them upside down for 30 minutes, skinned, washed, eviscerated and separated into wholesale cuts. Slaughter, dress weights and all other carcass characteristics were recorded accordingly. Product processing was carried out at the Animal Product Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria.

Chemical analysis:
Locust meal and feed samples were analyzed for proximate composition which include: moisture content (MC), dry matter (DM), crude protein (CP), crude fat (EE), crude fiber (CF) and ash (A) contents using AOAC [13] methods, while the nitrogen free extract (NFE) was determined by difference [NFE = 100 – (% CP + % CF + % EE + % Ash)] at the Food Science Laboratory, Institute for Agricultural Research, Ahmadu Bello

University, Zaria. The energy content of feed samples was estimated following the method of Sherief and Doaa [14].

Statistical analysis:

All data derived from the study were properly checked for outliers and transformed where necessary before putting through for analysis of variance (ANOVA) using SAS [15] software package. A significant level of 5% was used. Treatment means that were significantly different were compared using Dunnet's Test of the SAS package [15].

Model used in the analysis;

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

Where:

Y_{ij} = any dependent variable

μ = Overall mean

T_i = Effect of treatment (0, 5, 10 and 15 % inclusion levels of locust meal)

e_{ij} = Random error.

Results and Discussion

Proximate analysis of the experimental diets and Locust meal:

Result for proximate analysis of the experimental diets and locust meal is presented in Table 2. The result derived shows that the dry matter (DM) of the diets varied from 87% in the diet with 10% inclusion of locust meal (LM) to 89% in the diet with 5% inclusion level. However, the Locust had 91% dry matter content. The crude protein (CP) content of the diet with 10% inclusion level of LM were lower (18%CP) and higher in the diet with 5% inclusion level of LM (19%CP). Locust meal had 30%CP which was the highest value obtained. However, the crude fibre (CF) of LM was the least (6%) compared to those of j diets. The result further indicates that diet containing 5% inclusion level of LM had the highest value of crude fibre (13%) than diet with 15% level of inclusion (10.82%), respectively. The ether extract (EE) content of the diet containing 10% inclusion level of LM was higher (1.34%) than that of the diet with 5% level of inclusion of LM (1.13%). Locust meal had 4.55% content of ether extract. The ash contents of LM and diet containing 5% inclusion level were higher and comparable (7%) than in the other diets (6%). The nitrogen free extract (NFE) of the LM was the least (49%) compared to diets with 5% and 15% inclusion levels of LM (60% and 64%), respectively.

Table 2: Proximate Composition of Locust Meal and the Experimental Diets Containing inclusion levels of Locust Meal as Replacement for Soyabean Meal

Parameters	Replacement levels of Soyabean o (%)				Locust Meal
	0	5	10	15	
Dry matter (%)	88.86	89.24	86.64	88.87	90.65
Crude protein (%)	18.94	19.00	18.23	18.38	30.01
Crude fibre (%)	10.94	13.01	12.78	10.82	6.07
Ether extract (%)	1.25	1.13	1.34	1.16	4.55
Ash (%)	5.60	6.89	5.60	5.76	7.01
NFE (%)	63.20	59.90	61.90	63.88	48.98

Growth performance and feed conversion ratio

Results of growth performance and feed conversion ratio of grower rabbits fed diets containing inclusion levels of locust meal as substitute to Soyabean meal are presented in Table 3. Initial weight of the rabbits was similar (P>0.05) across the treatments.

Rabbits fed diets with 5% and 15% levels of inclusion of locust meal (LM) in the diet had statistically similar (P<0.05) and higher values for final weight than those fed diet with 10% level of inclusion of LM. Also, rabbits fed diet with 5% level of inclusion of LM had the highest (P<0.05) for weight gain in comparison to those fed 0, 10 and 15% inclusion level. The mean value for daily feed intake of rabbits fed 5% level of inclusion in the diet was significantly higher (P<0.05) than those fed 10% level of inclusion in the diet.

Rabbits fed the control diet and diets with 5% and 15% levels of inclusion of locust meal had significantly lower (P<0.05) feed conversion ratio than those fed 10% level of inclusion. However, rabbits fed diets with 10% and 15% levels of inclusion of locust meal had significantly higher (P<0.05) feed cost per kg gain compared to those fed the control diet. There was 1% mortality in rabbits fed the control diet compared to those fed diets containing varying inclusion levels of locust meal. Mortality records were however statically not significant across the treatment groups.

Table 3: Growth performance of grower rabbits fed diets containing Inclusion levels of Locust Meal as Replacement for Soyabean Meal

Parameters	Replacement levels of Soyabean Meal (%)				SEM
	0	5	10	15	
Initial weight (g)	830.25	868.30	909.70	918.45	53.39^{NS}
Final weight (g)	1418.9^{b}	1517.86^{a}	1353.3^{c}	1515.02^{a}	20.63
Weight gain (g)	588.96^{b}	649.86^{a}	444.36^{c}	597.02^{b}	12.58
Ave daily weight gain (g)	10.52^{a}	11.60^{a}	7.94^{b}	10.66^{a}	0.50
Ave daily feed intake (g)	56.52^{b}	61.86^{a}	50.83^{c}	58.34^{b}	0.93
Feed conversion ratio	5.37^{a}	5.33^{a}	6.40^{b}	5.47^{a}	0.23
Feed cost/kg gain (₦)	503.01^{a}	571.54^{b}	773.06^{c}	731.17^{c}	25.54
Ave daily water intake (ml)	82.24^{c}	125.20^{b}	165.32^{a}	173.45^{a}	13.33
Mortality %	1	0	0	0	0.00

^{abc}Means with different superscripts on the same row differed significantly (P<0.05); SEM = Standard error of mean; NS = Not Significant

The use of locust meal (LM) in rabbit diet has been advocated due to its friendly nature and ability to satisfy the nutritive requirements and social behavior of rabbits [16]. Insects are important sectors of African economy that have the potential to improve quantity and quality of livestock products [17]. The feed intake of rabbits fed 5% level of inclusion of LM in the diet was higher than those fed 10%, although the value was lower than 79g per day stated by Frederic *et al.* [18]. This result may be related to the crude protein and fibre contents of the diets (Table 2). According to Andrade *et al.* [19], the initial crude protein content of the diet affects feed intake and growth performance in rabbits. Liu *et al.* [20] stated that the crude fibre content of the diet is the main driving force for determining growth performance in fattening rabbits. These authors further reported that the higher crude fibre in rabbit diets affects the intestinal transit in the gut which further affects the digestibility of dry matter (DM), crude protein (CP), ether extract (EE) and nitrogen free extract (NFE), respectively. This assertion can be observed in rabbits fed 5% inclusion level of LM than those fed

other treatments. This indicates that the level of fibre in rabbit diets should be between 10-13% for optimum performance [18].

The significant decrease in the final weight of rabbits fed 10% level of inclusion of locust meal in the diet may be due to increase concentration of fermentable substrates which might decrease protein utilization [20]. It could also be possible that the rabbits were stressed due to cage confinement which prevented them from expressing their natural behavior. Bai *et al.* [21] reported that stress condition affects growth performance in rabbits. The average daily weight gain (ADWG) of rabbits in this study was lower than the reported values of 52g/day and 54g/day, respectively [22, 23]. These variations may be attributed to differences in rabbit breeds and the feed ingredients used. This was evident in the feed conversion ratio (FCR) recorded in this study (5.33) as presented in Table 3, compared to (2.62) reported in hybrid rabbits with high feed conversion efficiency [23]. Generally, results obtained in this study coincide with the investigations of Liu *et al.*[20] in Hyla rabbits and Sihem *et al.*[24] when black soldier defatted meal was used as partial replacement for soyabean meal in broiler chickens.

Carcass characteristics, prime cuts and organs weights of rabbits

Table 4 shows results of carcass characteristics of growing rabbits fed diets containing inclusion levels of locust meal. Rabbits fed diets with 5% and 15% levels of inclusion of LM had significantly higher ($P<0.05$) live weight compare to those fed diet with 10% inclusion level. Results of slaughter weight of the rabbits followed a similar trend ($P<0.05$). However, rabbits fed diet with 15% level of inclusion of locust meal had significantly higher ($P<0.05$) carcass weight compared to those fed the control and diet with 5% level of inclusion, respectively. Significant ($P<0.05$) treatment effects was observed on dressing percentage of the growing rabbits; with those fed diet containing 10% inclusion level of LM having the highest value compared to those fed 5% level of inclusion.

Table 4: Carcass characteristics of grower rabbits fed diets containing Inclusion levels of Locust Meal as Replacement for Soyabean Cake

Parameters	Replacement levels of Soyabean Meal (%)				SEM
	0	5	10	15	
Live weight (g)	1538.96 ^{b}	1639.86^{a}	1450.76 ^{c}	1642.52 ^{a}	19.14
Slaughter weight (g)	1461.96 ^{b}	1565.80 ^{a}	1380.76 ^{c}	1570.52 ^{a}	13.35
Carcass weight (g)	829.71 ^{c}	817.14 ^{c}	894.57 ^{b}	914.43 ^{a}	7.66
Dressing (%)	53.91 ^{b}	49.83 ^{c}	61.66 ^{a}	55.67 ^{b}	1.01

^{abc}Means with different superscript on the same row differ significantly ($P<0.05$); SEM = Standard error of mean

Results of prime cuts of growing rabbits fed diets containing inclusion levels of locust meal is illustrated in Table 5. Rabbits fed diet with 10% inclusion level of locust meal had significantly higher ($P<0.05$) percentages of shoulder, loin and legs, respectively than those fed diet with 5% levels of inclusion of LM. The highest percentage value of thigh was reported in rabbits fed the control diet ($P<0.05$) in comparison to those fed diet with 15% inclusion level. However, the relative

percentage of head of the rabbits fed diet with 15% inclusion level of LM was significantly higher (P<0.05) than those fed the control diet.

Table 5: Prime cuts of grower rabbits (% of LWt) fed diets containing Inclusion levels of Locust Meal as Replacement for Soya bean Cake

Parameters (%)	Replacement levels of Soya bean Meal (%)				SEM
	0	5	10	15	
Shoulder	5.33^{b}	5.16^{c}	6.55^{a}	5.39^{b}	0.04
Loin	5.10^{d}	5.17^{c}	8.33^{a}	5.50^{b}	0.10
Thigh	11.08^{a}	9.38^{c}	10.72^{b}	8.64^{d}	0.11
Head	5.01^{d}	5.28^{c}	5.51^{b}	5.59^{a}	0.03
Legs	1.89^{b}	1.82^{c}	1.99^{a}	1.87^{b}	0.01

^{abcd}Means with different superscript on the same row differ significantly (P<0.05); LWt = Live weight (g); SEM = Standard error of mean

Results of organs weight of growing rabbits fed diets containing inclusion levels of locust meal expressed as percentages of live weight are illustrated in Table 6. Significant differences (P<0.05) were observed in all the parameters measured except in weights of small and large intestines (P>0.05). It was noted that rabbits fed diet with 10% inclusion of LM had significantly higher (P<0.05) percentages of heart, liver, lungs, kidneys, skin and weight of stomach, respectively compared to rabbits fed diet with 5% LM inclusion in the diet. It was also noted that the spleen of rabbits fed the experimental diets was significantly (P<0.05) higher that those fed the control diet. However, rabbits fed diet with 15% inclusion level of LM had higher (P<0.05) percentages of head and tail compared to those fed diet with 5% inclusion level.

Table 6: Organs weight of grower rabbits (% of Live weight) fed diets containing Inclusion levels of Locust Meal as Replacement for Soyabean Meal

Parameters	Replacement levels of Soya bean Meal (%)				SEM
	0	5	10	15	
Length of SI (cm)	236.00^{b}	239.57^{ab}	246.00^{a}	232.57^{b}	6.02
Length of LI (cm)	191.14^{a}	177.29^{b}	176.71^{b}	185.29^{a}	3.33
Heart (%)	0.15^{b}	0.12^{c}	0.24^{a}	0.13^{b}	0.01
Liver (%)	1.32^{b}	1.36^{b}	1.58^{a}	1.30^{b}	0.03
Lungs (%)	0.43^{b}	0.37^{c}	0.51^{a}	0.31^{d}	0.02
Kidneys (%)	0.38^{b}	0.26^{d}	0.46^{a}	0.35^{c}	0.01
Spleen (%)	0.04^{b}	0.06^{a}	0.07^{a}	0.08^{a}	0.01
Skin (%)	4.71^{d}	5.19^{c}	5.73^{a}	5.53^{b}	0.02
Tail (%)	0.32^{b}	0.26^{c}	0.32^{b}	0.39^{a}	0.01
Wt. of stomach (g)	1.37^{a}	1.41^{a}	1.39^{a}	1.33^{b}	0.11
Wt. of Small intestine (g)	2.68	2.71	2.63	2.55	0.20
Wt. of Large intestine(g)	2.96	2.83	2.57	3.09	0.33

^{abcd} Means with different superscript on the same row differ significantly (P<0.05); SEM = Standard error of mean

Rabbits are cherished by many people because of their potential meat quality [25]. In this study, it was clear that including locust meal in the diet of grower rabbits had effect on carcass characteristics, prime cuts and organ weights (Tables 4, 5 and 6, respectively). The effect of diet composition on carcass characteristics of rabbits has been a matter of concern [20]. The values of carcass weight, prime cuts and organ weights reported in this study were lower than the values of Uhlirova *et al.* [23] and Laura *et al.* [26]. This difference can be due to differences in rabbit breeds used and the test ingredients. Although rabbits of different breeds and sexes were used in this study, dressing percentage recorded coincide with the investigations of Oloruntola *et al.* [27] and Uhlirova *et al.* [23]. However, the values recorded for dressing percentage and skin (Tables 4 and 5) were lower than the reported values of 69% and 284g, respectively [28]. This difference might be related to the physical adaptation of the digestive tract of rabbits fed 5% inclusion level of locust meal to increase in feed intake and crude fibre level of the diets (Tables 1 and 2).

The dressing percentage of rabbits fed 10% inclusion level of locust meal were higher than the values of 58% reported in broiler rabbits [26]. This result indicates that rabbits have the potential to supply high quality meat for consumption from less competitive feedstuffs available in the society [29, 30]. The values recorded for prime cuts in this study were however lower than the values reported by Sihem *et al.* [24] in Hyplus rabbit. It was found that in this study lower levels of inclusion of locust meal in the diet of growing rabbits (5-10%) had the best slaughter weights, dressing percentages, prime cuts and organ weights, respectively. This therefore shows that feeding treatments had positive effect on carcass traits of growing rabbits which are the most desirable traits cherished by consumers in different parts of the globe [25, 29, 30].

With the reduction in the quantity of soyabean meal and its exorbitant cost in the market in Nigeria due to kidnapping and banditry in the country the use of locust meal in the diet of growing rabbits remains a valuable option for providing good quality rabbit meat to consumers.

Conclusion and Applications

According to the results available from this research, it is therefore concluded that:

1. Inclusion of locust meal (LM) in the diet of growing rabbits as a replacement to soyabean meal improved growth performance and carcass characteristics of rabbit enterprise in Nigeria because, it produces a similar return on investment as the soyabean meal.
2. Rabbits fed diet with 5% LM inclusion in the diet had better growth performance. Results suggest that including locust meal in grower rabbit's diet at 5% is a worthwhile business for rabbit farmers who are willing to provide wholesome and quality rabbit meat for consumption in Nigeria.
3. Rabbit farmers in Nigeria; can replace Soyabean meal with 5% locust meal in the diet of growing rabbits for better growth performance and carcass quality.

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