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RESEARCH ARTICLE

Effects of Feed Restrictions on Growth Performance, Carcass Traits and Meat Quality of Growing Rabbits

PN Onu[1], EO Ahaotu[2] and CM Ayo-Enwerem[1]

[1]Department of Animal Science, Ebonyi State University, Abakiliki, Nigeria
[2]Department of Animal Production and Technology, Imo State Polytechnic, Umuagwo, Nigeria

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***Corresponding Address:**
EO Ahaotu
emmaocy@yahoo.com

ABSTRACT

Effects of duration of restricted feeding on growth, carcass traits and meat quality of fattening rabbits were studied. Sixty male chinchilla rabbits of 6 weeks old were divided into four treatment groups with five replicates each. The duration of restricted feeding (6 hours eating/day) lasted for zero, two, three and four weeks for treatments 1, 2, 3, and 4, respectively, followed by *ad-libitum* feeding up to the end of the experiment at age of 18weeks. Body gain in weight were not statistically influenced by increasing the duration of restricted feeding, but daily feed intake was reduced from 3.79 to 19.81% and zero to 16.19% at 14 and 18weeks respectively. No significant effect in feed conversation or mortality rate was observed with increasing the duration of restricted feeding. Carcass traits and meat quality were not affected by increasing the duration of restricted feeding. Age of rabbits at slaughter influenced nearly all carcass traits. Starved body weight, carcass weight, dressing percentage, loin percentage and abdominal fat percentage were increased, while giblets percentage and head percentage were decreased with increasing slaughter age. Hind-and-forequarter percentages were not statistically influenced with increasing slaughter age. A positive linear relationship was found among live body weight, carcass weight, dressing percentage and loin percentage. Dressing percentage was positively correlated with abdominal fat percentage, but negatively correlated with giblets percentage and head percentage.

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INTRODUCTION

Livestock production and productivity in Nigeria is limited by feed constraints among other factors. Cost of feeding constitutes over 70-80% of the total cost of production in rabbit farming (Ahaotu *et al., 2*008; Bawa *et al.*., 2007). There is low per capita animal protein consumption in developing countries particularly in the humid tropics (FAO, 2004). Due to the high cost of feeds, many rabbit farmers depend on green forages or a mixture of some home grains and kitchen wastes for feeding rabbits. Efforts should be made to minimize the feed cost in order to increase the net profit. Decreasing feeding cost could be achieved by using cheap feeds or improving feed efficiency of the common feed.

Feeding techniques with possible impacts on improving feed efficiency include restricting energy and protein intake. Limiting the time of access to feed and quantitative feed of rabbits may prevent feed wastage and possible overfeeding. Miller (2004) indicated that the medium level of full-feed (ca. 90% full-feed) slightly affected the live weight gain and the efficiency of feed utilization, but the low level of full-feed (ca. 77-80% full-feed) showed remarkable differences to full-feed. They reported also that mortality percentage was lower and carcass composition was superior for full-feed over those for restricted-feed levels at 12 and 16 weeks.

Safaloah (2004) showed that reducing daily eating time down to 9 hours of growing rabbits (from 4-12 weeks of age) had reduced daily feed intake by 15% and improved feed conversion by 13% without changing the average daily gain. Therefore, this study was carried out to determine the effects of feed restriction and age on growth performance, carcass traits and meat quality of growing rabbits.

MATERIALS AND METHODS

The study was carried out at the Poultry Farm, Animal Production Department, School of Agriculture, Imo State Polytechnic Umuagwo Ohaji, Nigeria. Sixty male chinchilla rabbits of 6 weeks old were used in this study. The rabbits were divided into four treatment groups of 15 rabbits each. The average initial body weight of different treatments was approximately similar. Each treatment had five replicates of 3 rabbits each. Each replicate was housed in an esparto hutch. The rabbits were fed a commercially pelleted diet of 17.7% protein and 2895 ME/kg feed. The duration of restriction (6/18 hours with/without access to feed) lasted for zero 2, 3, and weeks followed by an *ad libitum* feeding up to the end of the experimental period (12weeks) for treatments 1,2,3, and 4 respectively. The rabbits were fed from 8am to 2pm during the restricted period. At the end of the feeding period, the feeders were removed and returned next morning. Rabbits in all treatments had full access to drinking water. Average body weight, body weight gain, feed consumption, cumulative feed conversion and mortality were recorded and calculated weekly up to the 18^{th} week of age for each individual replicate. At 14 and 18weeks of age, four representative rabbits from each treatment were starved for about 16hours; individually weighed, slaughtered, skinned and eviscerated. Eviscerated carcass with giblets (liver, kidneys and heart) and without head were individually weighed and dressing percentage was calculated (eviscerated carcass + liver + heart + kidneys in relation to pre-slaughter weight). Eviscerated carcasses were cut up to hindquarters, loin and forequarters with chest. The different cuts, giblets and abdominal fat were each weighed and related to the carcass weight as a percentage. The right side of the loin- and hindquarter muscles from each carcass were removed to evaluate the physical characters of the meat. The pH-value was measured after 15 minutes from slaughtering (pH_1), then the samples were kept in the plastic bags and stored in a refrigerator at $+4^0$C for 24hours, then the pH-value was measured again (pH_2). After that the samples were frozen at -15^0C until required for further evaluations. For measuring final pH-value (after storage), meat brightness, juice holding capacity and cooking loss, the frozen samples were left to thaw in a refrigerator at $+4^0$C for 24 hours without removing them from the plastic bags. The pH-value was measured directly using the pH-meter. Meat brightness was measured by colour brightness-meter (Gofo-Meter).

To determine the juice holding capacity, a piece of 0.3g muscle from each individual meat sample was put on filter paper (previously held over saturated Kcl solution in a desiccator) and pressed between two glass plates for five minutes according to Grau and Hamm method (1957). The areas of meat and meat juice were estimated by the axis method according to Hofmann (1982). The juice holding capacity was calculated from the following formula:

Juice holding capacity (WHC) = meat's area/total area x 100

For estimated cooking loss, a sample of about 25g muscle was placed in a polyethylene bag, then tightly closed and boiled for 25minutes. Then, the samples were removed from the water, left to reach room temperature, dried with filer paper and re-weighed to calculate the cooking loss as a percentage from the initial weight.

The statistical analyses were carried out according to SAS programme (2002) utilizing the following model:

Yijk = observed value of the concerned

μ = overall mean for the concerned trait

Di = the fixed effect due to duration of severe restriction i

Aj = the fixed effect due to age j

(DA)ij = the interaction effect between duration of severe restriction i and age j

Eijk = random error

RESULTS AND DISCUSSION

Growth Performance

The results on growth performance of the growing rabbits are presented in Table 1. Rabbits in treatment 2 which was restricted only for 2 weeks of age, but the differences among treatments were not significant. Body weights were 2.252, 2.330, 2.045 and 2.095kg at 14weeks of age for treatment 1, 2, 3 and 4 respectively. The corresponding figures at 18weeks old were 2.700, 2.978, 2.440 and 2.703kg. Daily gain had also the same trend as body weight. Rabbits in treatment 2 which eat 6 hours daily for two weeks gained more than those eating *ad libitum* by 5.23 and 13.72% at 14 and 18 weeks of age respectively. Rabbits in treatment 3 and 4 which eat 6 hours daily for 3 and 4 weeks respectively, gained less than the control treatment by 12.97 and 9.34% at 14 week. At 18weeks old, rabbits had compensated the depression on daily gain and became similar to the control group. The depression in daily gain was attributed to the reduction in daily feed intake with increasing the duration of feed restriction. In spite of the insignificant differences in body weight and daily gain among different treatments, there were highly significant differences ($P \leq 0.01$) in daily feed intake. The reduction in daily feed intake represented 3.79, 19.81 and 16.01% from the treatment at 14 weeks old for treatment 2, 3 and 4 respectively. With advancing age (18 weeks old), daily feed intake in treatment 2 was appropriately similar to the control treatment, but in the other treatments (3 and 4) were less by 16.19 and 9.86% respectively than the control treatment.

Increasing the duration of feed restriction more than 2 weeks (treatment 3 and 4) had no further improvement in feed conversion. The values at 14 weeks old were 4.07, 3.72, 3.73 and 3.72 for treatments 1, 2, 3 and 4, respectively. The corresponding values at 18weeks old were 5.28, 4.63, 5.03 and 4.74. The optimum feed conversion was observed in treatment 2 at both ages, but the differences among treatments were insignificant.

Concerning the mortality rate, it appears that mortality was not due to the treatments given and the numerical data obtained were within the normal limit. These results are in agreement with the findings of Lebas *et al. (*1997), Ekpenyong (1984) and Lukefahr (2010). They reported that reducing daily eating time down to 9 hours for 4 to 12 weeks old had reduced daily feed intake by 6 to 15% but feed conversion was improved by 7 t0 13% while daily gain was practically unchanged in growing rabbits. Finzi (1992) also reported that the medium level of full-feed (ca.90% full-feed) slightly affected the live weight gain and the efficiency of feed

Table 1: Least squares means + SE of performance of growing rabbits in different treatments

Item		Treatments				
		1	2	3	4	
Initial weight	(kg)	0.646±0.018	0.641±0.018	0.640±0.018	0.640±0.018	NS
7-14weeks old	S(kg)	2.252±0.043	2.330±0.043	2.045±0.043	2.095±0.043	NS
Body weight	(g)	28.680±0.770	30.180±0.770	24.960±0.770	26.000±0.770	NS
Daily gain	(g)	115.580^{a}±2.460	111.200^{b} ±2.460	92.680^{c}±2.460	97.080 ^{c}6±2.460	**
Daily feed intake		4.070±0.080	3.720±0.080	3.730±0.080	3.740±0.080	NS
Feed conversion:1	(pieces)	0.0	0.1	0.0	0.0	NS
Mortality						
7-18weeks old	(kg)	2.700±0.080	2.978±0.080	2.440±0.080	2.703±0.080	NS
Body weight	(g)	22.600±0.840	25.700±0.840	19.740±0.840	22.600±0.840	NS
Daily gain	(g)	117.480^{a}±2.420	118.080 ^{a}±2.420	118.080^{a}±2.420	105.900^{b}6±2.420	**
Daily feed intake		5.280±0.130	4.630±0.130	5.030±0.130	4.740±0.130	NS
Feed conversion:1	(pieces)	0.0	0.1	0.0	0.0	NS
Mortality						

** = P≤0.05; NS = P>0.05

Table 2: Least squares means + SE of carcass traits of growing rabbits as influenced by different treatments and ages

Item		Treatments				
	Weeks	1	2	3	4	Age (Weeks)
Starved body wt (g)	14	21143.75±89.94	2256.25±45.98	2083.75±024.70	1937.50±077.53	2105.31^{b}±41.50**
	18	2696.25±87.31	2996.25±35.44	2640.00±105.97	2867.50±230.52	2800.00^{a}±70.61**
Carcass wt (g)	14	1197.10^{ab}±61.20	1254.05^{a}±20.75	1128.13^{ab}±017.19	1041.55^{a}±032.50	1155.21^{b}±26.38**
	18	1561.68±46.60	1741.30±40.40	1518.63±051.95	1696.38±113.25	1629.49^{b}.39.12**
Dressing (g)	14	55.78±00.57	55.61^{a}±00.82	54.16±001.01	53.81.±000.52	54.84^{b}±00.40
	18	57.94±00.31	58.10±00.84	57.60±001.32	59.37±000.92	58.25^{a}±.00.45**
Hindquarter (%)	14	34.95±00.75	34.43±00.67	34.18±000.85	34.34±000.46	34.28±00.31
	18	33.95±01.42	34.01±00.42	33.17±000.85	33.09±000.79	33.56±00.34^{NS}
Forequarter (%)	14	35.96±00.87	35.74±01.08	36.48±000.52	36.45±000.41	36.15±00.35
	18	35.39±00.32	35.12±00.50	35.45±000.34	35.45±000.41	35.39±00.19 ^{NS}
Loin (%)	14	19.30±00. 71	18.95±00.54	19.14±000.73	19.17±000.33	19.4^{b}±00.27**
	18	20.55±00.65	21.14±00.39	21.50±000.52	21.49±000.92	21.17^{a}00.31**
Giblets (%)	14	6.33±00.35	6.75±00.27	7.21±000.27	7.24±000.36	6.88^{a}±00.17**
	18	4.77±00.21	4.89±00.37	5.06±000.30	4.75±000.13	4.87±00.12 ^{NS}
Abdominal fat (%)	14	4.23±00.72	4.14±00.30	3.00±000.41	2.81±000.25	3.54^{b}±00.26 ^{NS}
	18	5.35±01.04	4.48±00.67	4.83±000.88	5.08±000.31	5.02^{a}±00.35**
Head (%)	14	10.64±00.14	10.83±00.26	10.66±000.22	11.05±000.53	10.80^{a}±00.09**
	18	10.68±00.57	9.70±00.22	10.44±000.35	9.31±000.38	10.03^{a}±00.23**

** = P≤0.01; NS = P≤0.05 NS = P<0.05

utilization, but the low level of full-feed (ca.77-80% full-feed) showed remarkable differences than full-feeding in growing rabbits.

Carcass traits

Data in Table 2 indicated that treatment 2 was superior in starved body weight at 14 and 18 weeks old, but the differences among treatments were insignificant. There was a significant difference (p≤0.05) in carcass weight between treatment 2 and 4 at 14 weeks of age, while the difference at 18weeks of age was insignificant. Dressing percentage was slightly decreased with increasing the duration of feed restriction at 14 weeks of age. At 18th week of age there was no certain trend for the dressing percentage, although treatment 4 realized the highest percentage, 59.37%. Dressing percentage at 14 weeks of age was 55.78, 55.61, 54.16 and 53.81% for treatments 1, 2, 3 and 4 respectively. The corresponding figures at 18 weeks of age were 57.94, 58.10, 57.60 and 59.37%.

Carcass cut-up parts were not significantly influenced by increasing the duration of feed restriction. Treatment 2 had higher hindquarter percentage, but lower forequarter percentage than other treatments at 14 or 18 weeks old. Loin percentage decreased with increasing the duration of severe feed restriction up to 3 weeks (treatment 3 and 4) at 18 weeks old. A similar trend was also observed at 18 weeks of age except treatment 3. As expected abdominal fat percentage decreased with increasing the duration of feed restriction at 14 weeks of age, the opposite was observed at 18 weeks old but the values remained lower than the control treatment. Head percentage had irregular trend with increasing the duration of severe feed restriction at 14 and 18 weeks old.

The age had a significant effect (P≤0.01) on starved body weight, carcass weight, dressing percentage, lion percentage, giblets percentage, abdominal fat percentage and head percentage, lion percentage and abdominal fat percentage were increased (P≤0.01) while giblets percentage and head percentage were decreased (P≤0.01). Hindquarter percentage and forequarter percentage were slightly decreased with increasing slaughter age. The effect of interaction between the duration of severe feed restriction and age on the above mentioned carcass traits were not significant.

Conclusion

Results revealed that heavier rabbits had darker meat and higher cooking loss percentage in hindquarter and also higher pH value after storage of loin region in

Table 3: The correlation among carcass trait of growing rabbits

			2	3	4	5	6	7	8	9
1.	Live body weight		0.98	0.56	0.56	-0.17	-0.35	0.51	-0.53	-0.77
2.	Carcass weight			0.69	0.59	-0.23	-0.35	0.58	-0.58	-0.82
3.	Dressing	%			0.53	-0.37	-0.26	0.66	-0.56	-0.76
4.	Loin	%				-0.27	-0.63	0.25	-0.26	-0.63
5.	Hindquarter	%					-0.26	-0.70	0.41	-0.16
6.	Forequarter	%						-0.09	0.19	0.26
7.	Abdominal fat	%							-0.57	-0.54
8.	Head	%								0.31
9.	Giblets	%								

P≤0.05, r=0.35, P≤0.01, r=0.45

Table 4: Least squares means + SE of physical characteristics of rabbit's meat as influenced by different treatments and ages

Items	Treatments					
	Weeks	1	2	3	4	Age Week
Loin meat:						
pH_{15min}. Value	14	6.59±0.15	6.64±0.08	6.58±0.08	6.74±0.04	6.64±0.05^{NS}
	18	6.53±0.06	6.56±0.07	6.54±0.04	6.51±0.04	6.53±0.02^{NS}
$pH_{24hr.}$ Value	14	5.72±0.05	5.66±0.03	5.82±0.15	5.69±0.07	5.72±5.04
	18	5.83±0.03	5.66±0.03	5.80±0.05	5.82±0.07	5.81±0.02^{NS}
$pH_{after\ storage}$Value	14	5.59±00.5	5.58±0.04	5.79±0.18	5.66±0.15	5.65^{B}±0.06*
	18	5.86±0.04	5.88±0.04	5.81±0.09	5.81±0.10	5.65 ^{B}±.0.01*
Colour	14	83.50±2.66	84.75±1.03	81.25±1.03	84.00±2.12	83.38±0.89^{NS}
	18	83.25±0.48	82.00±2.00	81.50±3.28	82.00±0.91	82.19±0.90 ^{NS}
Water holding capacity	14	21.26±1.36	25.85±4.21	27.64±3.26	25.61±4.72	25.09±1.73 ^{NS}
	18	22.25±1.61	26.46±1.84	26.46±3.09	26.51±3.21	25.31±1.22 ^{NS}
Cooking loss %	14	31.31±0.59	32.39±0.96	31.24±1.71	32.30±0.47	31.81±0.49 ^{NS}
	18	32.14±0.91	33.35±0.75	32.36±1.03	32.61±0.82	32.62±0.41 ^{NS}
Hindquarter	14	6.63±0.10	6.77±0.11	6.80±0.08	6.61±0.10	6.70±0.05 ^{NS}
	18	6.61±0.07	6.59±0.05	6.61±0.04	6.55±0.10	6.59±0.03 ^{NS}
pH_{15min}. Value	14	5.90±0.05	5.92±0.03	6.14±0.15	5.77±0.07	5.93±5.05 ^{NS}
	18	5.95±0.05	5.66±0.03	5.80±0.05	5.82±0.07	5.81±0.02 ^{NS}
$pH_{24hr.}$ Value	14	5.77±0.09	5.84±0.08	6.09±0.16	5.70±0.11	5.85±0.06 ^{NS}
	18	6.01±0.02	6.00±0.05	5.98±0.08	5.89±0.12	5.97±0.04 ^{NS}
$pH_{after\ storage}$Value	14	81.50±1.33	82.50±0.65	77.00±1.83	80.50±0.65	80.38^{b}±0.7 **
	18	83.75±0.48	82.25±1.25	81.25±2.46	82.25±0.48	82.38^{a}±0.68*
Colour	14	25.29±4.51	24.12±2.03	23.40±2.86	22.26±2.43	23.76±1.42 ^{NS}
	18	21.49±1.44	24.62±1.64	27.18±3.30	26.31±5.13	24.90^{b}±1.55*
Water holding capacity	14	30.72±1.01	32.68±0.59	29.40±1.84	32.44±0.79	31.31^{b}±0.62*
Cooking loss %	18	34.46±0.93	35.40±0.65	33.24±0.77	34.37±0.49	34.45^{a}±0.38*

** = P≤0.01; * = P≤0.05; NS = P>0.05

comparison to lighter ones. A positive linear relationship existed between pH value taken after 24hours from bleeding out and pH value after storage. Cooking loss percentage decreased with increasing pH value taken after 24hours from slaughtering. Nearly all the physical properties of loin meat were positively correlated (r=0.43 to 0.80) with the corresponding characteristics of hindquarter meat.

These results agree with the findings of Aduku and Olukosi (1990) and Ahaotu *et al.* (2008). They reported that dressing percentage and carcass cut-up parts of growing rabbits were increased with increasing age.

The correlation coefficients among carcass traits are presented in Table 3. Starved body weight, carcass weight, dressing percentage and loin percentage were closely correlated with each other (r=0.53 to r=0.98). The positive association between hot carcass weight and dressing percentage may be due to reduced visceral percentage in heavier rabbits (Ahaotu *et al*., 2009 Abdominal fat percentage was significantly increased with increasing body weight, carcass weight and dressing percentage (r=-0.53 to r=-0.58) and giblets percentage (r=0.76 to r=-0.82). Loin % was negatively correlated with forequarter percentage and giblets percentage (r=-0.63). A similar trend was also observed between abdominal fat percentage from one side and hindquarter percentage (r=-0.70), head percentage (r=-0.57) and giblets percentage (r= -054) from other side. Lukefahr *et al.* (1989), and Omole and Onwudike (1983) recorded also highly significant correlation between carcass weight, dressing % and carcass cut-up parts weight.

Meat Quality

Data in table 4 indicate that the physical properties of rabbit meat were not influenced by increasing the duration of feed restriction. After 24hours of bleeding out, both lion and hindquarter had pH values of normal meat and were not influenced by different treatments. The pH values of normal meat and were not influenced by different treatments. The pH values after storage showed that the keeping quality of rabbit's meat was not affected by increasing the duration of severe feed restriction. Meat colour, water holding capacity and cooking loss percentage of each loin and hindquarter meat were not influenced with increasing the duration of severe feed restriction. The control treatment had the lowest water holding capacity in loin meat at 14 or 18weeks old. A similar trend was observed in hindquarters at 18th week of

Table 5: The correlation coefficients among properties of rabbits' meat

		2	3	4	5	6	7	8	9	10	11	12
1)	$pH_{15min.}$ (loin)	0.17	0.19	0.04	0.02	-0.07	-0.13	-0.08	0.12	-0.07	-0.10	-0.39
2)	$pH_{15min.}$ (hindquarter)		-0.14	0.03	-0.24	-0.10	-0.06	-0.20	-0.27	-0.47	-0.09	-0.27
3)	$pH_{24hrs.}$ (loin)		0.67	0.88	0.80	0.05	0.17	0.40	0.19		-0.44	-0.19
4)	$pH_{24hrs.}$ (hindquarter)				0.64	0.84	0.13	-0.04	0.47	0.20	-0.58	-0.52
5)	Final pH (loin)					0.80	0.10	0.25	0.58	0.29	-0.30	-0.02
6)	Final pH (hindquarter)						0.05	0.02	0.43	0.26	-0.50	-0.27
7)	Colour (loin)							0.60	0.02	-0.11	-0.06	0.01
8)	Colour (hindquarter)								-0.02	0.11	-0.01	0.38
9)	Water-holding capacity (loin)									0.43	-0.16	-0.21
10)	Water-holding capacity (hindquarter)										-0.18	-0.11
11)	Cooking loss (loin)											0.59
12)	Cooking loss (hindquarter)											

$P \leq 0.05$ r=0.35; = $P \leq 0.01$; r=0.45

age, but at 14 weeks old the control treatment was superior in comparison to the other treatments.

Cooking losses from each of the loin and hindquarter were higher in treatments 2 than those in the other treatments at 14 or 18 weeks of age.

The effect of age on the physical properties was significant only on the ph value of loin after storage, meat colour and cooking loss of hindquarter. Rabbits aged 18 weeks recorded higher ($P \leq 0.01$) pH value of loin after storage, meat colour and cooking loss of hindquarter. Rabbits aged 18weeks recorded higher ($p \leq 0.05$) and higher ($P \leq 0.01$) cooking loss percentage in hindquarter meat than younger rabbits (14 weeks old). Meat tends to be darker in older animals due to the deposition of brown pigment in muscle and also to the greater amounts of myoglobin (Maerten and Coudert, 2006, McNitt *et al.,* 2000). Increasing water-holding capacity with advancing age may be due to the lower moisture/protein ratio is associated with the higher ability of muscle in question to retain water. Agunbiade *et al.,* (1999) indicated that the water-holding capacity improved with increasing pH value of the meat. Increasing cooking loss percentage with advancing age may be attributing to the increasing in muscle shrinkage and in fat content of the meat (Farrell and Raharjo, 1984; Sauders, 1998; Portsmouth, 2002).

Data in table (5) indicated that, the correlation coefficients between pH values after 24 hours from slaughtering and after storage in each loin and hindquarter were highly significant (r=0.64 to r=0.88). A positive linear relationship existed also between colour (r=0.60), water-holding capacity (r=0.43) and cooking loss percentage (r=0.59) in each loin and hindquarter muscle. The opposite trend was found between cooking loss percentage and pH value taken after 24hours from bleeding out.

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