


Restricted concentrate with *ad libitum* forage feeding: effects on performance and carcass yield of growing rabbits

Concentrado restringido con la alimentación de forraje *ad libitum*: efectos sobre el comportamiento y rendimiento de la canal de conejos en crecimiento

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Received: 03/13/2012 First reviewing ending: 06/06/2012 First review received: 07/19/2012 Accepted: 07/26/2012

ABSTRACT

Effect of concentrate feed restriction in the presence of *ad libitum* forage feeding on performance, carcass yield and relative organ weights were investigated in weaner rabbits in a humid tropical environment in Nigeria. Thirty six growing rabbits of mixed breed (Chinchilla x Dutch x California White) and sexes with an average weight of 600g were assigned to three feeding regimen in a completely randomized design. The study lasted for 8 weeks. The three feeding regimen were: (A) *ad libitum* concentrate feeding + *ad libitum* forage feeding (control), (B) skip-a-day concentrate feeding/week + *ad libitum* forage feeding and (C) skip-2-days concentrate feeding/week + *ad libitum* forage feeding. The forage used was air-dried *Tridax procumbens*. Drinking water was supplied free-choice throughout the duration of the experiment. Each treatment group was replicated six times with two rabbits housed/replicate. Weight gain, final body weight, feed intake and feed: gain ratio of rabbits were not significantly ($P > 0.05$) different among the treatment groups. Although feed intake was not different among the three treatments, however concentrate intake, forage intake as well as percentage concentrate and forage in daily feed intake were significantly ($P < 0.05$) influenced by treatments. Total concentrate intake was significantly higher in rabbits on treatment A (*ad libitum* feeding) compared with rabbits on treatment B which was also significantly higher than the intake on treatment C. Rabbits fed *ad libitum* consumed 10.75 and 25.94% more concentrates than rabbits on skip-a-day and skip-two-days per week concentrate feeding. Daily concentrate intake reduced from 33.35g on treatment A to 29.76g and 24.69g in treatment B and C respectively. The daily forage intake however increased with severity of concentrate restriction, the trend being $C > B > A$. The concentrate percentage of daily feed intake reduced with increased severity of concentrate restriction while that of forage increased with concentrate restriction from 56.15% in *ad libitum* concentrate fed group to the highest amount of 68.45% in rabbits on skip-two-days of concentrate feeding per week. Dressing percentage and retail cuts were not significantly ($P > 0.05$) affected by feeding regime. Similarly the physical structure and weights of internal organs (livers, kidneys, lungs and hearts) were not affected by experimental treatments ($P > 0.05$). The results obtained from this study showed that rabbits can be subjected to two days skipping of concentrate feed per week with *ad libitum* forage feeding without compromising performance and carcass measurements.

Key words: Feeding regimen, forage, rabbits, carcass yield

RESUMEN

Se investigaron los efectos de la restricción de alimento concentrado en la presencia de la alimentación de forraje *ad libitum* sobre el comportamiento, el rendimiento en canal y pesos relativos de órganos en conejos destetados en un ambiente húmedo tropical en Nigeria. Treinta y seis conejos en crecimiento de raza mezclada (Chinchilla x Dutch x California White) y sexos con un peso promedio de 600 g se asignaron a tres regímenes de alimentación en un diseño completamente aleatorizado. El estudio se prolongó durante 8 semanas. Los tres regímenes de alimentación fueron: (A) alimentación con concentrado *ad libitum* + alimentación con forraje *ad libitum* (control), (B) alimentación con concentrado cada dos días por semana + alimentación con forraje *ad libitum* y (C) alimentación con concentrado cada tres días por semana + alimentación con forraje *ad libitum*. El forraje utilizado fue de *Tridax procumbens* secado al aire. El agua potable se suministró de libre elección durante toda la duración del experimento. Cada grupo de tratamiento se repitió seis veces con dos conejos alojados/repetición. La ganancia de peso, el peso corporal final, consumo de alimento y la relación consumo:ganancia de los conejos no fueron significativamente ($P > 0,05$) diferentes entre los grupos de tratamiento. Aunque el consumo de alimento no fue diferente entre los tres tratamientos, sin embargo, el consumo de concentrado, el consumo de forraje, así como el porcentaje de concentrado y forraje en el consumo diario de alimento fueron significativamente ($P < 0,05$) influenciados por los tratamientos. El consumo total de concentrado fue significativamente mayor en los conejos del tratamiento A

(alimentación *ad libitum*) comparado con los conejos en el tratamiento B, el cual también fue significativamente mayor que la ingesta del tratamiento C. Los conejos alimentados *ad libitum* consumieron 10,75 y 25,94% más concentrado que aquellos conejos con alimentación con concentrado cada dos y tres días por semana. El consumo diario de concentrado se redujo de 33,35 g en el tratamiento A a 29,76 y 24,69 g en el tratamiento B y C, respectivamente. El consumo diario de forraje, sin embargo, aumentó con la severidad de la restricción de concentrado, la tendencia fue C > B > A. El porcentaje de concentrado del consumo diario de alimento se redujo con incrementos de la severidad de la restricción de concentrado, mientras que aquel del forraje se incrementó con la restricción de concentrado de 56,15% en el grupo alimentado con concentrado *ad libitum* hasta la mayor cantidad de 68,45% en los conejos alimentados con concentrado cada dos días por semana. El rendimiento en canal y los cortes al por menor no fueron significativamente ($P>0,05$) afectados por el régimen de alimentación. Similarmenete, la estructura física y el peso de los órganos internos (hígado, riñones, pulmones y corazón) no fueron afectados por los tratamientos experimentales ($p>0,05$). Los resultados obtenidos de este estudio mostraron que los conejos pueden ser sujetos a una alimentación de concentrado cada dos días por semana con forraje *ad libitum* sin comprometer el rendimiento y las medidas de la canal.

Palabras clave: Régimen de alimentación, forraje, conejos, rendimiento en canal.

INTRODUCTION

Rabbit production has gained considerable interest recently in Nigeria because of the exorbitant prices of the conventional sources of meat, such as cattle (beef), goats (chevon), sheep (mutton), pig (pork) and poultry. Rabbits are renowned for their fecundity and prolificacy (Biobaku and Dosunmu, 2003); ability to utilize forages (Aduku and Olukosi, 1990). Rabbit meat is low in fat and cholesterol (Biobaku and Oguntona, 1997) thus making the flesh a desirable one for diabetics, hypertensive and middle aged people.

However, rabbits like most other monogastric animals derive most of their nutrients from concentrates. This dependence on concentrates has created a lot of demand on cereal grains. In order to address the problem, there is the need to find alternative ways, which are cheap, adequate and readily available for feeding livestock. Similarly, the development of alternative feeding systems that will be relatively cheap when compared with conventional feeding system of finished feeds is desirable.

In recent years, there has been an increased interest in studying feed restriction in broiler rabbits as a mean of reducing cost of production. Early feed restriction also help to address problems associated with early life fast growth rate such as increased body fat deposition. The aim of early feed restriction is to decrease the risk of enteritis and mortality.

Feed restriction could therefore, be exploited in the feeding of rabbits, especially in periods of inadequate supply of concentrate. It could also be a promising strategy for optimizing body development of young rabbits and thus the production of cheap animal protein (Eiben *et al.*, 2001). The aim of feed

restriction of female rabbits before the first mating is to increase the performance of does.

This study was embarked upon, to determine the effect of concentrate feed restriction with *ad libitum* forage feeding on performance and carcass yield of rabbits.

MATERIALS AND METHODS

Location

The experiment was carried out, between January and February, which marks the peak of dry season in Nigeria, at the rabbitry unit of the Teaching and Research Farm, Directorate (TREFAD), University of Agriculture, Abeokuta. It lies within the rainforest vegetation zone of South West Nigeria with a mean annual rainfall of 1100 mm and a temperature of 34.7 °C and a relative humidity of 82%. It is in the region of 70 m above sea level, 7 °S 5° N longitude 3°W 11.2°E.

Experimental animals and management

Thirty six, six weeks old growing rabbits of mixed breed (Chinchilla x Dutch x California White) and sexes with an average weight of 600 ± 12 g were assigned to three dietary treatments in a completely randomized design. The rabbits were previously weaned at five weeks of age. The rabbits were treated for endo and ectoparasites using Ivomec® at 1ml/50 kg live weight. Thereafter they were acclimatized for a week, during this period they were fed concentrate and forages *ad libitum*. Twelve rabbits were assigned to each of the dietary treatments. Each of the feeding regimens was replicated six times with two rabbits housed together serving as replicate in a cell measuring 64x62x48 cm.

The three feeding regimens are as follows:

1. *ad libitum* concentrate feeding + *ad libitum* forage feeding.
2. Skip a day concentrate feeding/week + *ad libitum* forage feeding.
3. Skip 2 days concentrate feeding/week + *ad libitum* forage feeding.

ad libitum as used here mean unrestricted access to both concentrate and forage.

The composition of the concentrate fed during the trial is shown in Table 1. The forage used is *Tridax procumbens*, (Composition on % dry matter basis: crude protein 33.25, ether extract 6.80, crude fibre 7.25 and ash 2.11), which was fed fresh after air-drying overnight under shade. The trial lasted for 8 weeks during which data were collected on total feed intake, concentrate intake, forage intake and weight gain.

Carcass Analysis

Rabbits were slaughtered on termination of the feeding trial, the slaughter age was 14 weeks. Six rabbits whose weight were close to the mean treatment weight were selected from each treatment, tagged and moved to the meat processing laboratory

Table 1. Composition of concentrate diet.

Ingredient	(%)
Maize	47.50
Groundnut cake	10.00
Soybean meal	8.00
Wheat offal	31.00
Bone meal	3.00
Salt	0.25
Vitamin/mineral premix †	0.25
Total	100.00
Determined Analysis	
Protein (%)	18.74
Ether extract	4.58
Crude Fibre	15.68
Metabolisable Energy (MJ /Kg)‡	10.93

† Contains Vit. A 4000000 IU, Vit. D. 800000 IU, Vit. E 40000 mg, Vit. K3 800 mg, Vit. B1 1000 mg, Vit. B2 6000 mg, Vit. B6 5000 mg, Vit. B12 25 mg, Niacin 6000 mg, Pantothenic acid 20000 mg, Folic acid 200 mg, Biotin 8 mg, Manganese 300000 mg, Iron 80000 mg, Zinc 20000 mg, Cobalt 80 mg, Iodine 400 mg, Selenium 40 mg, Choline 800000 mg.

‡ = Calculated

(a distance of two kilometers). The animals were fasted from feed but allowed access to water over a 12 hour period, reweighed to get the slaughter weight (SW) and stunned by hitting with a wooden mallet at the base of the neck before slaughtering by cutting the jugular vein. Carcass was obtained by removing the skin, distal part of the tail, fore and hind legs, digestive tract and urogenital organs. Carcasses were then cooled at 4 °C for 24 h and re-weighed to obtain dressed carcass weight (DCW). The proportion of DCW to SW was determined to get the dressing out percentage (DoP). Edible organ weights were presented as percentage of DCW. The carcass was split between the 7th and 8th thoracic and between the 6th and 7th lumbar vertebrae to obtain the fore-, intermediate and hind parts. Carcass parts were weighed and expressed as % of cold dressed carcass.

Chemical analysis

The proximate composition of the test ingredients and experimental diets were determined by the method of A.O.A.C. (1990).

Statistical analysis

Data was analyzed by one way analysis of variance using Genstat (2005) statistical package. Significant differences between treatment means were determined using the Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The mean values for the performance indices of rabbits are presented in Table 2. Weight gain (total and average daily), final body weight, feed intake (total and average daily) and feed: gain ratio of rabbits were not significantly ($P > 0.05$) different among the treatment groups. Although feed intake was not different among the three treatments, however concentrate intake (total and average daily), forage intake (total and average daily) as well as percentage concentrate and forage in daily feed intake were significantly ($P < 0.05$) influenced by treatments. Total concentrate intake was significantly higher in rabbits on treatment A (*ad libitum* feeding) compared with rabbits on treatment B which was also significantly higher than the intake on treatment C. Rabbits fed *ad libitum* consumed 10.75 and 25.94% more concentrates than rabbits on skip-a-day and skip-two-days per week concentrate feeding. Daily concentrate intake reduced from 33.35 g on treatment

A to 29.76 and 24.69 g in treatment B and C respectively. The daily forage intake however increased with severity of concentrate restriction, the trend being C > B > A. The concentrate percentage of daily feed intake reduced with increased severity of concentrate restriction while that of forage increased with concentrate restriction from 56.15% in *ad libitum* concentrate fed group to the highest amount of 68.45% in rabbits on skip-two-days of concentrate feeding per week.

Restriction of concentrate feeding with *ad libitum* forage feeding did not have a significant effect on daily weight gain in this study. Earlier studies on restriction feeding in rabbits have always reported reduction in daily weight gain (Perrier and Ouhayoun, 1996; Jerome *et al.* 1998; Tumová *et al.* 2002, 2003 and Yakubu, 2007). Reduced daily weight gain in restricted rabbits was linked to lower daily feed intake. Decrease in the body weight gain during feed restriction is a function of plane of nutrition thereby resulting in inadequate intake of nutrients required to sustain rapid growth and development (Esonu *et al.*, 2002). In this study however feed intake was not lowered as the rabbits on skip-a-day and skip-two-day concentrate feeding had unlimited access to forage which they must have used to meet their dietary need. This is clear from the fact that feed intake was similar across treatment even though the partitioning of what constituted the intake varies. Rabbits being pseudo-ruminants have improved capacity to handle forages and still be able to derive nutritional benefits from them. Many reports exist in

literature that rabbits perform well with mixed regime of forages and concentrates without adverse effect (Onwudike, 1995, Nworgu *et al.*, 1998, Bamgbose *et al.*, 2003). Feeding rabbits on sole forage in the tropics resulted in negative effect of weight loss (Adegbola *et al.*, 1985; Bamikole and Ezenwa., 1999) and low feed intake (Ezenwa *et al.*, 1998), inferior body weight gain as compared to those whose forage diets were supplemented with concentrate feed (Shoremi *et al.*, 2001). Tumova *et al.* (2003) showed that feed efficiency was not significantly affected by feed restriction systems for growing rabbits. Iyeghe-Erakpotobor (2007) reported that the use of concentrates alone has not given optimum results and the feeding of high concentrate and low forage levels as practiced by rabbit producers has in recent times resulted in very expensive rabbits.

The effect of restricted concentrate feeding on carcass characteristics of rabbits is presented in Table 3. Result of the effects of feeding regimen on retail cuts of rabbits is presented in Table 3. Dressing percentage was not significantly ($P > 0.05$) affected by feeding regime. The dressing out percentage was in the range 54.50-55.77. The values obtained for dressing percentage in this study is similar to 52.05 - 53.36% reported by Sobayo *et al.* (2008), but lower than 69.49 - 73.98% obtained by Lamidi *et al.* (2008). The non significant effect of feeding regimen on dressing percentage was in agreement with the results of Ferreira and Carregal (1996), Tumova *et al.* (2003) and Boisot *et al.* (2004), who reported that restriction did not affect dressing percentage but at

Table 2. Effect of restricted concentrate feeding with *ad libitum* forage feeding on performance of growing rabbits.

Performance Indices	<i>ad libitum</i> feeding (A)	Skip-a-day concentrate feeding/week (B)	Skip-two-day s concentrate feeding/week (C)	SEM
Initial weight (g)	608.30	607.44	607.32	1.56
Final weight (g)	1293.33	1286.00	1268.30	11.38
Total weight gain (g)	685.03	678.56	672.98	8.22
Average daily weight gain (g)	12.23	12.11	12.02	1.24
Total feed intake(g)	4258.64	4406.64	4359.04	10.23
Average daily feed intake (g)	76.04	78.68	77.84	6.05
Total concentrate intake (g)	1867.44 ^a	1666.66 ^b	1383.04 ^c	4.01*
Average daily concentrate intake (g)	33.35 ^a	29.76 ^b	24.69 ^c	1.86*
% Concentrate in daily feed intake	43.86 ^a	37.83 ^b	31.72 ^c	3.15*
Total forage intake(g)	2391.2 ^c	2740.08 ^b	2983.68 ^a	5.50*
Average daily forage intake (g).	42.70 ^c	48.93 ^b	53.28 ^a	2.65*
% forage in daily feed intake.	56.15 ^c	62.19 ^b	68.45 ^a	3.00*
Feed: gain ratio	6.21	6.49	6.47	0.08

Means within the same row bearing different superscript are significantly different according to Duncan's Multiple Range Test (* $p < 0.05$)

variance with the report of Lebas and Laplace (1982), that in the middle of the restriction period dressing percentage was higher in restricted rabbits in comparison with the *ad libitum* fed ones.

Feeding regimen had no effect on retail cuts in this experiment. These results are in agreement with the findings of Perrier and Ouhayoun (1996), but Combes *et al.* (2003) reported a significantly higher proportion of hind part and hind legs in *ad libitum* fed rabbits.

The division of a carcass into primal parts will enable comparison to be made between various defined areas of the carcass. Increased weight of retail cuts improves profitability of rabbits (Agunbiade, 2009). Carcass characteristics are important factors to consider when evaluating alternative feeding programs. Ledin (1984) concluded that carcass and dissection characteristics were not influenced by restriction.

The physical structure and weights of internal organs (livers, kidneys, lungs and hearts) were not affected by experimental treatments ($P > 0.05$). Studies have shown little effect of feed restriction on relative organ weights, carcass portions, meat quality and dressing out percentage (Matics *et al.*, 2008; Metzger *et al.*, 2009). More interesting, a potential of reducing carcass adiposity (perirenal, scapular and intramuscular fat deposition) by limited feed intake has been demonstrated in other studies (Gondret *et al.*, 2000; Metzger *et al.*, 2009).

The result of the gut characteristics measured (Table 4) showed that the empty intestinal weight and full caecum weight were significantly influenced by type of restriction. Rabbits on two-days/week of concentrate restriction had the highest ($P < 0.05$) empty intestinal weight. The value recorded for rabbits on *ad libitum* concentrate feeding and those on one-day/week of concentrate restriction were however similar ($P > 0.05$).

Table 3. Effect of restricted feeding with *ad libitum* forage feeding on carcass yield and visceral organ weights of rabbits.

Carcass indices	<i>ad libitum</i> Feeding (A)	Skip-a-day Concentrate Feeding (B)	Skip-two-days Concentrate Feeding (C)	SEM
Fasted live weight(g)	1268.33	1260.37	1263.30	12.95
Carcass weight (g)	710.14	693.08	688.49	6.80
Dressing percentage	55.77	54.99	54.50	4.52
Weight of prime cuts (% Dressed weight)				
Fore part weight	15.29	15.48	15.13	0.35
Fore leg weight	7.51	6.81	6.55	0.25
Hind part weight	18.30	18.52	17.99	0.60
Hind leg weight	8.29	8.48	8.13	0.40
Thoracic cage weight	9.17	9.35	8.50	0.33
Intermediate part weight	14.25	14.20	14.22	0.57
Weight of internal organs (% of liveweight)				
Liver	3.13	3.19	3.15	0.12
Kidney	0.50	0.50	0.54	0.02
Lungs	0.51	0.50	0.53	0.02
Heart	0.24	0.25	0.26	0.01

No significant differences were observed among treatments.

Table 4. Effect of restricted concentrate feeding with *ad libitum* forage feeding on on gut characteristics of rabbits.

Gut characteristics (%)	<i>ad libitum</i> feeding (A)	Skip-a-day Concentrate Feeding (B)	Skip-two-days Concentrate Feeding (C)	SEM
Full intestinal weight	18.63	20.45	19.91	0.52
Empty intestinal weight	6.79 ^b	7.77 ^{ab}	8.39 ^a	0.30*
Full caecum weight	8.02 ^b	8.79 ^b	10.77 ^a	0.60*
Empty caecum weight	2.06	2.30	2.31	0.12

Means within the same row bearing different superscript are significantly different according to Duncan's Multiple Range Test (* $p < 0.05$)

The high empty intestinal weight ($P < 0.05$) value recorded for rabbits on concentrate restriction in comparison with those fed *ad libitum* concentrate could be as a result of high fibre content arising from the significantly higher forage intake which led to an increased capacity of the intestine to accommodate the resistant starch and fibre in the forage. The sizes of gut have been reported to be affected by the nature, forms and size of the dietary treatment given to livestock (Agunbiade, 2009). A similar observation was observed with full caecum weight. Forages are known to have low energy (Choct, 1997; Agunbiade *et al.*, 2002) than concentrates which could lead to high consumption because animals normally eat to satisfy their energy need first. This increased feed consumption could lead to increased caecal content.

CONCLUSIONS

It is concluded from this study that subjecting rabbits to concentrate feed skipping of up to two days per week in the presence of *ad libitum* forage feeding has no adverse effect on performance, carcass characteristics and prime cuts. This will result in reduction of feed cost for producing a unit weight of rabbit meat.

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