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NUTRIENT INTAKE, GROWTH PERFORMANCE AND CARCASS YIELD OF WEANER RABBITS FED GRADED LEVELS OF DRIED CITRUS (*C. sinensis)* PULP

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ABSTRACT

A study was conducted to investigate the response of weaner rabbits to graded dietary replacement of wheat offal with dried citrus pulp (DCP) at 0, 10, 20 and 30% (weight/weight) respectively .A total of Sixty-four, male and female weaner rabbits of 56 days old, were randomly assigned to four dietary treatments with sixteen rabbits each and consisting of four rabbits per replicate in a completely randomized design. The study lasted for 112 days during which data was obtained on nutrient intake, performance characteristics and carcass yield. The crude protein intake of the rabbits decreased ($P<0.05$) significantly as the DCP inclusion in the diets increased. There were significant ($P<0.01$) differences in the values obtained for the final weight, total weight gain, average weight gain, metabolic weight gain and growth rate across the treatment groups. The growth rate was 10.29 g/d in the control fed rabbits but further decreased with increasing level of DCP in the diets with values of 11.29, 6.30 and 5.80g/d obtained respectively for rabbit fed with 10%, 20%, and 30% DCP inclusion level. The lowest feed conversion ratio was obtained at the 0% level of DCP inclusion. The retail cut parts indicated a significant ($P<0.05$) difference in the values for rack and ranged from 11.92 to 18.06g. It was concluded that although, rabbits fed with control diet had the highest overall performance, 10% dietary inclusion of DCP supported improved growth and better carcass yield.

Keywords*:* Dried citrus pulp; weaner rabbits; carcass analyses; performance; nutrient intake

INTRODUCTION

The major sources of energy in the diet of rabbit in Nigeria are maize and guinea corn contributing 60-80% of the feed. The current prohibitive prices of cereals and the competitive uses, too which they are being put especially as major staple foods in many areas of developing world and as an industrial raw material, threaten more than before, the potential for increasing animal protein production. The future for efficient and profitable production meat form ruminant animals and rabbit would, therefore, depend on finding cheaper of alternatives sources of energy that is not directly required as components of human diets. According to Cheeke (1991), production trends are on the increase as rabbits have been chosen as an

alternative animal for meat production on small-scale family farms in developing countries. According to Cheeke (1984), rabbits are herbivorous animals with small body size, short gestation interval, high reproductive potential; and rapid growth rate. Another characteristic of rabbits is their ability to utilize forages and by-products, which make rabbits suitable as meat producing small livestock in developing countries. A pre-requisite for realizing or achieving the genetic potential of the rabbit is satisfying its nutritional needs (Akanni *et al.,* 2007). Feeding by-products of the crops and food processing industries to livestock is a practice as old as the domestication of animals by humans. It has two important advantages, these being to diminish dependence of livestock on grains that can be consumed by humans (which was almost certainly the primary original reason), and to eliminate the need for costly waste management programs (which has become very important in recent years as the world human population has increased and the amount of crop and food by product has increased, particularly in developed countries). World orange production for 2013 is put at average of 51.3 million tones/year (United States Department of Agriculture, USDA. 2013). The citrus fruit includes several important fruits, with the most important on a worldwide basis being sweet orange (*C. Sinensis*, 67.8% of world citrus production; USDA, 2013), tangerine (*C. reticulate*: 17.9%), lemon (*C. limon*: 6.3%) and grapefruit (*C. paradisi*: 5.0%). Minor citrus genus that comprise the bulk of the remaining 3.0% include sour orange (*C. quarantium*), Shaddock (*C. grandis*), citron (*C. media*) and lime (*C. aurantifolia*). About 24% of the world production of citrus is in the Mediterranean countries of Spain, Italy, Greece, Egypt, Turkey and Morocco, with Brazil (24%) and the USA (21%) being major individual citrus producing countries.

The aim of the study is to investigate the effect of graded levels of dried citrus pulp on nutrient intake, growth performance and carcass characteristics of weaner rabbits.

MATERIALS AND METHODS

Description of the study site

The study was carried out at the Rabbitary Unit of the Teaching and Research Farm, College of Animal Science and Livestock Production, University of Agriculture, Abeokuta. The experimental site was located in the derived savannah vegetation zone of south-western Nigeria. The climate in the area is tropical, with a wet season from March to October and a dry season from November to February. Annual rainfall averages about 1100 mm and the peak rainfall occurs in the period June-September. The temperatures and relative humidity ranges during the study were 32-35^{0}C and 75-83%, respectively. The experiment was conducted in the dry season (December-March 2008).

Collection and processing of fresh citrus pulp

Fresh citrus pulp was collected from Lafia Canning Factory, Apapa, Ibadan in Oyo State of Nigeria. The citrus pulp was collected from the factory at the point of processing and sun-dried immediately. The processing involved mechanical washing and peeling of the citrus fruits before crushing to remove the rind leaving the mesocarp with the hulls after crushing. The crushed hulls were collected from an exhaust outside the factory into the vehicle and transported for drying. The collected pulps were free from seeds as the seeds had been automatically removed from the hills during processing in the factory. The fresh pulps were sun-dried immediately after collection, for seven days

on asphalt surface, milled and used for the trial.

Experimental diets

Four experimental concentrate diets were formulated where dried citrus pulp replaced wheat offal at 0, 10, 20 and 30% (w/w) respectively. Other ingredients in the diets, which remained constant, were maize, soya-bean, blood meal, rice bran, dried brewers; grain, bone meal, oyster shell, salt and vitamin/mineral premix (Table 1).

Table 1: Ingredient composition (g/kg) of the experimental concentrate Diets

Ingredients	Dietary treatments			
	1	2	3	4
Maize	400.00	400.00	400.00	400.00
Wheat offal	300.00	200.00	100.00	0.00
Dried citrus pulp	0.00	100.00	200.00	300.00
Soya bean meal	60.00	60.00	60.00	60.00
Rice bran	10.00	10.00	10.00	10.00
Blood meal	2.00	2.00	2.00	2.00
Dried brewer's grain	193.00	193.00	193.00	193.00
Bone meal	20.00	20.00	20.00	20.00
Oyster shell	10.00	10.00	10.00	10.00
Salt (NaCl)	2.50	2.50	2.50	2.50
Premix*	2.50	2.50	2.50	2.50
Total	1000	1000	1000	1000
Determined analysis (g/kg DM)				
Dry matter	898	897	898	897
Crude protein	184	173	169	168
Crude fibre	129	104	129	113
Ether extract	38.7	37.6	38.3	39.5
Ash	68.9	71.3	67.6	70.8
Neutral detergent fibre	397	402	409	410
Acid detergent fibre	187	197	199	201
Acid detergent lignin	62.8	83.4	79.8	82.1

Rabbit management and experimental design

Sixty four (64) rabbits aged eight weeks and weighing between 450-500g obtained from the Rabbitary Unit of the University Farm were used for the study. Sixteen (16) rabbits were assigned to each dietary treatment and the treatment *groups* were randomly assigned to pens in four replicates in a completely randomized experimental design. During the pre-experimental period, the rabbits were fed with commercial pellets and wilted forage (*Tridax procumbens*). The health of the animals was strictly monitored by administering antibiotics (tetracycline) orally and the animals were de-wormed with anti-helminth (piperazine). The rabbits were housed individually in hutches. Feeders and drinkers were properly washed and disinfected throughout the experimental period of 112 days.

Data collection and analyses

The study lasted for 112 days (16 weeks) during which the rabbit were fed twice in the morning (7:30-8:00am) and in the afternoon

(2.00-3.00pm). Known quantity of feed was offered to the rabbits daily and residual collected and weighed to determine daily feed intake. The rabbits were weighed at the beginning of the experiment and subsequently on a weekly basis. The parameters measured were: weight gain (g), feed intake (g) and final mature weight (g). Also determined were feed conversion ratio (FCR) calculated as feed intake (g) divided by weight gain (g), protein intake (g/d), protein efficiency ratio (PER), nutrient intake and carcass yield. The milled samples of the feed were subjected to proximate analysis (AOAC, 1995) and fibre fractions (Van Soest and Robertson, 1985).

Statistical analyses

All data collected were subjected to one-way analysis of variance (ANOVA) in a completely randomized design. Significant means between the treatments were separated by Duncan's Multiple Range Test using SPSS (1999). Model sums of squares were partitioned to test linear, quadratic and cubic trends (Gomez and Gomez, 1983).

RESULTS

Table 2 shows the nutrients and fibre intakes of rabbits fed graded levels of dried citrus pulp. There were significant differences (C:P < 0.05) in the dry matter intake among the treatments at the cubic level. The highest value was observed at the 10% inclusion of dried citrus pulp in the diet followed by 0% and 30% inclusion in the diets increased, resulting in a significant quadratic and cubic relationships (Q: P < 0.01 and C: P < 0.01). Intake of EE, ash, NDF, ADF and ADL decreased significantly (L: P < 0.01; Q:P < 0.01; C:P <0.01) as the level of inclusion of DCP increased across dietary treatments. NDF intake values ranged from 12.6g/d in 30% inclusion level of DCP to 19.3g/d in the control group and were significant at the linear quadratic and cubic level (L:P < 0.01; Q: P < 0.01; C: P < 0.01).

Table 2: Nutrient intake (g/d) of weaner rabbits fed dried citrus based diets

Parameters	Levels of inclusion of dried citrus pulp				SEM	Probability a		
	0%	10%	20%	30%		L	Q	C
DM intake	43.45b	53.33a	32.45c	32.93c	3.42	NS	NS	*
CP intake	8.43a	6.84b	6.26b	4.97c	0.34	N	**	**
EE intake	1.24c	1.39b	1.60b	1.92a	0.07	**	**	**
Ash intake	3.47a	2.99b	2.42c	2.15c	0.14	**	**	**
NFE intake	31.94	41.52	22.62	19.04	4.03	NS	NS	NS
NDF intake	19.28a	16.20ab	14.73b	12.56b	0.67	**	**	**
ADF intake	8.77a	8.33a	7.20ab	6.18b	0.29	**	**	**
ADL intake	3.13a	3.13a	2.90ab	2.52b	0.08	**	**	**

NS: Not significant
*Probability for linear (L), quadratic (Q) and cubic (C) trends
* = P < 0.05
** = P < 0.01

Table 3 shows the growth performance of rabbits fed graded level of dried citrus pulp (DCP) in the diets. There were significant differences (L: Q C:P <0.01) among the values for the final weight, total weight gain, metabolic weight and growth rate across the treatment groups. Protein intake decreased with increased level of dried citrus pulp in the diets resulting in significant (L: Q C:P <0.01) linear, quadratic and cubic relationships. Protein efficiency ratio followed similar trend as protein intake at a cubic trend (C:P <0.01). The growth rates decreased with increasing level of dried citrus pulp inclusion in the diets from 10% to 30%. However, growth rate in the control diet was higher than 20% and 30% inclusion of dried citrus pulp respectively. The feed conversion ratio (FCR) was not significantly (P<0.05) influenced by the dietary treatments.

Table 3: Performance characteristics of weaner rabbits fed graded levels of dried citrus pulp

Parameters	Levels of inclusion of dried citrus pulp				SEM	Probabilitya		
	0%	10%	20%	30%		L	Q	C
Initial BWT (g)	741.98	751.17	755.59	725.59	10.44	NS	NS	NS
Final BWT	1606.4a	1690.7 a	1286.6b	1213.2b	63.64	**	**	**
Metabolic BWT gain (g)	200.53 a	206.31 a	181.67 b	173.71 b	4.39	**	**	**
Total weight gain (g)	864.44 a	927.00 a	530.92 b	487.05 b	58.98	**	**	**
Growth rate (g)	10.29 a	11.19 a	6.30 b	5.80 b	0.71	**	**	**
Total feed intake (g)	3649.5 ab	4479.7 a	2725.8 b	2766.0 b	272.34	NS	NS	**
Average daily intake (g)	43.45 a	53.33 ab	32.45 b	32.93 b	3.24	NS	NS	NS
Feed conversion ratio	3.99	5.43	5.51	5.66	0.44	NS	NS	NS
Protein intake (g/d)	8.33 a	6.84 b	6.26 b	4.97 c	0.43	**	**	**
Protein efficiency ratio	1.32 a	1.64 ab	1.17 b	1.02 b	0.08	NS	NS	*

BWT = Body weight
*Probability for linear (L), quadratic (Q) and cubic (C) trends
NS: Not significant * = P < 0.05 ** = P < 0.01
Feed conversion ratio (g dry matter intake/g BWT gain)
Protein efficiency ratio (g protein intake/g BWT gain)

Table 4 shows the effect of DCP diet on the relative carcass and organs weights of the experimental rabbits. Live weight (g) values ranged from 1283.30 to 1843.30g and were significantly different (L:P <0.05) at the linear probability level. Live weight values decreased with increasing level of dried citrus pulp in the diets. The retail cup parts indicated that significant difference (L:P <0.05) at the linear level was also obtained for rack with values of between 11.92 to 18.06g. The rack values decreased with increasing levels of dried citrus pulp and were highest at the control level. However, there were no significant differences (L: Q C:P <0.01; 0.05) in the other parameters measured for carcass characteristics.

Table 4: Carcass characteristics of weaner rabbits fed dried citrus pulp based diets

Parameters	Levels of inclusion of dried citrus pulp				SEM	Probability a		
	0%	10%	20%	30%		L	Q	C
Live weight (g)	1843.30	1750.00	1333.30	1283.30	110.91	*	NS	NS
Dressing weight (%)	75.47	71.59	62.57	70.84	2.39	NS	NS	NS
Shrunk body weight (%)	95.02	62.79	83.32	91.24	7.82	NS	NS	NS
Hot carcass weight (%)	64.70	63.11	53.38	60.36	2.21	NS	NS	NS
Empty carcass weight (g)	174.30	71.78	62.63	70.44	2.36	NS	NS	NS
Retail cut parts (g)								
Head	9.60	8.67	9.16	10.08	0.29	NS	NS	NS
Tail	6.17	0.29	0.22	0.14	0.03	NS	NS	NS
Shoulder	9.06	8.30	7.24	7.79	0.29	NS	NS	NS
Rack	18.06	16.09	13.64	11.92	1.15	*	NS	NS
Lions	11.11	12.25	9.30	14.03	0.73	NS	NS	NS
Leg	14.01	13.62	12.14	14.26	0.34	NS	NS	NS
Organ weight (% of live weight)								
Bile	0.08	0.06	0.04	0.04	0.03	NS	NS	NS
Liver	2.91	2.94	3.25	3.36	0.22	NS	NS	NS
Kidney	0.69	0.65	0.65	0.70	0.04	NS	NS	NS
Heart	0.22	0.23	0.23	0.20	0.07	NS	NS	NS
Lungs	0.68	0.84	0.67	0.78	0.04	NS	NS	NS
Spleen	0.04	0.05	0.19	0.06	0.04	NS	NS	NS
GIT	2072.	20.58	20.69	20.80	0.69	NS	NS	NS

NS: Not significant
*Probability for linear (L), quadratic (Q) and cubic (C) trends
* = $P < 0.05$

DISCUSSION

The results of nutrient intake indicated that the dry matter intake was highest at 10% inclusion of DCP and decreased as the level increased in the diets. This may probably be explained with the findings by Bhattacharya and Harb (1973) that average daily intake of rations decreased as the proportion of citrus pulp increased. Also, as the inclusion of DCP increased from 10%, the palatability of the feed should have greatly reduced because of the high inclusion of citrus pulp and the possible residual volatile essential oil of the peel it contains, which was reported to be bitter (Mba et al. 1976: Oni, 2008). The EE intake is of a particular interest because it showed increased values from the control to 30% inclusion of DCP in the diets. The dry matter values in this study were considerably lower than the range of 110-130g reported by Lebas *et al*. (1980), Igwebuike *et al*. (1995) and Olayeni (2005) under tropical conditions. The wide variations of the values recorded in this study from the above authors could be a reflection of environmental factors and the bitter taste of DCP. The values fall within the range of 61.2 -74.1g and 37.6-54.5g as reported by Idowu *et al.* (2006) and Fafiolu *et al.* (2006) respectively, for growing rabbits.

The performance characteristics of rabbits fed dried citrus pulp indicated that the highest weight gain and growth rate were recorded at the 10% inclusion of DCP. This result could be attributed to higher nutrient intake especially the dry matter and protein intake of the animals. The low weight gain of the animals at DCP above 10% could also be attributed to the lower dry matter and protein intake of the animals fed at 20 and 30% respectively. Although, the protein intake between 0% and 10% inclusion of DCP was statistically different, the PER was highest at 10% inclusion of DCP. Dried citrus pulp is relatively fibrous and this could be responsible for depression in the recorded weight gain as fibre impair digestion and absorption of nutrients (Fernendez and Jorgensen, 1986) especially with increase in the level of DCP in the diets. Fibre increases the bulkiness of a diet and limits the weight of feed eaten by birds, thereby imposing a physical limitation upon the intake of digestible nutrients (Fanimo and Odurombi, 2006). The growth rate obtained in this study was similar to results obtained by Nworgu and Ogbosika (2003) for ripe plantain peel meal as an alternative energy source in rabbit's diets. Eherhart (1980) and Onifade and Tewe (1993) reported values higher than 123g and 25.4g/day for feed intake and weight gain respectively in rabbit's diet. The feed conversion ratio falls within the range of values reported by Oyawoye and Nelson (1998) and Adegbola and Okonkwo (2002) when rabbits were fed with cassava leaf based diets with values ranging from 2.93 to 4.20 and 3.13 and 5.25, respectively.

Dietary inclusion of DCP in the diets of weaner rabbits showed no effect (L: Q C:P >0.05) on the carcass yield and cut parts except the rack which showed a significant effect (L:P<0.05), implying that DCP inclusion did not result in any anatomical modification of the carcass, on internal and cut parts yields. It also confirmed the suitability of DCP as an ingredient in the diet of weaner rabbits. The significant effect (L: Q C:P <0.05) on live weight of the rabbits due to dietary inclusion of DCP imposed a similar effect on the racks weight of the birds reducing significantly with increased DCP inclusion.

CONCLUSION

Wasteful dried citrus pulp produced in the country can be processed cheaply into dried citrus meal which can be included in rabbit feeds to enhance its performance. The final live weight, daily weight gain and daily feed intake of the animals were generally low at 20% and 30% DCP inclusion. The carcass characteristics in terms of dressing percentage, shrunk body weight and organ weight reduced with increased level of DCP in the experimental diet. Dried citrus pulp inclusion at 10% therefore, produced better growth performances as well as better carcass yield.

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