GROWTH PERFORMANCE OF GROWER RABBITS FED DIETS SUPPLEMENTED WITH DRIED CITRUS (*Citrus sinensis* L.) PULP AS REPLACEMENT FOR MAIZE

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Abstract
A 56-day study was carried out to investigate the growth performance of grower rabbits fed diets containing graded levels of dried citrus pulp as replacement for maize. Seventy-two crossbred grower rabbits weighing 1400±0.11 g were randomly allocated to four experimental groups replicated thrice with 6 rabbits each. The control treatment (CTRL) was a standard rabbit ration. The other treatments contained 10, 20 and 30% ground dried citrus pulp designated as DCP10, DCP20 and DCP30 respectively as replacement for maize. Fresh forages were provided to supplement dietary fibre levels. Water and the diets were administered *ad libitum*. Feed intake and final body weight were measured on daily basis and FCR was calculated. The CTRL, 10 and 20% replacement of maize had equal final body weight (1770 g) which was significantly ($P<0.05$) heavier body weights than other treatment groups while CTRL (1770 g) had heavier ($P<0.05$) body weight than 30% replacement (1550 g). 30% replacement had the least ($P<0.05$) feed intake, final body weight but the best FCR (2.7). Replacing 20% of maize in the diet of grower rabbits with DCP is recommended since it gives higher body weight.

Keywords: rabbits, dried citrus pulp, agro-industrial byproduct, growth performance, waste-to-wealth

Introduction

Nigerians face the challenge of low animal protein intake due to high livestock production costs leading to expensive animal products that limits their accessibility. This prompts the need to increase meat production by exploiting livestock species that are yet to play a major role in animal protein supply in Nigeria (Owen *et al*., 2008). Akinmutimi and Onwukwe (2002) recommended focusing on exploring highly prolific animals with fast growth rate and short generation intervals like the rabbit. Rabbits are an ideal alternative for meat production on small scale family farms to enhance animal production trends in developing countries. Rabbit production is a veritable way of alleviating animal protein deficiency in Nigeria and it is encouraged as a means of improving the daily protein intake of individuals and income (Taiwo *et al*., 2005). Dried citrus pulp (DCP) is by-product of citrus consumption or processing, which improves the productive performances of livestock species but which otherwise constitutes environmental nuisance (Hon *et al*., 2009). It is a sustainable feed resource readily available from roadside dealer and processing plants. Mashed or pelleted DCP is a highly desirable feedstuff, which could replace maize in rabbit ration at 20% inclusion level of inclusion or less (Arthington *et al*., 2002). Different inclusion levels of DCP improve the growth performance, meat quality and blood parameters of weaners rabbits (Jingzhi *et al*., 2017). Rabbits adapt quickly to diet containing 20% DCP (Crawshaw, 2004) and 30-40% dietary inclusion for fattening rabbits does not impair growth performance or carcass traits (Caparra *et al*., 2007). Thus, the objective of this study was to evaluate the effect of dried citrus pulp on the growth performance of grower rabbits since there is already overwhelming literature on the weaners.

Materials and methods

Experimental site

This 56-day experiment was conducted at the Rabbit Research Facility of Teaching and Research Farm, Department of Animal Science, Ebonyi State University, Abakaliki. Abakaliki is situated within 07° 30' E and 08° 30'E latitude and 5° 40'N and 6° 45'N longitude (Nwakpu, 2008) in the derived Savannah zone of South-East agro-ecological zone of Nigeria. Annual rainfall and temperature range between 1500 to 1800 mm p.a. and 21°C to 30°C respectively (Osakwe and Ekwe, 2007).

Experimental materials

The crossbred grower rabbits of twelve weeks old were procured from the Experimental Farm of College of Medicine, University of Calabar, Calabar, Nigeria, while the citrus for the pulp was sourced from Abakpa Market in Abakaliki, Nigeria.

Experimental animal, diet, design and procedure

The leftover of juice extraction from sweet orange (*Citrus sinensis*) was chopped into pieces and sundried to reduce the moisture content, then ground into a mash with hammer mill and incorporated into the formulated diet. CTRL was basal diet with 0% DCP as control diet, the others contained CTRL supplemented with 10, 20 and 30% DCP and designated as DCP10, DCP20 and DCP30 respectively. The rabbits were reared intensively in hutches fitted with aluminum feeders and drinkers. They were acclimatized for one week before commencing the experiment. Water was served to the animals *ad libitum* as well as forages (Guinea grass and centrosema to supplement for fibre content of the diet. 18 crossbred grower rabbits of both sexes were randomly allocated to four experimental groups replicated thrice with 6 rabbits each. The feed composition and calculated nutrient composition of the dietary treatments is presented in the Table 1.

Data collection and statistical analysis

The initial weights, body weight, feed intake were obtained using a digital weighing balance while the FCR was calculated from the feed intake and body weight gain. Data collected were subjected to one-way ANOVA in Completely Randomized Design. Differences between statistical means were separated using Fisher's Least Significant Difference (F-LSD) (Steel and Torre 1980) as modified by Obi (2010).

Table 1: Feed composition and calculated chemical composition of the experimental diet (g/kg)

Ingredients	**CTRL**	**DCP10**	**DCP20**	**DCP30**
Maize	400	300	200	100
Dried citrus pulp	0	100	200	300
Soybean	50	50	50	50
Wheat offal	300	300	300	300
Palm kernel cake	230	230	230	230
Bone meal	3	3	3	3
Lysine	5	5	5	5
Methionine	5	5	5	5
Salt	3	3	3	3
Premix	4	4	4	4
Total	1000	1000	1000	1000
Calculated chemical composition				
Crude protein (%)	15.41	15.25	15.01	14.80
Crude fibre (%)	6.5	6.5	6.3	6.0

Energy (ME) (kcal/kg DM)	3200	3150	2900	2800

Results and Discussion

The result of the growth performance indices of the grower rabbits fed diets containing graded inclusion levels of dried citrus pulp is presented in Table 2.

Table 2: Growth performance indices of grower rabbits fed diets containing graded levels of dried citrus pulp

Parameters	CTRL	DCP10	DCP20	DCP30	±SEM
Initial body weight (g)	1400	1400	1400	1400	0.11^{NS}
Final body weight (g)	1700^{b}	1770^{a}	1770^{a}	1500^{c}	63
Body weight gain (g)	300^{a}	310^{a}	370^{a}	230^{b}	97
Total feed intake (g)	4950^{c}	5510^{b}	6330^{a}	4040^{d}	61
Mean daily intake (g)	88b	98b	113a	72^{b}	12
FCR	2.91^{c}	3.11^{b}	3.58^{a}	2.70^{d}	0.19

a, b = Means on the same row with different superscripts are statistically significantly (P<0.05).
SEM = Standard error of the mean.

At 10 and 20% replacement of maize DCP there were no significant (P>0.05) differences in body weight. However, the body weights of the two treatments were significantly (P<0.05) heavier than that of control and those fed a diet in which 30% of maize was replaced with DCP. Total feed intake of all treatment groups differed significantly (P<0.05). Varying the inclusion levels of DCP resulted in feeds that were neither isocaloric nor isonitrogenous. Increasing levels of DCP led to decreasing energy, protein and fibre levels in the diets. Increasing the dietary inclusion of DCP from 10 to 20% replacement of maize did not significantly (P>0.05) increase the body weight though the rabbits from both treatments had consumed significantly (P<0.05) more feed than those in the control treatment, and those fed diet with 30% replacement of maize. It rather increased feed intake with a corresponding body weight gain (Arthington *et al.*, 2002) whereas 30% replacement appeared to have affected the taste of the feed thus significantly (P<0.05) reducing feed intake with a correspondingly lower (P<0.05) weight gain. FCR differed significantly (P<0.05) among treatments. Despite a more efficient feed utilization, those fed a diet with 30% replacement had significantly (P<0.05) less feed intake and body weight gain. This finding contradicts Caparra *et al.*, (2007) who reported that 30 - 40% inclusion levels did not impair growth performance. Perhaps, the astringent taste of the essential oils in DCP reduced feed intake. Essential oils contain bioactive compounds that have the potential to act as multifunctional feed supplements for animals including effects on growth performance, digestive system, pathogenic bacterial growth and lipid oxidation (Simitzis, 2017). Thus, the essential oil, which had a higher concentration per unit intake as inclusion levels increased up to 20% apparently impacted positively on the gut microflora thus improving feed efficiency. However, at 30%, it seems to impact positively on FCR despite reduced feed intake occasioned apparently by the essential oils.

Conclusion and Recommendation

All the inclusion levels tested appeared to impart some benefit on the rabbits. A diet with 10 and 20% replacement of maize with DCP gave heavier body weight with more feed intake. On the other hand, those fed diets with 30% replacement gave better feed utilization with less feed. Thus, a diet in which 20% of maize is replaced with DCP is recommended as it will ease the pressure of competition for maize. However, further study is recommended to evaluate the effect of DCP on the gut microflora of rabbits and cost benefit analysis to determine cost efficiency of 30% replacement. This will boost the economy as the dried citrus pulp in rabbit diet will improve the environment by converting citrus waste to wealth, create a citrus value chain and reduce the pressure of competition for maize.

References

Akinmutimi A. H and Onwukwe C. C (2000). Effect of cooking with various concentrations of potash on nutrient composition of lima beans. *J Agric Biotechnol*, 1: 1-3.

Arthington JD, Kunkle WE and Martin AM (2002): Citrus pulp for cattle. *Vet. Clinic* 18, 317-326.

Caparra P, Foti F, Scerra M, Sinatra MC and Scerra V (2007) : Solar dried citrus in lamb diets: effect on growth and carcass and meat quality. *Small Rum. Res.* 68: 303-311.

Crawshaw R (2004): Co-product feeds. Animal feeds from the food and drinks industries. Nottingham University press. https://www.feedipedia.org/node/680. Accessed 7 January 2019

Hon FM, Oluremi OIA and Anugwa FOI (2009): The effect of dried sweet orange (*Citrus Sinensis*) fruit pulp meal on the growth performance of rabbits. *Pakistani J Nutri*., 8(8): 1150 – 1155. doi:10.3923/pjn.2009.1150.1155

Jingzhi Lu, Xianghua Long, Zhifei He, Yingchun Shen, Yanhong Yang, Yuanqing Pan, Jiahua Zhang & Hongjun Li (2018) Effect of dietary inclusion of dried citrus pulp on growth performance, carcass characteristics, blood metabolites and hepatic antioxidant status of rabbits. *J Appl. Anim. Res.*, 46:1, 529-533. https://doi.org/10.1080/09712119.2017.1355806

Nwakpu PE (2008): Principles of animal production. Unpublished lecture notes, Department of Animal Science, Ebonyi State University, Abakaliki, p. 8

Obi, U. I. (2010): Statistical methods f detecting difference between treatment means and research methodology issues in laboratory and field experiments. 2ed. AP Express Publishing Company Limited, Nsukka, Nigeria., pp 198.

Osakwe II and Ekwe OO (2007): Variation in relative palatability of different forages fed to rabbits. *Anim. Res. Int.*, 4: 608-610.

Owen OJ, Alawa JP, Wekhe SN, Isirimah NO, Chukwuigwe EC, and Aniebo AO (2008): Incorporating poultry litter in animal feed: a solid waste management strategy. *Egyptian J Anim. Prod.*, 18, 317-326.

Simitzis, P.E. (2017): Enrichment of animal diets with essential oils - a great perspective on improving animal performance and quality characteristics of the derived products. *Medicines*, 4(2): 35 - 55. doi: 10.3390/medicines4020035

Steel RGD and Torrie JH (1980): Principles and procedures of statistics. a biometrical approach, 2nd Edition, Mchraw Hillbook Company.

Taiwo AA, Adejuyigbe AO, Adebowale AE, Oshatan JS, and David OO (2005): Performance and nutrient digestibility of weaned rabbits fed forage supplemented with concentrate. *Nigerian J Anim. Prod.*, 32(1): 74-78.