ADAN J. Agric. 2024, 5: 66-73 **DOI:10.36108/adanja/4202.50.0180**

ISSN 2736-0385

Performance of rabbits fed diets containing different levels of orange waste meal as energy source during the reproductive phase

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Abstract

The study assessed the reproductive performance of rabbits fed different levels of orange waste meal (OWM). The orange waste was gathered, sun-dried, and milled before feed formulation. Four experimental diets were formulated to supply 18% crude protein and 2600 ME (Kcal/kg). Diet 1 was the control, while OWM replaced maize at 20, 40, and 60% in treatment diets 2, 3 and 4 respectively. Forty (40), eight weeks old rabbits (32 does and 8 bucks) of a cross between American Chinchilla and New Zealand white rabbits used for the experiment were weighed and distributed into four groups with ten rabbits (8 does and 2 bucks). Groups were randomly assigned to one of the four dietary treatments in a completely randomized design. Animals were fed the diets and raised under the same experimental condition until sexual maturity at five months. At sexual maturity, does and bucks of the same treatment groups were crossed, and does kindle within thirty-two (32) days. Four parities were obtained during the experiment. Data collected were subjected to analysis of variance and significant means separated by Duncan's multiple range test. Rabbits fed control and treatment diets recorded similar ($p>0.05$) values for the average daily feed intake, average litter size at birth and average litter size at weaning. The average weekly weight gain and the average litter weight at weaning were significantly ($P<0.05$) influenced by the treatment diets. It was therefore concluded that orange waste meal could replace 60% of maize in the diets of rabbits without adverse effects on reproductive performance.

***Keywords**: Rabbits; litter size; litter weight; orange waste; energy source.*

Introduction

Rabbits are remarkable animals known for their high reproductive capacity, rapid growth, ability to convert cellulose to protein, and adaptability to grain-free diets, with low requirements for initial investment (El-Sabrout *et al*., 2023). Unlike chickens and pigs, which are largely dependent on grains and oil cakes such as corn and soybean meal, rabbits have the unique ability to obtain protein and energy from cellulosic plants. They also have an impressive protein utilization rate of 20%, similar to that of chickens (22%) and far exceeding that of pigs (16–18%) and cattle (8–12%). This particular characteristic makes rabbit farming a sustainable enterprise characterized by less competition with human food resources (Cullere and Zotte, 2018). They are raised to provide alternative meat for man due to the shortfall in production from other conventional sources, like poultry, cattle, sheep and goats. In animal production, feeding plays a vital role in attaining the optimum productivity and quality per quantity of animal products (Agunbiade *et al*., 2002). Concentrates are vital ingredients for the growth and production of rabbits, but this is affected adversely due to the high cost of feed/feedstuffs owing to the stiff competition between man and animal (mostly

monogastric) that feed mainly from grains and oil seeds (Moustafa *et al*., 2008).

Considering the cost implication and the availability of these feedstuffs, animal nutritionists have sought alternative feedstuffs to enhance the administration of well-balanced feed at a relatively lower cost to rabbits and incorporating agro-industrial byproducts into animal diets is one way of solving the problem of feed shortages and high cost of production in Nigeria (Hon *et al*., 2009).

Orange waste meal has proven to be a unique energy source in partial replacement of maize, sorghum and wheat in rabbit ration (Pet-Edu, 2011). It contains a high level of energy amounting to 3756.14 ME (Kcal/kg), with all-year-round availability, making it a unique product for feeding rabbits. With rabbits undergoing coprophagy and caecotrophy (pseudo-rumination and gut fermentation), where large fibre substances are absorbed into the caecum and acted upon by special bacteria and enzymes into absorbable nutrients like simple sugar, starches and amino acids, utilization of orange waste pulp meal is advantageous at pre-partum, partum and postpartum stages of production (Hon *et al*., 2009, Pet-Edu, 2011). There is a dearth of information on the utilization of orange waste meal as an energy source in breeder's rabbit ration, therefore the study was designed to evaluate the litter traits performance of breeder rabbits fed diets with OWM as an alternative energy source.

Materials and Methods

Experimental site

The feeding trial was conducted in the Department of Animal Science Teaching and Research Farm, University of Calabar, Nigeria, while the chemical analysis was conducted at the Central Laboratory, Faculty of Agriculture, University of Calabar-Nigeria. Calabar is located between latitude 04.57^{o}N and longitude 08.20^{o}E, with annual rainfall ranging from 1260mm to 1280mm, temperature of 25-30^{0}c with relative humidity between 70 and 90% and an elevation above sea level of 99m

Processing of experimental material

Sweet orange wastes (a residue obtained after juice extraction) were obtained from the local fruit juice processing industry in Calabar municipality, Cross River State, Nigeria. They were chunked into smaller pieces and sundried to a moisture content of 10-12%. The sun-dried samples were milled using a High-Speed Industrial Grinder, (Dry Miller Machine 800G) and stored prior to chemical analysis and feed formulation.

Proximate analysis

Proximate analysis of the orange waste meal and the experimental diets were carried out to determine their proximate composition (AOAC, 2020). The fractions determined were the crude protein, ether extracts, crude fibre, and ash. The Nitrogen Free Extract (NFE) was determined by subtracting the sum of other components including moisture from 100.

Experimental diets

Four experimental diets were formulated (Table 1) to supply the crude protein value of 18% and a metabolizable energy of about 2600 kcal/kg. Diet 1 containing maize as energy source was the control while orange waste (pulp) meal was used to replace maize at 20%, 40% and 60% levels for diets 2, 3 and 4, respectively as energy source.

Table 1: Composition of Experimental Diets

	Levels of orange waste meal			
Ingredients	**0%**	**20%**	**40%**	**60%**
Maize	45.50	36.40	27.30	18.20
Orange waste meal	-	9.10	18.20	27.30
Soybean meal	15.20	15.20	15.20	15.20
Wheat offal	25.00	25.00	25.00	25.00
Bone meal	3.00	3.00	3.00	3.00
Palm kernel cake	10.00	10.00	10.00	10.00
Salt	0.50	0.50	0.50	0.50
Lysine	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10
*Vitamin/mineral premix	0.50	0.50	0.50	0.50
Total	**100**	**100**	**100**	**100**
Determined analysis				
% Crude protein	18.06	18.00	18.00	18.02
ME(Kcal/kg)	2609	2601	2602	2604
Crude fibre (%)	5.46	5.98	6.67	7.31

*Grower mineral premix containing the following per kg. Vitamin A, 8,000000IU; Vitamin D3, 1,600000IU; Vitamin E, 5,000IU; Vitamin K, 2,000 mg; Thiamine, 1,500 mg; Riboflavin B2 4,000 mg; Pyridoxine B6, 1,500 mg; Anti-oxidant, 125 g; Niacin,1,500 mg; Vitamin B12, 10 mg; Pantothenic acids, 5,000 mg; Folic acid, 500 mg; Biotin, 20 mg; Choline chloride 200r, manganese, 80 g; Zinc, 50 g; iron, 20 g; copper, 5 g; Iodine 1.2 g; Selenium, 200 mg; Cobalt, 200 mg

Experimental animals and procedures

A total of forty (40), eight-week-old crossbreed (New Zealand White x American Chinchilla) rabbits consisting of eight males and 32 females were purchased from a private farm in Calabar municipality for the experiment. The rabbits were weighed and randomly distributed into four groups of eight females and two males. Groups were randomly distributed to one of the four experimental diets described earlier and fed to sexual maturity at five months. Each treatment was replicated thrice with four females and one male. The animals were individually housed in wooden cages of dimensions 120x60x50 cm in a two-tier hutch. Concentrates and water were provided in concrete crocks with an equal quantity of experimental diets (120 g/animal) offered across the groups on daily basis.

At sexual maturity, does were weighed and introduced to the buck with the same treatment for mating. After successful mating, males were returned to their cages and the mating dates were recorded. Pregnancy diagnosis was done by palpation and weight method. Does were supplied wooden nesting boxes on day 25 of pregnancy.

Data monitored were the average daily feed intake and weight gain during pregnancy and lactation, litter size and weight, and stillbirths. Kindling rate = (number of does kindled / number of does mated) x 100 and kitten mortality at 7 days postpartum. Four parities were obtained in

all the treatment groups within 6 months which was the duration of this experiment.

The experimental design employed was a completely randomized design, data collections were subjected to the analysis of variance ANOVA procedures (AOAC, 2020) and the significant means were separated using the Duncan Multiple Range Test.

Results and Discussion

Proximate composition of orange waste meal and maize

he proximate composition (Table 2) revealed that maize's crude protein and fats contents were 9.05± 0.03% and 3.94 0.07% compared to5.60± 0.04% and 1.67± 0.02%, respectively recorded in orange waste meal. The orange waste meal was superior to maize in ash content, while the two samples were similar in their carbohydrate composition, whereas orange waste meal had a higher crude fibre content of 8.6%. Gestating and lactating rabbits can effectively digest fibrous food, hence utilising the high energy of the orange pulp meal.

Mineral composition of orange waste meal and maize

Maize was richer in all the minerals (Table 3) monitored, except for iron where OWM had a superior value (220.24±0.02 mg/100 g). The prevalence of third-trimester pregnancy anaemia has been attributed to low levels of iron in the blood among animals (Eweis *et al.*, 2021). In this research, it was observed that OWM recorded a higher level of iron than maize indicating that the sample can supply the needed iron throughout the gestation period. The dietary supplementations of these compounds can cover the low contents of calcium and phosphorus in the OWM.

Table 2. Proximate composition of orange waste meal and maize

Constituents (%DM)	Orange waste meal	Maize
Crude protein	5.60 ± 0.04	9.05± 0.03
Crude fibre	9.60 ± 0.01	2.52± 0.06
Ash	3.90 ± 0.03	1.74± 0.05
Carbohydrate	80.23± 0.06	82.75± 0.02
Crude fat	1.67 ± 0.02	3.94± 0.07

Values are Means ± SD (n=3)

Table 3. Mineral composition of orange waste meal and maize

Constituents (mg/100 g)	OWM	Maize
Calcium	1.63 ± 0.01	48.30 ±0.08
Magnesium	4.90 ±0.03	107.90 ± 0.06
Sodium	1.53 ±0.06	59.20 ± 0.09
Potassium	1.81 ±0.01	324.80 ± 0.03
Iron	220.24 ±0.02	4.80 ± 0.04
Phosphorus	14.54 ± 0.02	299.60 ±0.02

Values are Means ± SD (n=3)

Effect of feeding orange waste meal diets on the reproductive performance of rabbits

The mean daily feed intake (Table 4) ranged from 74.21g in does fed 60% OPM diet to 77.59g in does on a 20% OPM diet. The variation in the mean daily feed intake was not significant ($p>0.05$) among the treatment groups, suggesting the general acceptability of the feed by rabbits as animals eat to

satisfy their energy requirement (Dairo *et al*., 2005). The similarity in the feed intake between rabbits fed control and those on treatment diets also suggests the adequacy of the energy intake from the feed during gestation and lactation periods. The mean daily feed intake observed in the experiment was higher than the range (36.39-48.31 g) reported by Carabano and Piquer (1998) for rabbits fed cassava peels. The range (65-80g) reported by Boiti (2004) was similar to the findings of this research, while the average daily feed intake of 27.9-96.4g and 141-211g reported by Iyeghe-Erakpotobor *et al.* (2008) for pregnant and lactating rabbits fed diets containing concentrate and forage (*Stylosanthes hamata*) combinations was higher than the values obtained in this study.

Does placed on treatment diets recorded the highest ($p<0.05$) average weekly weight gain relative to the ones placed on control diet. Similarities in the average weekly weight gain between rabbits fed a 20% OWM diet and those on 40 and 60% OWM diets imply that they were efficient in converting the nutrients inherent in OWM to satisfy their requirement during gestation (foetal development) and milk synthesis. Most of the nutrients absorbed by rabbits fed control diet could have been used for foetal development and less for weight appreciation as evidenced in the lower weight gains recorded in this experiment (Lukefahr and Cheeke, 1991). The result of this experiment agrees with the findings of Aduku and Olukosi (1990) and Johnson-Delancy (2006) who observed a decrease in the mean weight gain of rabbits during pregnancy and lactation.

Variation in the average litter size at birth was not significant ($p>0.05$) among the treatment groups. However, numerically, rabbits fed 40 and 60% OPM diets recorded the highest litter size at birth relative to those on the control and 20% OWM diets. The result suggests that the OWM diets were suitable and supplied the necessary nutrients required by the gestating animals (Lukefahr and Cheeke, 1991, Johnson-Delancy, 2006, Hon *et al*., 2009)]. The result of this work agrees with the findings of Iyabode *et al*. (2014) who reported a mean litter size range of 3.75-6.25 for rabbits fed diets supplemented with different levels of rumen digesta. The authors observed an increase in litter size with higher levels of the fibrous digesta in the diet. The dietary fibre has a positive effect on the gut health, welfare and reproductive performance of rabbits, especially during the gestation period (Johnson *et al*., 2003).

The average litter weight at birth showed no significant difference ($p>0.05$) among treatment groups. However, kittens from does fed the treatment diets recorded higher weight at birth than those fed control diet. The birth weight (2160.5 g) for kittens reported by Effiong and Wogar (2007) agrees with the report of this study. The result implies that OWM diets supplied the necessary nutrients required by the rabbits to produce healthy kittens.

The average litter size at weaning between rabbits fed control diet and those on OWM diet was similar ($p>0.05$), although numerically, those fed 60% OWM diet numerically had a superior value relative to other groups. Superior performance and survivability of the kittens suggest that the treatment diets at 60% OWM provided a sufficient amount of essential nutrients that enabled the rabbits produce quality milk for the fryers (Iyeghe-Erakpotobor, 2008). The better performance could be attributed to factors of good mothering ability, maternal environment and effect of dietary fibre inclusion (Shiere and Corstianensen, 2008).

Rabbits on control diet and those fed 40 and 60% OWM diets recorded a significantly ($p<0.05$) higher average litter weight at

weaning (1812.43g and 1847.33g), respectively compared to those fed 20% OWM diet. The average litter weights from this experiment were within the range (1275 - 2112.7g) reported by Johnson *et al.*(2003) for breeder rabbits fed agro-industrial by-products and mixed forage. The average weaning weight of 2000g reported by Onuoha et al. (2020) for rabbits fed different inclusion levels of African yam bean diet was similar to values obtained in this study, while the range (909.99-972.02g) reported by Macías-Fonseca *et al.* (2021)was lower those obtained from this study.

The average mortality ranged from 18.30% for rabbits fed 60% OWM diet to 24.25% for rabbits fed control diet. The variation in the percentage mortality was not significant ($p>0.05$) among the treatment groups. At first parity, most of the experimental rabbits were inexperienced and failed to remove their furs to provide heat to the kittens. Most of the kittens died as a result of cold stress rather than the treatment effect.

Table 4. Effect of feeding orange waste meal diets on the reproductive performance of rabbits

	Percentage level of OWM				
Parameters	**0%**	**20%**	**40%**	**60%**	**± SEM**
Av. daily feed intake of gestating and lactating does (g)	77.14	77.59	75.88	74.21	0.57
Av. weekly weight gain of gestating and lactating does (g)	220.40[b]	382.82 [a]	355.42 [a]	300.96 [a]	5.99
Av. litter weight at birth (g)	45.56	57.81	53.29	56.73	1.09
Av. litter size at birth	5.38	5.17	6.56	6.51	0.39
Av. litter size at weaning	3.42	3.52	4.33	4.67	0.38
Av. litter weight at weaning (g)	1871.58[a]	1665.08[b]	1812.43 [a]	1847.33 [a]	4.48
*kitten's mortality (%)	24.25	21.77	23.46	18.30	0.66

Means on the same row with different superscripts are significantly different ($p<0.05$)

±SEM: Standard error of the mean

*Calculated by dividing the total number of kittens dead by the total number born alive and then multiplying by 100

Conclusion and Recommendation

It was therefore concluded that orange waste meal may be used to replace maize as energy source in rabbits' diets to improve reproductive performance. About 60% of the orange waste meal was recommended as a replacement for maize as energy source.

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